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FACING THE CEREALS/FLOURS FUTURE: SUSTAINABILITY AND HEALTH CONCERNS

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SUMMARY
Nowadays, sustainability and health are two of the main drivers of the food industry, and cereals and flours stakeholders are facing the same trends. The estimated population increased for the next 30 years is prompted the search of new raw materials, and especially alternative protein sources to meet the foreseen needs. Likewise, consumer's health concerns are encouraging the design of cereal and other grains based products with different technological and nutritional qualities. Those lifestyle changes force the search of new nutritive alternatives to improve the health pattern of bakery products. An overview of the range of raw materials available for bread making and the physical techniques to modulate nutritional properties, like starch and protein digestibility, would be presented. Flours selected from different sources can lead products with different technological and nutritional properties. Nevertheless, further health improvement could be also obtained through additional processing of the flours using intensive milling, flours fractionation and germination. Those treatments allowed modifying the glycaemic index and protein digestibility of the resulting bakery products.
Anyway, future challenges will require breakthrough innovations including non-traditional flours where sustainability and nutrition go hand in hand. In this scenario, preliminary results indicate that insect flours open new alternatives for developing bakery products.

Keywords: cereal, sustainability, health, nutrition

INTRODUCTION

Everybody is aware of the drastic changes that society is currently facing. The last century has brought about very big changes in technology that have been improving our life style. But besides those technological advances, the world is facing, among others, three main challenges. Firstly, a huge increase of the population for the next 30 years, and particularly the increase of elderly people, because in some parts of the world our senior citizens are a majority. Secondly, two opposite nutrition patterns are coexisting: hunger due to the lack of food in some parts of the world and obesity in some other parts due to excessive food intake;

and both patterns provoke numerous ailments and deaths. Finally, pollution, fields over-exploitation, burnt forests, besides great amounts of daily food waste are contributing to climate changes. The scenario shows plenty of challenges that require an urgent action.

Cereals have been staple food in many parts of the world and in some other are used for producing a great diversity of products, comprising different types of breads, pastries, cookies, soups, creams, bars, breakfasts cereals, infant's foods and so on. However, needs have been changed, and the questions that arose is if cereals are still able to answer those needs and if cereal researchers will be able to provide responses to those necessities.

In this paper a revision of where the cereal research has been moving on during the last decades and also some tips about possible future trends are presented.

CEREALS IN RESEARCH

Research in cereals have been very multidisciplinary and, like in any other topic, the number of publications in the last two decades are similar to the number of scientific documents in the twentieth century (**Figure 1**) (Web of Science, 2017).

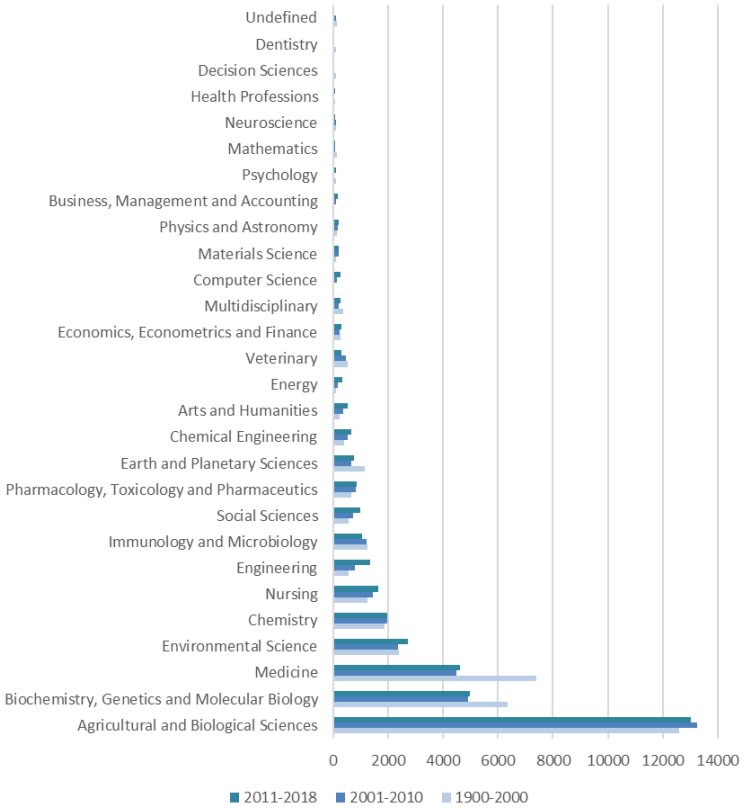

Figure 1 Number of cereal related manuscripts published in the different categories since 1.900 (Source: Web of Science, 2007).

Indeed, research in agricultural and biological science has been the main discipline for cereals in the last century, but also extensive research has been carried out in biochemistry, genetics and molecular biology and also medicine. Additionally, cereals have been present regarding environment, chemistry, nursing, engineering, immunology and microbiology, social sciences, energy and so on. Overall, they have contributed to a variety of aspects of our life.

Nevertheless, research drivers in cereals have been changing from the last century. A very good picture of the cereals research could be obtained from the key words of the manuscripts published since 1.900 (**Figure 2**). Initially, aspects like proteins analysis by chromatography or electrophoresis dominated the research. Then, in the nineties, studies were focused on wheat and its main components, starch and proteins. In the second decade of the twenty-first century, research conducted on wheat but moving on to aspects like dough, rheology and other cereals like rice, maize and oats, apart from starch and proteins. It is surprising that in the last decade (2011-2017) research has been focused on the analytical techniques, like calorimetry, viscosity analysis, texture and microscopy, as well as the chromatography and electrophoresis analysis. In addition, lately studies on antioxidants and digestibility reveal the health concerns regarding cereals.

Therefore, massive knowledge in cereals have been acquired through the years, which has allowed reaching more efficient use of cereals and their processing, besides the production of plenty of different products with better quality. However, current challenges are different and maybe even disruptive actions are needed to face them.

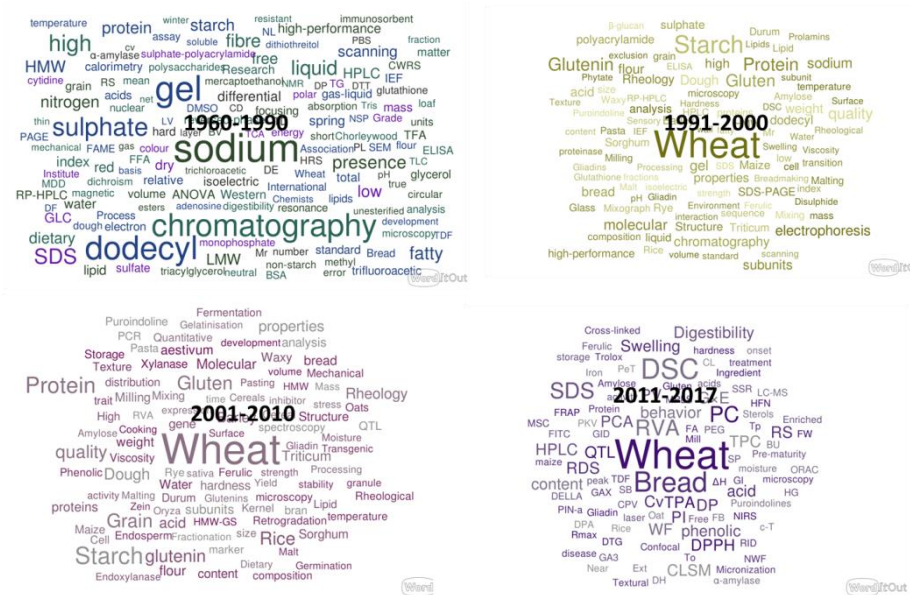

Figure 2 Keywords' clouds obtained from the manuscripts published since 1.900 related to cereals (Source: Web of Science, 2007).

SUSTAINABILITY IN CEREALS AND CEREAL-BASED PRODUCTS

As it was mentioned before, cereal-based products constitute staple food in many parts of the world, but their production is limited and it is anticipated that it will not be sufficient to feed the growing population. In consequence, alternative raw materials should be found to coexist with cereals. Production yields should be improved as well.

Alternative raw materials for obtaining cereal-based products

Some years ago, the use of pseudocereals for breadmaking was proposed (Rosell et al. 2009), for instance the use of flours from the highly nutritious Andean crops quinoa (*Chenopodium quinoa*), kañiwa (*Chenopodium pallidicaule*), and kiwicha (*Amaranthus caudatus*). Nonetheless, bread with aerated crumb structure could be obtained from 100% Andean crop flours only if some additional strategies are used, like the ones applied for gluten free bread (Matos and Rosell, 2015). Otherwise, bread with good sensory acceptability but variable colour by replacing wheat flour by 50% quinoa or kiwicha or 25% kañiwa. Nowadays, partial substitution of wheat flour by Andean crop flours constitutes a viable option to improve the nutritional value of the bread, with acceptable technological performance of dough blends and composite bread.

Legumes are the other crop that has been successfully used for producing bread (Ouazib et al., 2016), or cakes (Gomez et al., 2008; Gularte et al., 2012) with acceptable quality. It is important to notice that legume flours can be obtained directly by milling or modifying their properties by previous processing of the legumes. Ouazib et al. (2016) reported the partial substitution of wheat flour with either raw or processed chickpea (germinated, toasted and cooked) flour at different levels (10 and 20%). Authors showed that 10% wheat flour replacement resulted in minor changes in the bread quality and germinated chickpea flour was the most appropriate flour for making composite flours and for obtaining bread with acceptable specific volume, crumb hardness and nutritional composition (higher protein content).

In the search for new raw materials, it is crucial to consider the autochthonous crops of each country in order to decrease their dependence on commodities importation. For instance, field bean semolina was blended with rice or corn semolina to obtain bread, applying traditional technology used in Algeria (Bourekoua et al., 2016). The properties of the resulting bread were improved by a hydrothermal treatment of rice or corn flours that were then mixed with semolinas. The optimum formulation for rice/field bean bread contained 7.59 g/100 g treated rice flour and 96.66 g/100 g water, and for corn/field bean bread the optimum included 4.73 g/100 g treated corn and 78.81 g/100 g water.

A more disruptive approach is the inclusion of insects' flours in baked goods. Insects are becoming an interesting source of proteins for feeding, but also as a protein-rich food source for humans. Insects might be a sustainable and healthy commodity that could contribute to global food security, taking into account the

high biological value of their proteins. Therefore, it is important to explore the potential use of insects' flour as protein-rich ingredient for bakery products. Flour (5%, w/w f.b.) from *Acheta domestica* (Orthoptera, crickets) blended with wheat flour can provide bread with higher amount of proteins, although a reduction in the fat content would be advisable for better nutritional balance of bread (Martinez et al., 2018).

Applying modern technologies for improving existing cereals

Technologies and processing have undergone profound changes and some of them have been applied to cereals. Some examples of these trends can be found in breeding and milling. Different strategies based on the natural genetic variability found in the *Triticum ssp*. or on other innovative approaches like the RNA interference (RNAi)-mediated gene silencing approach to down-regulate the content of all α-, β- and ϖ- gliadins have been proposed. The aim of this strategies is to decrease the content on gluten proteins in which reside the majority of celiac disease epitopes (Gil-Humanes et al., 2012; Leon et al., 2010). Flour from these wheat lines has low toxicity for celiac patients and they kept sufficient viscoelastic properties to make bread with overall sensory acceptance, similar to those of normal flour, but with up to 97% lower gliadin content (Gil-Humanes et al., 2014). Authors highlighted that the low-gliadin flour has improved nutritional properties since its lysine content was significantly higher than that of normal flour (Gil-Humanes et al., 2014).

When it comesto milling, systems have been improved to increase flour yields and also to modify the flours functionality. Regarding the former, the application of jet milling has opened new opportunities to modify flour characteristics (Angelidis et al., 2016; Protonotariou et al., 2015). Jet milling allows producing superfine powders, being able to reduce particle size from 84.15 to 17.02 μm and the breakage of aleurone (Protonotariou et al., 2015). Although bread obtained from jet milled flour had lower specific volume, they showed lower estimated glycemic index.

STRATEGIES FOR OBTAINING HEALTHIER CEREAL-BASED PRODUCTS

Cereal based products have been in the base of the nutritional pyramid in the most of dietary guidelines. However, considering the new dietary habits and health concerns, it is time to personalize cereals based products to meet individual needs as much as possible. Nutritional requirements regarding minerals and vitamins through enrichment, ailments related to gluten intake or excessive carbohydrate intake, or even related to salt intake, are among the current problems.

Approaches to modulate digestibility of cereal based products

It is widely known that by designing cereal based products carefully and balancing the different ingredients, it is possible to modulate the product digestibility. Specifically, different types of fibres have been used to increase the fibre intake of

the population (Wang et al., 2002), besides the improvement of the whole meal products (Rosell et al., 2009). However, by controlling the particle size distribution of the flours it is possible to fractionate them, and therefore to modify their nutritional pattern and functionality (Hera et al., 2013). For instance, physico-chemical properties of rice flour are significantly affected by particle size heterogeneity as well as the properties of starch, which can affect significantly the quality of the resulting bread (de la Hera et al., 2014). That is even more noticeable with gluten free bread, since the starch performance dominates the quality characteristics of bread. A study carried out adding ultrafine carob flour to rice flour allowed obtaining bread with rather low estimated glycemic index (eGI 48) when compared to the standard white bread (Tsatsaragkou et al., 2017).

Another form of flour processing is by subjecting it to extrusion or even microwave (Martinez et al., 2014; Roman et al., 2014). Flour with different functionality could be obtained by using extrusion, which modifies the hydration, emulsifying, thermal and pasting properties of wheat flours, besides their susceptibility to enzymatic hydrolysis and their amount of resistant starch (Martinez et al., 2014; Roman et al., 2014).

Even bread making can be successfully applied to make healthy breads. For instance, when freezing and bake off technology was combined with the addition of fibres, a significant effect was observed on the glycemic index of the resulting wheat rolls (Borczak et al., 2012). In fact, freezing and fibres presence reduced the glycemic index by 34% in the case of partially baked and frozen rolls added with inulin and oat fibre. In addition, the freezing process and the addition of dietary fibre contributed to a significant increase of the slowly digestible starch and reduced the rapid digestible starch and starch digestibility index, but also higher antioxidant activity (Borczak et al., 2015).

Strategies for obtaining healthy cereal based products

Germination of the grains previous to milling is another attractive approach to increase the healthiness of the bakery product, although an optimization of that process is required in order to fully exploit its benefits. When germinating rice grains at different times, flours with different functionalities and nutritional pattern could be obtained (Cornejo and Rosell, 2015). Bread obtained from germinated flours can be enriched in γ-oryzanol, GABA and total polyphenol content. In addition, increase of antioxidant activity and reduce of the phytic acid content and glycemic index, as well as a slight decrease in *in vitro* protein digestibility has been described (Cornejo et al., 2015).

CONCLUSIONS

Although cereals seem like conventional commodities, where everything has been already researched and done, it must be considered that the world is facing new realities and future challenges. The accumulated knowledge about cereals (grains, starch, proteins, baked products, and so on), provide the best tool to face the new

challenges like sustainability and health. In this paper some points have been highlighted, although there are plenty in the vast research that is going on, which reveals that cereals are still hot topic and must contribute to current defies.

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MICROBIOLOGICAL SAFETY OF PHYLLO PASTRY

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Original Research Article
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SUMMARY
Pasta related products based on wheat grains represent foodstuffs that are characterized by the optimal ratio of basic nutrients. Pasta related products have almost a daily presence in nutrition. On the other hand, pasta related products, since they are dried very briefly, have a higher a_w value and thus are more susceptible to proliferation of microorganisms.
The aim of this study was to investigate the microbiological safety of pasta related products – phyllo pastry, produced from wheat flour and with the addition of whole grain wheat flour. The study examined the microbiological safety and sustainability of phyllo pastry. Phyllo pastry was analyzed on the production date and after 5, 7, 14, and 21 days of storage, at the temperature of 8 °C. Samples were tested based on the following parameters: the total number of microorganisms and the total number of yeasts and moulds.
The total number of microorganisms after 21 days of storage was in the range of 1.0 x 10^5 cfu/g (wheat flour phyllo) to 9.5 x 10^5 cfu/g (phyllo pastry with the addition of whole grain wheat flour). The total number of yeasts and moulds after 21 days of storage was in the range of 5.4 x 10^4 cfu/g (wheat flour phyllo) to 7.3 x 10^5 cfu/g (phyllo pastry with the addition of whole grain flour). The most frequently isolated species of moulds from phyllo pastry belong to the following genera: *Penicillium* sp and *Mucor* sp.

Keywords: microbiological safety, moulds, phyllo pastry

INTRODUCTION

Contemporary trends in food industry are based on balanced diet, which provides a good health and the prevention of diseases. Wheat based products are materials which are characterized by an optimal amount of basic nutrients. Wheat products are rich in carbohydrates, proteins, minerals, vitamins, and other nutritious materials. Moreover, they're well known as highly nutritious food. Different kinds

of wheat participate in a human diet. The demand for the products such as whole grain flour and whole grain products from various flours is on a constant rise.
In the world, as well as in our country, pasta related products are present in human nutrition on a daily basis. Production of pasta related products such as phyllo can be done in two ways: industrial and handicraft. Industrial production is automated, while in handicraft production the dough is made by hand. Technological flow of production includes the following stages of production: preparing the flour, mixing the flour with water, extrusion, cutting and pre-drying of phyllo, wrapping, packing and hand weighing of phyllo.
Phyllo (a dough-based wheat product) has been traditionally used for making savory pies (e.g. spinach, cheese, meat, chicken, etc.) as well as sweet pastry delicacies such as baklava etc., in the Eastern Mediterranean (Greece, Turkey, Lebanon etc.) countries, whereas in the last decade, phyllo has also become a popular food commodity among consumers in other countries (US, Europe etc.). Due to its relatively high water activity (a_w) ranging from 0.96 to 0.98, phyllo is mostly prone to spoilage by aerobic microorganisms such as *Pseudomonas* spp. and moulds, limiting its shelf-life to approximately 3-5 days, when stored under aerobic packaging and refrigeration (4 °C) (Tsiraki et al., 2017).
Quality and safety of the finished product directly depend on the quality and safety of raw materials–mainly quality of wheat and semolina, and compliance with specific technological process of production (Bejarović, 2001). The technological process of producing phyllo pastry from flour will not destroy the entire population of microorganisms that are present in flour. Some of them survive those processes and continue their development. Due to its chemical composition, flour represents a very convenient environment for development of various populations of microorganisms. The largest number of microorganisms in the flour comes from wheat itself, while a smaller number contaminates the flour during the process of manipulation. Wheat and wheat products are often subject to infection with various fungi, many of which synthesize mycotoxins (Šarić et al., 2004). The most frequent isolated mould species from the milling products belogs to the genera of *Aspergillus, Penicillium, Fusarium, Alternaria, Cladosporium, Mucor, Rhizopus*, *Eurotium* and *Emericella* (Kljusurić, 2000; Pitt and Hocking, 2009; Kocić-Tanackov, 2012).
The aim of this study was to investigate the microbiological safety of pasta related products – phyllo pastry, produced from wheat flour and with addition of whole grain wheat flour.

MATERIALS AND METHODS

Microbiological safety was examined in this work, as well as the stability of two phyllo pastry types: wheat phyllo pastry and the whole grain wheat phyllo pastry. Wheat flour (T-500) was used for the production of wheat phyllo pastry. Wheat flour T-500 and the whole grain wheat flour were used in the production of the whole grain phyllo pastry in 90:10 ratio. Water was added to prepared flour in

amount necessary to obtain the appropriate flour consistency for extending. After the extrusion process and the cutting, the short pre-drying was performed by the ventilator. The packaging of prepared phyllo pastries was conducted semiautomatic throughout the application of polypropylene packaging material in aerobic conditions. The prepared samples of phyllo pastries were stored in the refrigerator at 8 °C.

Phyllo pastry was analyzed on the day of its production and after 5, 7, 14 and 21 days of storage at the temperature of 8 °C. Respectively, the a_w of the samples was measured using a water activity measurement device (TESTO 650, Germany) with an accuracy of ± 0.001 at 25 °C. Samples were tested based on the following parameters: total number of microorganisms and total number of yeasts and moulds. The total number of microorganisms was determinated according to the standard SRPS EN ISO (SRPS EN ISO 4833-1, 2014). The total number of yeast and moulds was determinated by the Koch method of dilutions (Škrinjar, 2001). For dilutions preparation, 0.1% of sterile solution of peptone water was used. Isolation and determination of the total number of yeast and moulds were conducted on Dichloran 18% glycerol agar (DG18) (Himedia, India). The seeded media were incubated at 25 °C. The results were obtained after 5 and 7 days. Samples were analyzed in triplicates.

Monocultivation of moulds was conducted in the way that conidia and fragments of hypha from mould colonies were transferred on Czapek yeast (autolisate) extract agar (CYA) [$NaNO_3$ 3 g, K_2HPO_4 1 g, KCl 0.5 g, $MgSO_4 \times 7H_2O$ 0.5 g, $FeSO_4 \times 7H_2O$ 0.01 g, yeast extract 5 g, sucrose 30 g, solution of microelements 1 mL ($ZnSO_4 \times 7H_2O$ 1 g, $CuSO_4 \times 7H_2O$ 0.5 g, distilled water 100 mL), agar 20 g, distilled water 1000 mLl,pH 6.0 - 6.5] or Malt extract agar (MEA) (malt extract 20 g, peptone 1 g, glucose 20 g, agar 20 g, distilled water 1000 mL, pH 5.6 ± 0.2) or Potato dextrose agar (PDA, pH 5.6 ± 0.2) (Himedia, India). In accordance with macromorphological characteristics colonies which presumed to belong to the genera *Penicillium* and *Aspergillus* were seeded on CYA, and others on MEA and PDA. Seeded media were incubated 7 days at 25 °C. The criteria described by Samson et al. (2004), Samson and Frisvad (2004) and Pitt and Hocking (2009) were used for species identification.

RESULTS AND DISCUSSION

Changes in the total number of microorganisms (**Figure 1**) and the total number of moulds and yeasts (**Figure 2**) of wheat phyllo pastries and the whole grain wheat phyllo pastries were examined on the production day and during the storing process at 8 °C after 5, 7, 14 and 21 days.

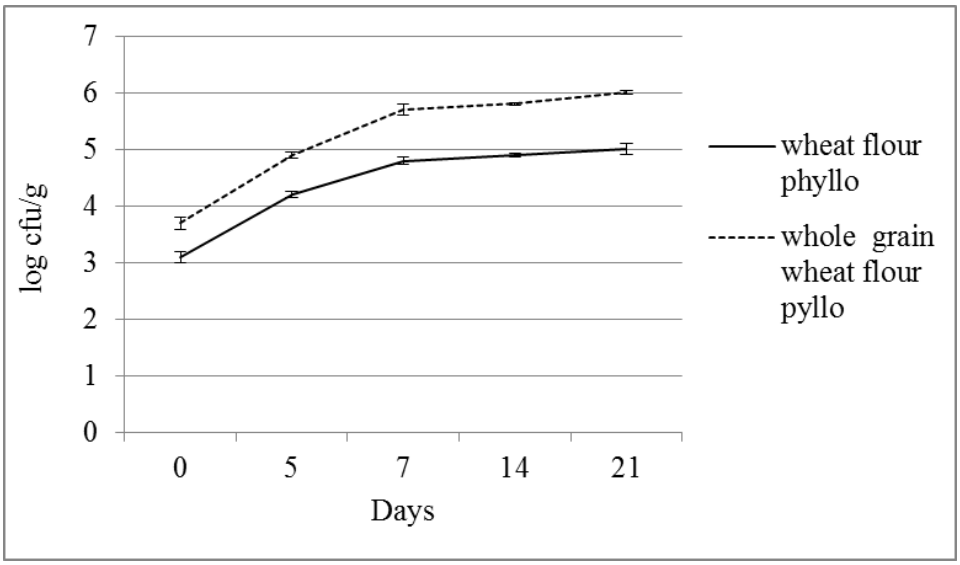

Figure 1 Changes in the total number of microorganisms on the production day and during the storing period at 8 °C (mean ± standard deviation)

The initial total number of microorganisms in wheat phyllo pastry was 3.1 log cfu/g, while at the whole grain wheat phyllo pastry was 3.7 log cfu/g. The tendency of total number of microorganisms increase was spotted during the storing process. After the 21st day of storing process, the total number of microorganisms in wheat phyllo pastry was 5 log cfu/g while in the whole grain wheat phyllo pastry was 6 log cfu/g.

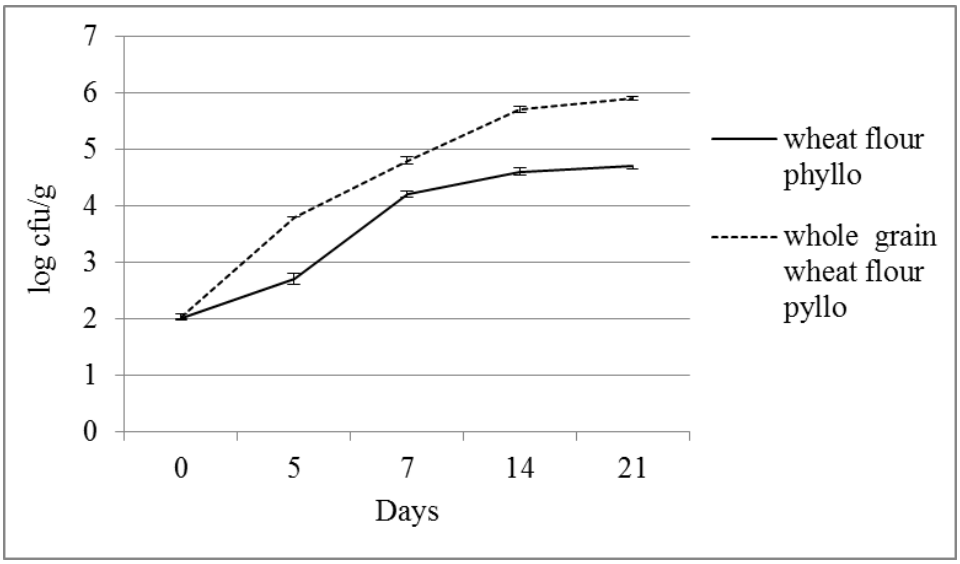

Figure 2 Changes in the total number of moulds and yeasts on the production day and during the storing period at 8 °C (mean ± standard deviation)

The initial total number of moulds and yeasts in wheat phyllo pastry was 2 log cfu/g. After 5 days of storing period, the total number of moulds and yeasts in wheat phyllo pastry was 2.7 log cfu/g while in the whole grain wheat pastry was 3.8 log cfu/g. The tendency of the total number of moulds and yeasts increase was continued during the storing process. After the 21st day of storing, the total number of moulds and yeasts in wheat phyllo pastry was 4.7 log cfu/g while in the whole grain wheat phyllo pastry was 5.9 log cfu/g. Along with the determined number of moulds, the obvious mouldiness was spotted after the 21st day of storing (**Figure 3**).

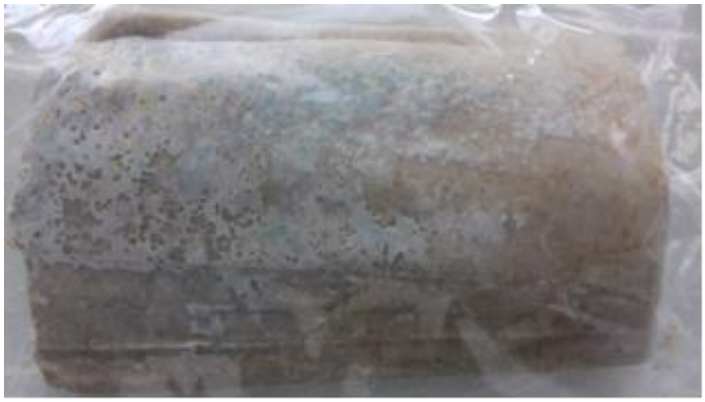

Figure 3 Whole grain wheat phyllo pastry after the 21st day of storing at 8 °C

The most frequent isolated species of moulds were classified in two genera *Penicillium* and *Mucor*. Mycopopulation of wheat phyllo pastry consisted of two species, *Penicillium aurantiogriseum* and *Mucor racemosus.* Mycopopulation of whole grain wheat phyllo pastry consisted of three species, *P. aurantiogriseum, P. expansum* and *Mucor racemosus*.

Penicillium species have potential to grow in most of the substrates (foodstuffs). During microbiological examination of food, *P. aurantiogriseu*m were the most frequently isolated species in our area (former Yugoslavia) (Samson and Frisvad, 2004). These species grow under wide temperature interval, from -2 to 30 °C (the optimal temperature is 23 °C). Furthermore, they also require a minimal a_w value of 0.81. Strain of *P. aurantiogriseum* is known as a various toxic compounds producer, such as: penicillic acid, penitrem A, cyclopiazonic acid, ochratoxin A (Ožegović and Pepeljnjak, 1995; Samson et al., 2004; Pitt and Hocking, 2009).

P. expansum also grows under wide temperature conditions, from -6 to 35 °C, with the optimal temperature of 25 °C. Minimal a_w value that is necessary for germination is from 0.82 to 0.83 (Mislivec and Tuite, 1970b; Hocking and Pitt, 1979; Pitt and Hocking, 2009). It can also grow in conditions with low oxygen content (less than 2.1%), while the presence of carbon dioxide in the atmosphere (under 15%) encourages their growth (Pitt and Hocking, 2009). *P. expansum* is the most isolated species from fruit. In addition, these species are phytopathogenic for many agricultural and fruit sorts. *P. expansum* are toxigenic species and can synthesize a

large number of mycotoxins, such as patulin, citrynin and roquefortine C (Samson et al., 2004; Pitt and Hocking, 2009).

Mucor is a very common and widespread genus in nature, occurring in soils, decaying vegetation, dung and many other moist habitats where rapidly growing fungi have an advantage. *Mucor racemosus* grows between -3 or -4 °C and 30 - 35 °C, with an optimum of 20 - 25 °C. The minimum a_w for growth is 0.92 (Samson et al., 2004; Škrinjar and Tešanović, 2007; Pitt and Hocking, 2009; Plavšić et al., 2015).

Microbiological population of pastry and the other wheat based products, mostly originates from wheat itself and its milling products. The obtained results of research are pointing towards the possible contamination source. In the whole grain phyllo pastry, the increased microbiological population was spotted in comparison to T-500 wheat phyllo pastry. The whole grain flour has the larger amount of bran then T-500 flour. Microorganisms present at the surface of the kernel in larger amount due to inadequate surface processing or incompetent manipulation, could get into the flour, which is the solid base for microorganism growth, and develop, due to the chemical composition.

Plavšić et al. (2012) announced results of buckwheat phyllo pastry research on the production day and 7 days after the storing period at 4 °C. After producion of buckwheat phyllo pastry, the total number of microorganisms was aproximatelly 10^3 cfu/g, and the total number of yeasts and moulds 10^2 cfu/g. After 7 days of storing process, the incresed number of population was spotted. The total number of microorganisms was aproximatelly 10^5 cfu/g, and the total number of yeasts and moulds 10^4 cfu/g.

Fresh bakery products such as dough pastries and pasta, because of their high water activity ($a_w > 0.88$) and pH values in the range 5.7 - 6.5, are prone to growth of diverse microorganisms, with primarily a microbiota, consisting of O_2 depending organisms such as *Pseudomonas* spp., yeasts and molds (Tsiraki, et al., 2017). According to the literature, the growth of aerobic bacteria and fungi (moulds) is the most common cause of spoilage in bakery products (Corsetti et al., 1998). Jespersene et al. (1994) reported that fresh maize dough consisted of fungi (10^5 cfu/g) identifying mainly *Penicillium*, *Aspergillus*, *Fusarium* and yeasts ($<10^3$ cfu/g) namely species of: *Candida*, *Saccharomyces*, *Trichosporon*, *Kluyveromyces* and *Debaryomyces*.

The change of water activity (a_w) value of wheat and the whole wheat phyllo pastry were followed after production and during the storing period at 8 °C after 5, 7, 14 and 21 days (**Table 1**).

Table 1 Water activity (a_w) value of wheat and the whole wheat phyllo pastry after production and during the storing period at 8 °C

Days of storage	Sample	
	wheat flour phyllo	whole grain wheat flour phyllo
0	0.94±0.01	0.93±0.01
5	0.94±0.01	0.93±0.01
7	0.93±0.01	0.93±0.01
14	0.93±0.01	0.93±0.01
21	0.92±0.01	0.92±0.01

Results are given as mean ± standard deviation (n=3)

Measured a_w value after production was 0.94 in the case of wheat phyllo pastry, and 0.93 for the whole grain phyllo pastry. After 21 days of storing, the decrease of a_w value was spotted (0.92), both for wheat and the whole grain wheat phyllo dough. The minimal a_w value for the most of bacteria, moulds and yeasts, causers of food spoilage, were between measured a_w values of wheat and the whole wheat phyllo pastries (Škrinjar and Tešanović, 2007).

The spoilage of baked goods is very much dependent on water activity. High a_w products such as bread and some pastries spoil rapidly from Penicillia (e.g. *P. roqueforti, P. brevicompactum* and *P. chrysogenum*), *Wallemia, Eurotium* species and other common moulds including the red bread mould, *Chrysonilia sitophila, Rhizopus* and *Mucor* species (Pitt and Hocking, 2009).

The durability of the product depends on the amount of water not related to the ingredients of that product, or so-called free water. The boiling and freezing point, water steam pressure, osmotic pressure and microbiological activity depend on the relationship between free and bound part of the water (Vereš, 1991). Drying time of phyllo pastry is short, almost insufficient to be able to reduce present microorganisms that originate mainly from the flour, thereby enabling the production of microbiologically safe product.

CONCLUSIONS

Stability and shelf life of food products were determined by the amount of unbonded water (a_w value) and the present microbiological population. The fresh pastry products such as phyllo pastry, due to high water activity value (a_w>0.90) present a good environment for the microorganisms growth and development. Microbiological population of phyllo originates mostly from the flour. Whole grain wheat flour poses the higher amount of kernel bran in comparison to flour T-500. The most frequent contaminants of flour and their products are moulds. On the basis of results obtained, it could be concluded that usability and shelf life of fresh phyllo pastry has to be limited to 7 days for wheat phyllo pastry and to 5 days in the case of the whole grain wheat phyllo pastry, at the temperature of 8 °C.

ACKNOWLEDGEMENT

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MICROBIOLOGICAL QUALITY ANALYSIS OF ORGANICALLY GROWN OILSEED PRODUCTS

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664.66 : 543.95

SUMMARY
In recent years, seed bread has become one of the favourite breads for consumers, due to its better taste, nutritional value, and positive health effects. This paper illustrates the process of the microbiological quality analysis of organically grown oilseeds, from which many different products can be obtained by cold pressing, including seeds and their semi-products that can be added to the bread. Since these products are not thermally treated in any way, their microbiological safety is questionable. Therefore, the goal of this paper was to implement microbiological control of those products and to compare the obtained parameters with the norms prescribed by the Food Hygiene and Food Microbiological Laws (NN 81/2013). The conducted microbiological methods conform to the requirements prescribed by Croatian norms which are based on the ISO-9001 quality standards. A total of 40 samples, including 6 samples of cold pressed oils, 9 organic butters, 6 organic protein flours, 8 kinds of seeds and nuts, and 11 mixtures of oilseeds and edible nuts for bread and crackers, were collected and analysed on a number of aerobic mesophyllic bacteria, bacteria of the *Enterobacteriaceae* family, moulds and yeasts. The samples were also screened for the presence of pathogenic *Salmonella* and *Listeria monocytogenes* species, and sulphite-reducing clostridia, dependent on the norms prescribed by the Law. It was shown that the measured values did not exceed the prescribed normative values in all samples.

Keywords: seed bread, oilseeds, edible nuts, organic protein flour, butter

INTRODUCTION

Oilseeds are plants whose fruits, seeds and other plant organs contain high amounts of fat and are suitable for processing into vegetable oils (Rac, 1964). Organic production is on a steady rise. Concerns about health and safety and influence on nature biodiversity and environment have the greatest impact on farmer´s decision regarding the conversion to the organic type of agriculture (Cranfield et al., 2010; Hole et al., 2005).

Cold pressed vegetable oils are produced by pressing, without heating, in order to maintain the full quality and nutritional value of the oil. The raw material must undergo the process of cleaning, peeling and milling. In order to get the best quality cold pressed vegetable oil, purification can be done exclusively by washing with water, precipitation, filtration and centrifugation. Such processing helps to preserve antioxidant ingredients and affect the total quality of oil (Mandawala et al., 2012).

Cereals, fruits, vegetables, whole nuts and seeds are the main sources of dietary fibre that have a wide range of positive health effects. Soluble dietary fibres affect the slower discharge of stomach contents, thus contributing the feelings of satiety and regulating body mass. Due to its viscosity and volume in the intestine, it binds itself to the cholesterol from the intestine, which is beneficial to the health of the bloodstream system (Salas-Salvadó et al., 2006). Walnuts have so far been associated with reduced risk of cancer, heart disease and several other chronic diseases also associated with changes in the gut microbial communities. Byerley et al. (2017) studied the effect of consuming walnuts on gut microbiome and found changes that included the growth of probiotic bacteria and reduction of opportunistic pathogens. Bread with the addition of sunflower seeds had a better taste than the control bread and was nutritionally more acceptable due to the composition of essential fatty acids, copper, zinc, tocopherols and other components that could improve nutritional status (Škrbić and Filipčev, 2007).

Nuts and nut products are at low risk from microbial contamination because of thick exterior structure and low water activity, but contamination by pathogenic bacteria can still occur and cause foodborne illness outbreaks (Li and Schneder, 2016; Danyluk et al., 2007). Nuts and cereals are often dried to the water activity lower than 0.70, which prevents survival and growth of microorganisms that could cause spoilage and disease. Humid environmental conditions during growth and harvest season contribute to contamination with moulds or *Salmonella* spp., beacuse shell becomes moist and susceptible to microorganism migration toward the core of nuts (Danyluk et al., 2007). Crops are exposed to microorganism from soil, manure, wild animals and irrigation water during their growth. Microbial contamination can also happen after harvesting, during the processing and storage. Some seed products can be dried using heat treatment, but others are minimally processed and some are treated with temperature not high enough to kill all pathogenic bacteria (Willis et al., 2009).

Oilseeds meals or cakes are important sources of protein and lipid in animal nutrition. In the diet of humans only a few meals and cakes are used. Sesame seed meal, coconut cake and meal from edible nuts are used in pastry and bakery. When oilseed cakes are used for human consumption, they must meet microbiological standards (Rac, 1964). The aim of this study was assessment of the microbiological safety of organic grown oilseeds, edible nuts and products obtained by their processing.

MATERIALS AND METHODS

A total of 40 samples were collected, 6 of which were cold pressed oils, 9 were organic butters, 6 samples were products from organic protein group, 8 samples were different kind of seeds and nuts, and 11 were mixtures for bread and crackers. Cold pressed oils were made of hemp, flaxseeds, pumpkin, apricot kernel, black cumin and coconut oil. Organic butters were made of hazelnuts, walnuts, pumpkin seeds, sesame seeds, sunflower seeds, almonds, peanuts, pistachios and Indian nuts. Four types of organic proteins have been analyzed, including flaxseed, pumpkin, hemp, sunflower seeds and pumpkin and sunflower cake left after pressing. In category of whole seeds and nuts, samples of pumpkin, flaxseeds, sunflower seeds without shell, sesame seeds, black cumin, walnuts, hazelnuts and almond seeds were analyzed. Bread mixtures were also analyzed under the names of producer: Nut, Fruit, Classic, Mediteran, Spacy, Univerzal and cracker mixtures: Nut, Fruit, Classic, Mediteran and Spacy that were tested according to the same requirements of the Microbiology Criteria for Food. The mixtures contained various ingredients such as: sunflower seed, flaxseed, pumpkin seeds, sesame seeds, coconut flour, ground almond, psyllium, cranberries, mulberries, garlic powder, dried tomatoes, basil and rosemary, walnuts, chia seeds, black pepper, cayenne powder, smoked paprika powder and sodium bicarbonate and the mixtures are foreseen for the thermal treatment for 1 hour on 160 °C.

The samples were tested based on the following parameters: the total number of aerobic mesophilic bacteria (AMB), the total number of bacteria of *Enterobacteriaceae* family (E), moulds and yeasts (M&Y), sulphite-reducing clostridia (SRK), *Salmonella* spp. (S) and *Listeria monocytogenes* (L.m.) species that are prescribed by the Food Hygiene Act and Microbiological Criteria for Food (NN 81/2013).

Microbiological parameters were determined according to the following ISO standards: ISO 21528-2:2008, ISO 4883-1:2013, ISO 4833-2:2013, ISO 15213:2003, ISO 6579:2002, ISO 11290-1:2008 and ISO 21527-1:2008.

RESULTS AND DISCUSSION

Obtained test results are shown graphically, except for *Listeria monocytogenes* and *Salmonella* because those microorganisms were not present in samples. The number of microorganisms are expressed in log cfu/mL in case of oil samples or in log cfu/g for results of butter analysis. Samples from **Figure 1** belong to group of Edible vegetable and animal fat, while samples shown in **Figure 2** belong to Edible fat and products and each product group has precisely prescribed microbiological safety requirements. According to the Microbiological Criteria for Food, samples from **Figures 1** and **2** are considered to be microbiologically safe if number of aerobic mesophilic bacteria is 10 cfu/g or 10 cfu/mL, moulds and yeasts are under 10 cfu/g or 10 cfu/mL, bacteria from *Enterobacteriaceae* family are allowed in concentration of 10 cfu/g or 10 cfu/mL or less. This group also has to be tested for

Listeria monocytogenes and has to be negative when analysing 25 g or mL of sample.

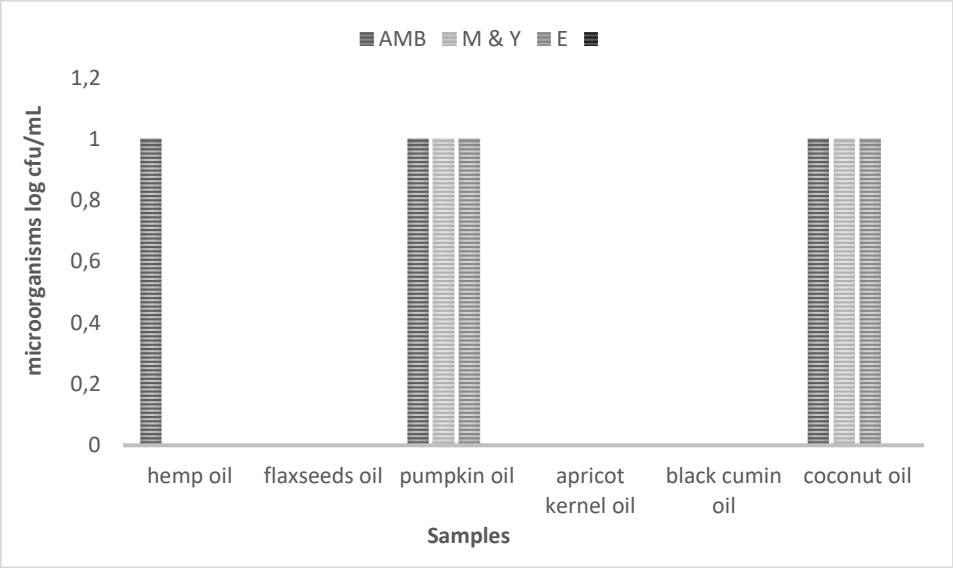

Figure 1 Microbiological analysis of cold pressed oils

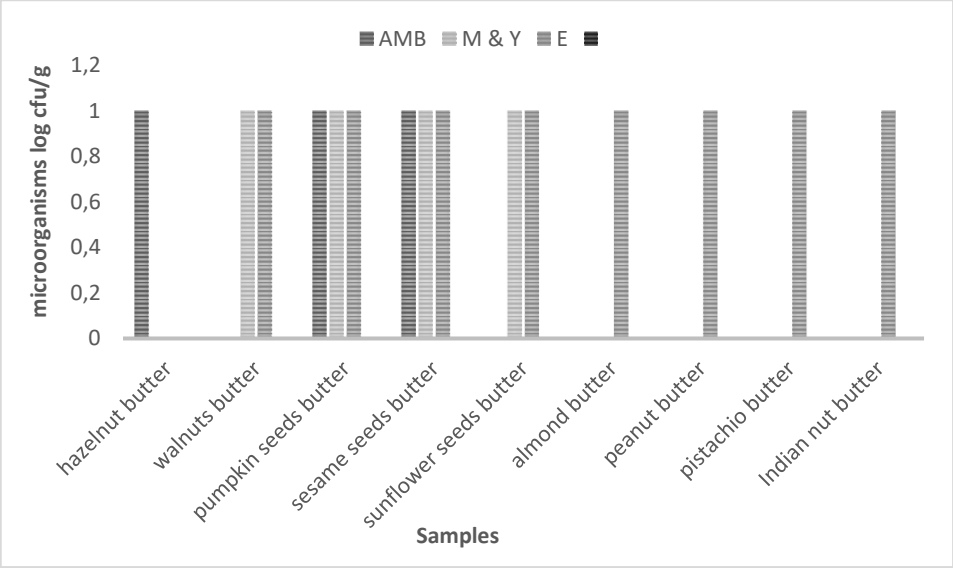

Figure 2 Microbiological analysis of organic butters

Samples which are displayed in **Figures 3, 4, 5** and **6**, belong to the group of protein products of herbal origin (based on soybean, other oilseeds, grain, yeast, etc.). According to Microbiological Criteria for Food maximum, the recommended number of aerobic mesophilic bacteria in that group is 10^4 cfu/g, moulds and yeasts are allowed in concentration of 10^2 cfu/g and bacteria from *Enterobacteriaceae* family are allowed in concentration of 10^2 cfu/g. This group has to be tested for

sulphite-reducing clostridia that can be present no more than 10 cfu/g and test for *Listeria monocytogenes* has to be negative for 25 g of sample. But bread and cracker mixtures from **Figures 5** and **6** can also be controlled as a part of other food groups with different requirements. Depending on their ingredients, they can be grouped as Grain and mill products (AMB max 10^5 cfu/g, E max 10^4 cfu/g, M&Y max 10^4), Dried and candied fruits, fruitage and seeds, dried vegetables and mushroom (AMB max 10^4 cfu/g, S not present in 25 g, E max 10^2 cfu/g, SRK max 10 cfu/g, M&Y max 10^2 cfu/g) or as Spices, seasoning plants and their mixtures (AMB max 10^5 cfu/g, S not present in 25 g, E max 10^3 cfu/g, SRK max 10^2 cfu/g and M&Y max 10^3 cfu/g). Microbiological criteria in these food groups are not so strict since products from this group are intended for baking and high temperature that contributes to the destruction of microorganisms.

Observing the oil samples contamination in **Figure 1**, it could be noticed that pumpkin seed oil was the most contaminated oil, containing 10 cfu/mL AMB, M&Y and E but, since it is the maximum amount prescribed by the Food Hygiene Act and Microbiological Criteria for Food (NN 81/2013), from microbiological point of view, the sample is considered safe. Pumpkin oil is known for its antibacterial and antifungal activity (El-Aziz and El-Kalek, 2011), but in some experiments antimicrobial activity was not proven (Hammer et al., 1999). Flaxseed, apricot kernel and black cumin oil were not contaminated by microorganisms. This could be related to Friedman et al. (2002) research who used 96 essential oils and 23 oil compounds, including apricot and black cumin oil that were active against *Cmpylobacter jejuni*, *Escherichia coli*, *Salmonella enteritica* and *Listeria monocytogenes.* That report on antimicrobial effectiveness suggests that the use of these oils may even improve other food safety.

As could be seen in **Figure 2**, all samples of organic butter contained maximum allowed amount of bacteria of *Enterobacteriaceae* family (10 cfu/g), but were microbiologically safe. Sesame seed butter analysis showed that it was the most contaminated product in this group, and the values of AMB and M&Y were maximum allowed, but still microbiologically safe. Customary heat treatment has not been carried out so it is possible that microorganisms may be left behind in seeds and nuts prior to grinding and that their growth and multiplication have increased the initial number of microorganisms. Non-processed sesame seeds (**Figure 4**) contained a smaller number of microorganisms and that suggests that contamination occurred during or after processing.

The microbiological analysis of **Figure 3** shows the results of organic protein flours and cake after pressing. Sunflower seed cake had the greatest contamination and was potentially microbiologically dangerous. The total number of all determined microorganisms was maximum allowed number, only SRK was slightly below the limit. Cakes are used to feed domestic animals, so their contamination is indirectly dangerous to humans. Hens can eat contaminated seeds or cakes and enter *Salmonella* spp. in organism. Infected hen can transfer bacteria to the egg and then to human, but in this case, all the samples were negative for *Salmonella* spp.

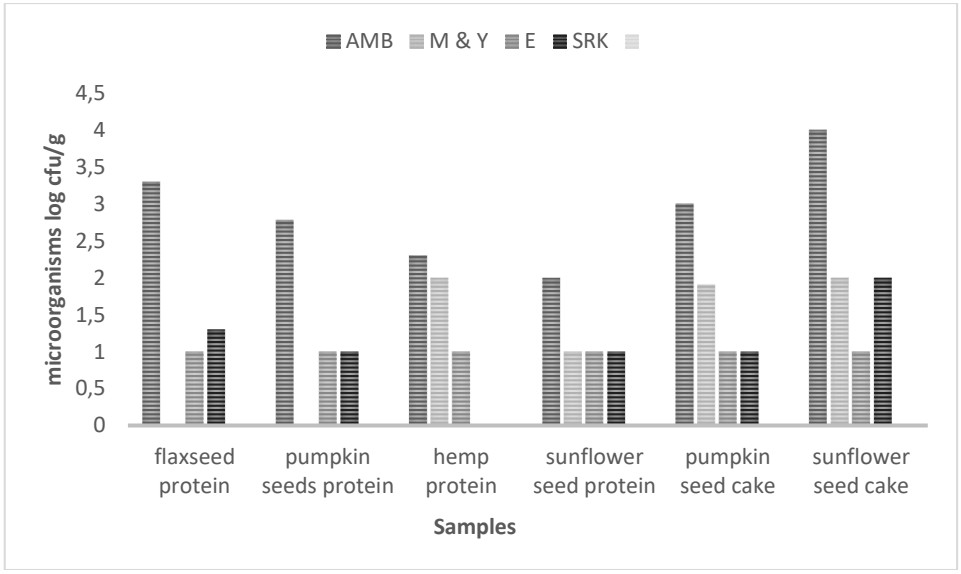

Figure 3 Microbiological analysis of organic protein flours and cake after pressing

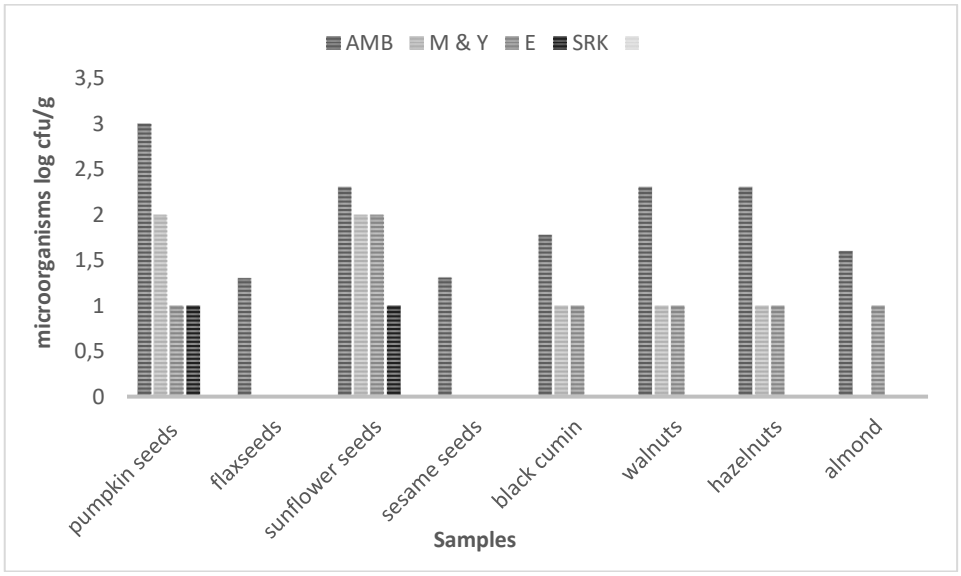

Figure 4 Microbiological analysis of whole seeds and nuts

Figure 4 shows the results of the analysis of whole seeds and nuts. It can be noticed that number of SRK in sunflower seeds was 10 cfu/g, while the sunflower cake had nearly 10^2 cfu/g. The cell wall is destroyed by pressing and it helps microorganisms to penetrate the cake easier than the whole seed. Although this contamination, compared to the Toth (2011) analysis, in which SRK was not found in sunflower seeds and cakes, this result is undesirable, but it is very low contamination when comparing to Microbiological Criteria for Food. The cake was not produced by elevated temperatures, which also affects the number of bacteria that can be

destroyed by the temperature of 121 °C. Since these bacteria are very resistant and can survive conditions that destroy vegetative bacterial cells, this SRK number is not uncommon. Organic sunflower seed butter contained bacteria from E family (10 cfu/g) and 10 cfu/g of moulds and yeasts, while there was no AMB. Based on the results, it can be concluded that the processing method affects the microbiological stability of the final product.

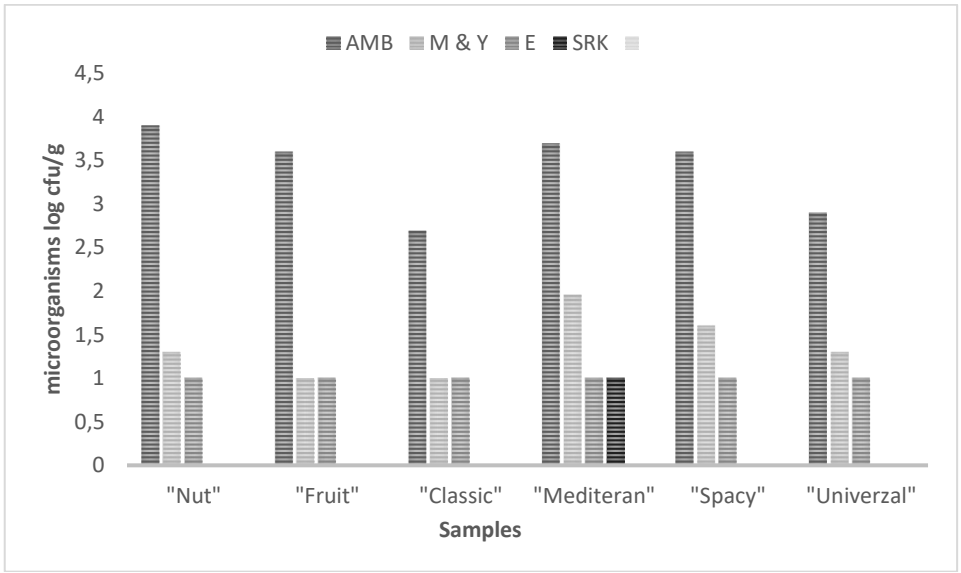

Figure 5 Microbiological analysis of bread mixtures

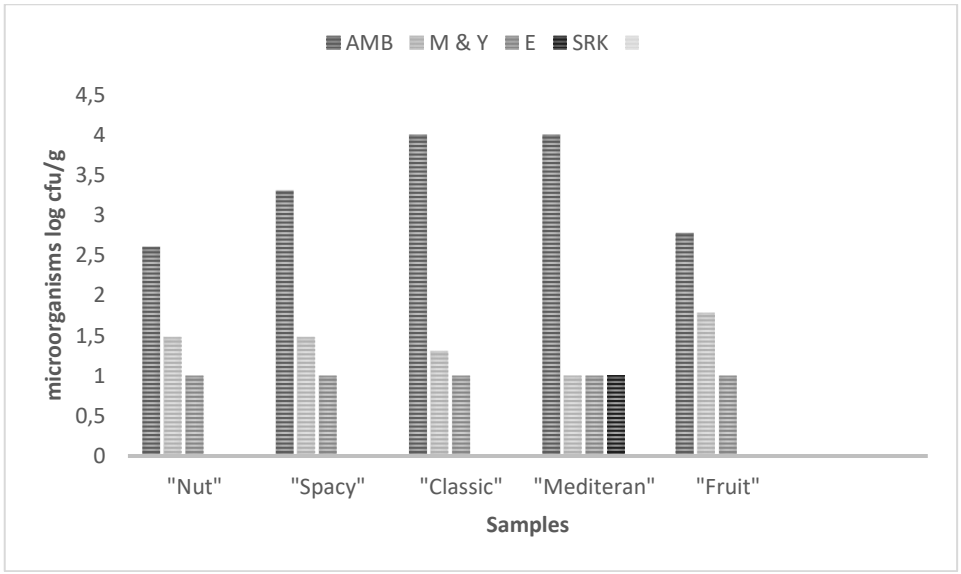

Figure 6 Microbiological analysis of cracker mixtures

Figures 5 and **6** show graphical results of bread and cracker mixtures analysis. Because they contain numerous ingredients, it is difficult to place them in the appropriate product group prescribed by the Law. The most contaminated was "Mediteran" blend for cracker with 10^4 cfu/g AMB and "Mediteran" mixture for bread with 5×10^3 cfu/g AMB. "Mediteran" mixture was also the only mixture that was contaminated with 10 cfu/g SRK in case of cracker and 10 cfu/g in case of bread mixture. All other samples proved to be negative for SRK and *Salmonella* spp. Although the results for number of AMB are more noticeable on the graph, than the results of other analysis, these figures are not of very high concern because, as mentioned earlier, these products are intended for baking at high temperatures and the number of microorganisms is acceptable.

CONCLUSIONS

Based on the results of the research conducted in this paper, the following conclusions can be drawn:

- All the analyzed samples were microbiologically correct despite the doubts since they were not thermally treated in any way.
- Microbiologically, the least contaminated were the samples of flaxseed cold-pressed oil, apricot kernel and black cumin oils because microorganisms of the species prescribed by the norms did not grow on a growth media, which is not surprising because it is widely believed that cold pressed oil on the organic method of producing plants has antimicrobial activity.
- The "Mediterranean" and "Classic" cracker mix samples were contaminated the most, with aerobic mesophilic bacteria (10^4 cfu/g) and the value was at the upper limit as prescribed by the Food Hygiene and Food Microbiological Laws (NN 81/2013), but samples were still microbiologically safe.
- The highest percentage of moulds and yeasts (10^2 cfu /g) were recorded in the sample of sunflower seeds and organic protein from hemp seeds.
- Most bacteria from the *Enterobacteriaceae* family (10 cfu/g) were found in pumpkin seed oil, in all analyzed organic butters, organic flaxseed protein and sunflower cake, but this is not of high concern as this number is allowed by norms.
- The highest number of sulfite-reducing clostridia (20 cfu/g) was measured in the sample of organic protein from flaxseed, but the normative allows up to 100 cfu/g of this type of bacteria.
- Neither the *Salmonella* spp. nor the bacterial species *Listeria monocitogenes*, were found in all 40 samples.

Oilseeds, their semi-products and products obtained by non-thermal processing may be contaminated with microorganisms during field growth, storage and all processing stages, and therefore their microbiological safety must be determined. In order to confirm the obtained results, further research should be carried out to

determine the safety of organically produced oilseeds from other producers and to compare samples with non-organic samples.

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CHANGES FROM DOUGH TO BREAD BY DIGITAL IMAGE ANALYSIS

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SUMMARY
Breadmaking of gluten-free products is more complex than those of gluten-containing products and, for that reason, specific settings have not been developed. It is known that hydration of ingredients is fundamental for obtaining gluten-free breads of acceptable quality. Nevertheless, scarce information exists about the proofing and baking conditions. The aim of this study was to characterize the proofing and baking process for obtaining breads with and without gluten, using digital imaging techniques for dough and bread analysis. Wheat, rice and corn flours were used to define the conditions of the breadmaking process (mixing, fermentation, baking). Dough rheological properties, assessed by Mixolab, showed that gluten-containing doughs have proper consistency, whereas gluten-free doughs resembled batters, with fluid consistency, which increased only during the heating stage. Proofing of wheat doughs was faster and reached higher volume than those obtained with gluten-free flours. The largest expansion of the doughs occurred during fermentation and continued during baking in doughs with gluten, while it decreased in gluten-free doughs. The bubble size was modified along the baking process; in general, the number of bubbles was rather low. Crumbs from the gluten-free breads were harder than those of wheat bread. The statistical analysis suggested weak correlations between dough consistency and the number and size of the bubbles present in crumb. In short, it is important to fix crumb structure of gluten-free products to avoid volume decreased at baking. Therefore, the optimization of baking settings would be advisable to improve gluten free bread quality.

Keywords: breadmaking, image analysis, gluten-free, bread

INTRODUCTION

Cereal-derived products, mainly from wheat, are considered basic for the diet because of their nutritional contribution and their wide availability (Matos and Rosell, 2013). In particular, bread contains essential constituents such as carbohydrates, proteins, fibres, lipids, salts and vitamins, being an important

resource of energy and nutrients (Amigo et al., 2016). However, the term "bread" includes a great diversity of products that are differentiated by their composition and manufacturing process (Rosell and Garzon, 2015).

Due to the fact that the baking process represents a complex interaction between physical, chemical and biological processes, numerous studies have been carried out in order to understand and model the process; those include the evaluation of physicochemical changes that occur and their impact on the characteristics of the final bread (Rosell et al., 2011). During baking, one of the most relevant changes at the macroscopic level is the expansion of the gas cores that give rise to the porous network or crumb. Deshlahra et al. (2009) formulated a model to predict the size distribution of gas bubbles and their growth in the oven undergone during the baking process for products derived from wheat. Della Valle et al. (2014) described the baking process in four basic stages and defined behaviour models for the most significant parameters in each of them. Besbes et al. (2014) recorded the temperature changes during the baking stage in wheat breads using temperature sensors, until the crumb reached 100 °C. Likewise, the relationship between the consistency and the incorporation of air as well as its relation with the quality of the final product has been quantified (Chin and Campbell, 2005). In addition, the perceived quality of the finished products is closely related to the changes produced in the microstructure obtained throughout the entire process (Aguilera, 2005). For these reasons, the microstructure has been the object of several studies, applying transmission electron microscopy (TEM) and scanning electron microscopy (SEM) (Upadhyay et al., 2012). These techniques allow analysing the structure of the dough and gluten network (Bache and Donald, 1998; Correa et al., 2010), as well as the effect of processing on bakery products (Baier-Schenk et al., 2005; Baixauli et al., 2007).

In recent years, the growing trend in the consumption of gluten-free products has led to the development of many different formulations for the improvement of these products. A large quantity of flours and starches without gluten, as well as gums, enzymes, proteins, etc. have been used to mimic the viscoelastic properties of gluten and to contribute to the improvement of the structure, acceptability and shelf life of gluten-free breads (Gujral and Rosell, 2004; Ribotta et al., 2004; Lazaridou et al., 2007; Marco and Rosell, 2008). In addition, in order to obtain gluten-free breads with high nutritional value and acceptable quality, the possibility of incorporating flours with high nutritional value such as amaranth, legumes, etc. has also been studied (Marco and Rosell, 2008; de la Barca et al., 2010; Capriles et al., 2016). Despite the huge research in gluten free products, studies for understanding the process of manufacturing gluten-free breads have been much more limited.

Therefore, the objective of the present work is to examine the changes that occur during the baking process of bakery products, applying digital image analysis. In order to extend the validity of the study, gluten and gluten-free doughs have been investigated, given the differences in their behaviour.

MATERIALS AND METHODS

Raw materials

Wheat flour provided by Harinera La Meta, SA (Lleida, Spain), corn and rice flour purchased from Derivats del Blat de Moro, SL (Parets del Vallés, Barcelona, Spain) (Deutsche Hefewerke GmbH, Hamburg, Germany) and xanthan gum, provided by Desarrollos Panaderos Levantinos, SL (Chiva, Valencia, Spain) were used for breadmaking. Salt was purchased in the local market.

Determination of moisture content and water absorption of the flours

The moisture of the flours was calculated by means of an infrared balance model Kern MLB 50 (KERN & SOHN GmbH, Balingen, Germany). In order to obtain a suitable consistency for the dough formed with the wheat flour, the percentage of water absorption was determined using a Mixolab equipment (Chopin, Villeneuve-la-Garenne, France), with the CHOPIN SIMULATOR profile, which consists of a constant kneading and temperature at 80 rpm and 30 °C, determining the water absorption to obtain a consistency of 1.1 Nm.

Comparative study of the consistency of dough from different cereals

Doughs were kneaded in a Brabender farinograph (Brabender OHG, Germany) using the 300 g bucket. Subsequently, the consistency of the doughs was determined by the Mixolab, adding 75 g of dough in the case of the wheat doughs and 100 g for the gluten-free batters in order to be able to detect the consistency. The consistency of the dough was recorded for 8 minutes at the temperature of 30 °C, and then it was subjected to the temperature increase (4 °C/min) to 90 °C for 7 minutes. From the consistency plot, the initial consistency (C1), the minimum value of consistency before heating, corresponding to the denaturalization of the gluten proteins (C2) and the maximum consistency related to the gelatinization of the starch (C3) were identified (Rosell et al., 2011).

Proving and baking of dough from different cereals

To determine the proofing ability of the doughs, a ball of 50 g of dough was introduced into a graduated cylinder of 5 cm internal diameter. In the case of the gluten-free batters, 50 g were added with a pastry bag to the same type of cylinder. They were introduced into a fermentation chamber (Salva Industrial S.A., Lezo, Guipúzcoa, Spain) at 30 °C and the volume increase was recorded in mL every 5 minutes. Measurements were performed in duplicate. Expansion of the dough in the oven was performed by introducing 50 g of dough, fermented for one hour at 30 °C, into a special oven glass test tube and baked at 185 °C for 30 minutes and recording the volume increase every 5 minutes, expressed in volume increase in mL (ΔV).

Baking process

To make breads, the following flour-based formulation was used: 2% fresh yeast and 1.5% salt. Rice and corn flours required 95% hydration and 0.5% xanthan gum addition. The wheat flour was hydrated with the absorption obtained in the Mixolab. All ingredients were kneaded in a Brabender farinograph (Brabender OHG, Germany) for 8 minutes at 30 °C. The gluten doughs (wheat) were divided into 100 g balls, rounded in a Brabender bowler for 10 seconds and placed in pre-greased metal moulds. Gluten-free batters (rice and corn) were placed in a pastry bag and 100 g of batter was dispersed in the metal moulds. The doughs were fermented in a fermentation chamber (Salva Industrial S.A., Lezo, Guipúzcoa, Spain) at 30 °C for 60 minutes. Finally, the doughs were baked for 30 minutes in an FM oven model F106 (FM Industrial, Córdoba, Spain) at 185 °C and 80% steam. For monitoring the baking process, the same procedure was followed, but using different baking times (4, 6, 8, 10, 15, 20 and 30 minutes). Four loaves were baked for each time. The loaves in their mould were immersed in liquid nitrogen to fix the structure and freeze-dried in a Virtis Genesis lyophilizer (SP Scientific, Gardiner, New York). A fermented dough obtained from each of the flours was also frozen and freeze-dried for reference (starting point of the baking). Dried samples were kept frozen until further analysis.

Digital Image analysis

Evolution of the crumb structure and colour during baking

The colour measurement was carried out with a Minolta CR-400 colorimeter (Konica Minolta, Co. LTD, Tokyo, Japan), expressed in CIE *L*a*b** coordinates, at two different points of each slice, obtaining the average for each of the samples. The parameter *L** represents the brightness, *a** the direction from red (+) to green (-) and *b** indicates the yellow (+) and blue (-) tone. This process was carried out in the freeze-dried breads for each of the different cooking times (4, 6, 8, 10, 15, 20 and 30 minutes of baking)

The cross section of the freeze-dried loaves was captured. Two slices were scanned for each sample using an HP Scanjet G3110 scanner (Hewlett Packard, USA) at 600 dpi resolution. The images were captured in RGB colour. The image analysis was carried out using the Fiji imageJ software, selecting a section area of 20x20 mm in each of the images. First, the contrast between the cell (alveoli) and the background was improved and the image was transformed into gray (8-bit) levels. To establish the threshold, the algorithm "Otsu" was used, which was the best predefined one to assess the crumb structure. Finally, the binary image was improved and particle analysis was performed. The quantified parameters from the crumb were mean of mean cell area (mm^2), mean of alveolar density ($cell/cm^2$), area of cell with respect to total area (% Area, calculated as percentage occupied by cell with respect to total section analysed) and the circularity average of the cell.

Data analysis

The experimental results were analysed by analysis of variance (Multifactorial ANOVA) with a level of significance of 95%. Statgraphics Centurion XVI.I statistical software (StatPoint Technologies, Inc., 2011) was used. A multivariate analysis was also performed to see the possible correlation between each of the analysed variables.

RESULTS AND DISCUSSION

Comparative study of the consistency of dough from different cereals

The average moisture of the flours was 13.34%, 11.68% and 13.68% for wheat, rice and corn, respectively. The water absorption of the wheat flour was 56.6% for reaching a consistency of 1.1 Nm. Due to the importance of the consistency of the doughs in the inclusion of gas cores during kneading, the consistency profile of the doughs from different flours and their behaviour during the heating was analysed (**Figure 1**). Doughs showed different profiles depending on the presence or not of gluten in the flours.

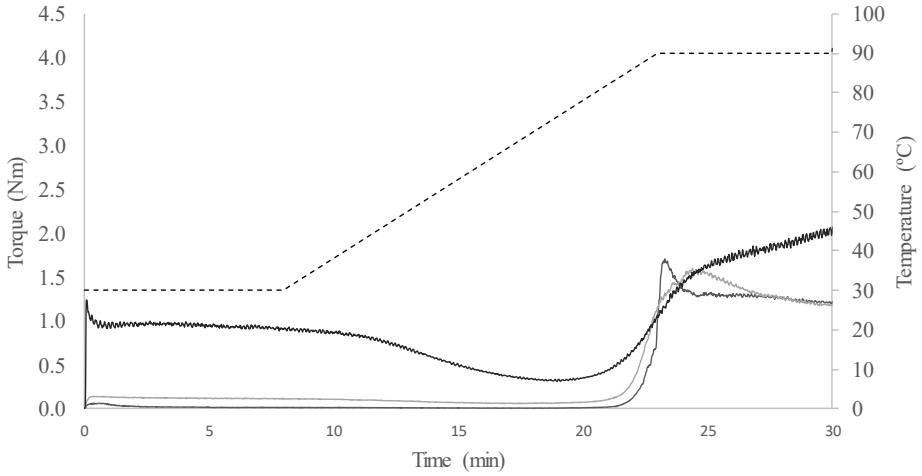

Figure 1 Evolution of consistency over time in different types of flours (**-** wheat, **-** rice and **-** corn) and the theoretical temperature (dashed line). α = rate of weakening of the protein by the effect of heat, β = rate of gelatinization of starch and γ = rate of degradation by enzymes

During the kneading at 30 °C, the rice and corn batters showed a very low consistency, with C1 values of 0.06 Nm and 0.14 Nm respectively, which prevented detection of C2. The hydration of gluten-free doughs plays an important role in the viscoelastic properties of the doughs during kneading (Torbica et al., 2010), being defined by the amount of water added in the formulation and by the hydration during the kneading. When large amounts of water are added (> 90%), the initial

consistency decreases, which is almost unnoticeable, although this high hydration is necessary to improve the technological characteristics of the breads (Rosell, 2013). Instead, the wheat doughs had an adequate consistency (Rosell et al., 2013) with C1 and C2 values of 1.10 and 0.31 Nm, respectively. During the heating, owing to starch gelatinization, there was an increase in consistency regardless of the type of flour (Rosell et al., 2007). In the case of rice flour, a larger (1.72 Nm) and more definite peak was observed at the end of the heating, probably due to the fact that the population of starch granules is more uniform or has a smaller particle size (Wondra et al., 1995), favoring the hydration. Perdon et al. (2001) observed that when the grinding was intensified, that is, when the particle size was smaller, greater water retention and swelling power were obtained. The corn curve showed more gradual increase of consistency (1.56 Nm). Matos and Rosell (2013), when studied the consistency profile of different rice based formulations containing xanthan, reported low values of C1 (around 0.05 Nm), being very similar to those obtained in the present study. In the case of the wheat doughs, the increase of the consistency due to heating started at lower temperatures. In addition, during the holding stage at 90 °C, only wheat doughs increased their consistency, while the gluten-free (rice and corn) batters did not show that pattern likely due to the lower stability of their starch granules at these temperatures (Rosell et al., 2011).

Proving and baking of dough from different cereals

The evolution of the volume of the different doughs during fermentation and baking (**Figure 2**) was evaluated. The volume increase was much higher during fermentation than in the baking stage; in the former even a decrease in the volume of the gluten-free batters was observed. In the wheat doughs the increase in volume during fermentation was greater than in the gluten-free batters. Specifically, a volume increase was observed in the wheat dough after 6 min proofing and only after 15 min proofing for rice and corn. This delay could be due to the different content in fermentable sugars, or diverse amount of damaged starch susceptible to be hydrolysed by α- and β- amylases. Another possible explanation would be the higher hydration of the gluten-free batters (95%), that could promote the diffusion of CO_2, being possible to detect only an increase in dough volume when sufficient carbon dioxide was produced. Lacking gluten, the batters had less resistance, but were able to retain the gas during fermentation thanks to the presence of a hydrocolloid (Torbica et al., 2010). In the baking stage the rice and corn batters maintained the volume acquired during the fermentation, but only for a limited period (2 and 5 minutes), after which there was a progressive loss until stabilization (5 minutes in rice and 15 minutes in corn). On the other hand, the fermented wheat doughs continued to increase their volume during baking due to the ability of the gluten network to retain gas, until the structure (5 minute cooking) was fixed by dehydration, denaturalization of proteins and gelatinization of starch (Gan et al., 2001).

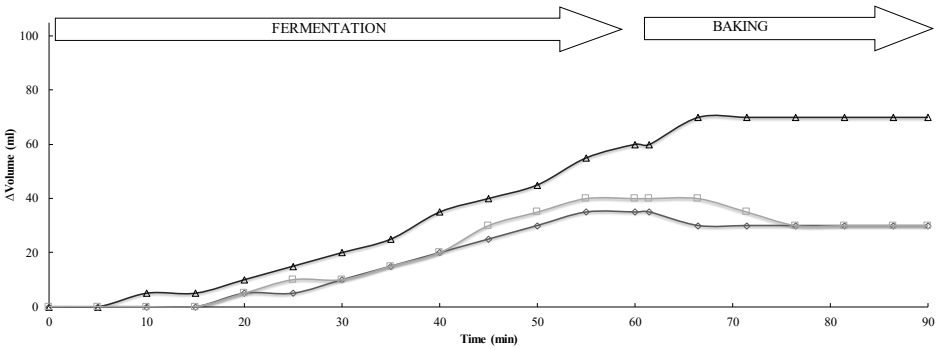

Figure 2 Evolution of the volume of the dough during fermentation and expansion during baking of the dough of different flours (wheat, rice and corn)

Digital Image Analysis

In order to analyse the formation of the crumb and the expansion of the cells during baking, image analysis of the alveolar structure of the doughs was carried out at different baking times (**Figure 3**).

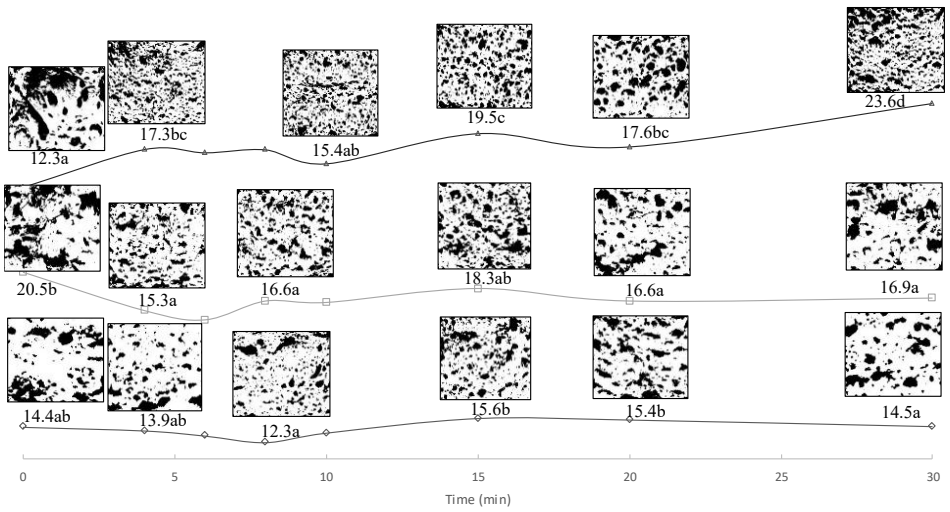

Figure 2 Changes in the alveolar structure (area of cell/total area) of the bread crumb of the different flours with the corresponding baking time (wheat, rice and corn). Different letters next to the values in the same type of flour indicate significant differences between them (p <0.05)

The size of the cells was modified throughout the baking process, but significant differences were observed depending on the type of flour used for making the dough or batters. In the rice batters, there was small variation of the structure, although there were significant changes in the size of the cells during baking

(**Figure 3**). The rice batter suffered a decrease of the volume after 2 minutes of baking until 7 min-baking, then a stabilization of the structure might occur due to the flexibility of the system conferred by starch gelatinization. This initial collapse led to a decrease of both the total area and the area of the cells (**Table 2**). Wheat dough did not follow a clear trend along the baking; it showed changes in the crumb structure, but when comparing the initial and final baking structure, a significant increase in the quotient between the cells area and total area, and total number of cells was detected (**Table 1**).

Table 1 Crumb structure parameters of wheat bread obtained by image analysis (average ± standard deviation)

Baking time (min)	Cell/cm^2	Mean cell area (mm^2)	Circularity
0	24 ± 9 ^{a}	0.55 ± 0.06 ^{b}	0.525 ± 0.047 ^{a}
4	69 ± 3 ^{bc}	0.25 ± 0.02 ^{a}	0.580 ± 0.012 ^{b}
6	68 ± 1 ^{bc}	0.25 ± 0.03 ^{a}	0.575 ± 0.006 ^{ab}
8	59 ± 0 ^{b}	0.29 ± 0.02 ^{a}	0.587 ± 0.029 ^{b}
10	66 ± 7 ^{bc}	0.24 ± 0.02 ^{a}	0.589 ± 0.012 ^{b}
15	66 ± 4 ^{bc}	0.30 ± 0.03 ^{a}	0.593 ± 0.015 ^{b}
20	73 ± 8 ^{c}	0.24 ± 0.01 ^{a}	0.589 ± 0.026 ^{b}
30	61 ± 6 ^{bc}	0.39 ± 0.05 ^{ab}	0.553 ± 0.013 ^{ab}

Different letters in the same column indicate significant differences at 95% confidence (p <0.05)

Table 2 Crumb structure parameters of rice bread obtained by image analysis (average ± standard deviation)

Baking time (min)	Cell/cm^2	Mean cell area (mm^2)	Circularity
0	36 ± 0 ^{ab}	0.40 ± 0.01 ^{bc}	0.521 ± 0.005 ^{a}
4	33 ± 1 ^{a}	0.42 ± 0.07 ^{c}	0.662 ± 0.110 ^{b}
6	39 ± 1 ^{abc}	0.34 ± 0.00 ^{abc}	0.537 ± 0.002 ^{a}
8	43 ± 1 ^{bc}	0.29 ± 0.03 ^{a}	0.585 ± 0.006 ^{ab}
10	45 ± 6 ^{c}	0.31 ± 0.08 ^{a}	0.581 ± 0.010 ^{ab}
15	45 ± 5 ^{c}	0.35 ± 0.03 ^{abc}	0.564 ± 0.008 ^{ab}
20	41 ± 0 ^{bc}	0.38 ± 0.01 ^{abc}	0.523 ± 0.071 ^{a}
30	45 ± 0 ^{c}	0.32 ± 0.00 ^{ab}	0.577 ± 0.001 ^{ab}

Different letters in the same column indicate significant differences at 95% confidence (p <0.05)

Table 3 Crumb structure parameters of corn bread obtained by image analysis (average ± standard deviation)

Baking time (min)	Cell/cm^2	Mean cell area (mm^2)	Circularity
0	25 ± 3 ^{a}	0.84 ± 0.06 ^{d}	0.452 ± 0.010 ^{a}
4	24 ± 1 ^{a}	0.64 ± 0.03 ^{bc}	0.460 ± 0.006 ^{a}
6	38 ± 6 ^{b}	0.37 ± 0.14 ^{a}	0.515 ± 0.011 ^{bcd}
8	26 ± 3 ^{a}	0.65 ± 0.01 ^{bc}	0.470 ± 0.003 ^{ab}
10	36 ± 0 ^{b}	0.45 ± 0.00 ^{a}	0.523 ± 0.009 ^{cd}
15	26 ± 2 ^{a}	0.71 ± 0.03 ^{cd}	0.480 ± 0.019 ^{ab}
20	40 ± 2 ^{b}	0.42 ± 0.04 ^{a}	0.540 ± 0.003 ^{d}
30	34 ± 4 ^{b}	0.51 ± 0.11 ^{ab}	0.491 ± 0.042 ^{abc}

Different letters in the same column indicate significant differences at 95% confidence (p <0.05)

In all types of flour, at the beginning of the baking process, less but larger cells (although differences in size were not significant) were observed (**Tables 1, 2** and **3**). In the wheat crumb, after 30 minutes of baking, the highest value of area occupied by cells (23.6%) of different sizes was recorded. In corn and rice, the highest values (18.3 and 15.6%, respectively) were obtained after 15 minutes of baking (**Figure 3**). Therefore, it could be deduced that after the highest values were obtained, no more CO_2 was incorporated and neither the structure underwent further expansion. Chakrabarti-Bell et al. (2014) reported that the gas bubbles were more spherical and smaller in more elastic doughs; conversely, in less elastic doughs bubbles tended to break and to coalesce, appearing as great bubbles at the expense of the disappearance of the small ones. The mean area and the circularity of the cells obtained in the rice batters at the end of the baking were similar to the results obtained with wheat. It was the corn flour that presented the largest cells, which could be related to the greater hardness of the crumb compared to the other flours.

Analysis of correlation between trials

A multivariate analysis was carried out to see the possible correlation between the results of temperature, consistency, image analysis parameters, weight loss and dough volume increase in the oven (**Table 4**). In addition, the individual correlation analysis of the different doughs was carried out to verify the individual influence of the type of flour.

The temperature showed a positive correlation with the consistency of the dough, mainly due to the results obtained in the corn batters (r_{corn} = 0.7689, p<0.05) (**Table 4**). As the temperature increased, the consistency increased mainly due to the gelatinization of the starch. The temperature also correlated very weakly with the percentage of area occupied by the cells (r = 0.3237, p<0.05) and with the weight loss (r = 0.7494, p<0.001). Referring to consistency, it was correlated with cells/cm^2

(r = 0.3978, p<0.05) and with the percentage of area occupied by the cells (r = 0.3947, p<0.05). The number of cells/cm^2 was correlated with the parameters L^* (r_{rice} = 0.8796, p<0.05) y a^* (r_{rice} = -0.8875, p<0.05) in the rice, since the disposition of the cells affected the measurement of colour.

Table 4 Regression coefficients (r) among the experimental variables obtained with the three types of flours

	Consistency	Cell/cm^2	% Area	Mean Cell Area	Circularity	L^*	a^*	b^*	ΔVolume
Temperature	0.5101**		0.3237*						
Consistency		0.3978*	0.3947*						
Cell/cm^2				-0.8080***	0.6053***		0.3593**	-0.4148**	0.6030**
% Area									
Mean Cell Area					-0.7481***		-0.4516**	0.5872***	-0.5922**
Circularity							0.3959**	-0.5451***	
L^*							-0.3317**		
a^*								-0.6667***	

***p-value < 0.001. **p-value < 0.01. *p-value < 0.05.

CONCLUSIONS

The digital image analysis of the different kinds of dough and bread allowed identifying the structural changes that occur in the doughs during baking, observing a reduction in the number of cells and their size, although both were dependent on the type of flour used.

ACKNOWLEDGMENT

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OPTIMIZATION OF FRENCH BREAD BAKING USING SUPERHEATED STEAM

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SUMMARY

French bread is well known all around the world. We see the bread-maker as an "artist" making many different products with only a few simple ingredients: flour, salt, water, sometimes, yeast along with a few other ingredients (ascorbic acid, bean flour, exogenous enzymes). French bread requires energy, time and dexterity. In this paper, the link between the heat and the mass transfer for a French loaf of bread is highlighted, as well as the interaction between the oven and the product. The link between thickness, mass and internal pressure of the product as driven by temperature and relative humidity in the oven is addressed. The stress is on the impact of steam on the porosity and the size of the starch grains. Using this knowledge, it becomes clear that the baking process is two-fold: the first phase is the expansion of the dough and the second phase is a drying process leading to crust formation. Based on this knowledge, superheated steam is used as an energy vector added to the classical ones, namely, radiative and contact. We present a pilot oven and a new baking process using superheated steam at the *key time*. This strategy leads to a baking time reduction (26%) and to a lowering of energy consumption (12%). The obtained product was tested by an expert panel and jugged to be of the quality of a traditional product.

Keywords: baking process, heat and mass transfer, microstructure, superheated steam

INTRODUCTION

Bread is both a basic foodstuff and a famous French product, which requiring time and dexterity. Several thousands of years BC, Egytians and Babylonians first discovered the use of yeast for making bread (Roussel and Chiron, 2002). The story of what is now called French bread is much shorter and truly began in the 19th century with a bread production centered on the use of simple ingredients, namely, wheat flour, salt, water and yeast. Under the impetus of French bread makers and in order to restrict the use of food additives, the appellation "pain de tradition Française" was given to French bread by the French Governement on Septembter 13, 1993 (decree n° 93-1074). This appellation restricted the use of soybean flour

to less than 2% and the use of malted flour to 0.5%. Furthermore, only *Saccharomyces cerevisiae* yeast was allowed and preservation by deep freezing was prohibited by this decree (Feillet, 2000). French bread consumption has increased strongly over the last 15 years, mainly due to the diversity of products cf e.g., **Figure 1**.

Figure 1 Diversity of French breads proposed to consumers

Among the expected properties of the product, a thin, golden crust which must be shiny and crisp should be mentioned. The crumb is a complex porous media described by some experts as "wild" due to its irregular porosity made up of small and big bubbles. In this respect, the bread-maker is often seen as a kind of magician mastering the output of complex process including physical transformations, chemical reactions and biological activities to which mechanical and heat energy are added. Making bread comprises different stages (Zanoni et al., 1993; Sommier et al., 2002; Wagner et al., 2007): (i) Kneading in a mixer, (ii) tank fermentation, (iii) weighing-dividing shaping (iv) last fermentation and (v) baking. The very first step is to weight the different ingredients prior kneading them in the mixer. Kneading ensures that the dough mixture (wheat flour, water, yeast and salt) is homogenous, smooth, firm, viscoelastic and that it incorporates tiny air bubbles. In addition, fermentable sugars start to be released during kneading, which enables the yeast to multiply and grow later in the process. The final temperature of the dough is a key parameter and it must be close to 24 °C. A first fermentation is performed in a tank before dividing and shaping (Guinet, 1982). A subsequent phase of fermentation takes place in a climate control proofer at 27 °C and at 85% of relative humidity (RH). During this stage the dough piece will expand due to the force of the gas released by the fermentation process. During the last step, heat transforms the dough into bread. This transformation is the result of heat exchange between the oven and the product. In this paper, we relate the

thickness, the mass and the internal pressure of the product to the temperature and the relative humidity in the oven. Stress is put on the impact of steam on porosity and microstructure (e.g. size of starch grains). Using this knowledge, it becomes clear that the baking process is twofold: the first phase is the expansion of the dough and the second phase is a drying process leading to crust formation. Many drying processes use superheated steam (also called "dry steam"). The main advantages of this technic are a high heat transfer leading to a high drying rate, a closed loop system reducing energy consumption, and the evaporated moisture which can be collected/treated to recover valuable volatile organic compounds. We use superheated steam as an energy vector added to the classical ones: radiative and contact. We present a pilot oven and a new baking process using superheated steam at some *key time*. This leads to a baking time reduction (36%) and to a lower energy consumption (12%). The product was tested by an expert panel and deemed to be of the same quality as a traditional product.

MATERIALS AND METHODS

The oven is a traditional Bongard electric oven for bread, 12 kW power. It was modified to combine the traditional baking mode with superheated steam. A concrete resin hearth lying above an electric resistance and heating up to the same temperature range as that of the vault (< 300 °C) was placed on a weighing device (**Figure 2**). Saturated steam coming from a boiler could be injected by an electro valve. A chimney (or exhaust pipe) could be open when necessary, e.g. 5 minutes before the end of a traditional baking process. Different sensors allowed following temperature and pressure in the product. Weight was recorded all along the baking process. The temperature and the relative humidity of air in the oven were measured by thermocouples (K type) and a dew point sensor, respectively.

Dough was obtained following the standard bread baking recipe (**Table 1**). The detailed formula, the equipment and the time required for mixing, shaping and resting operations are listed in **Table 1**. Before placing the dough piece on the sole in the oven, a single slit was made along the surface of the dough. As soon as the dough was loaded, saturated steam was injected for 1 to 3 seconds and was condensed on the surface of the product. During the baking process Super-Heated Steam (SHS) was used as an energy vector added to the classical ones (radiative and contact). Injection was done through small pipes, each 1 cm in diameter and pre-drilled with 0.8-cm diameter holes every 1.5 cm along their length. These small pipes were placed a few centimetres above the product. Duration of steam injection and steam temperature could be adjusted depending on the type of the product cf e.g., bread or cake.

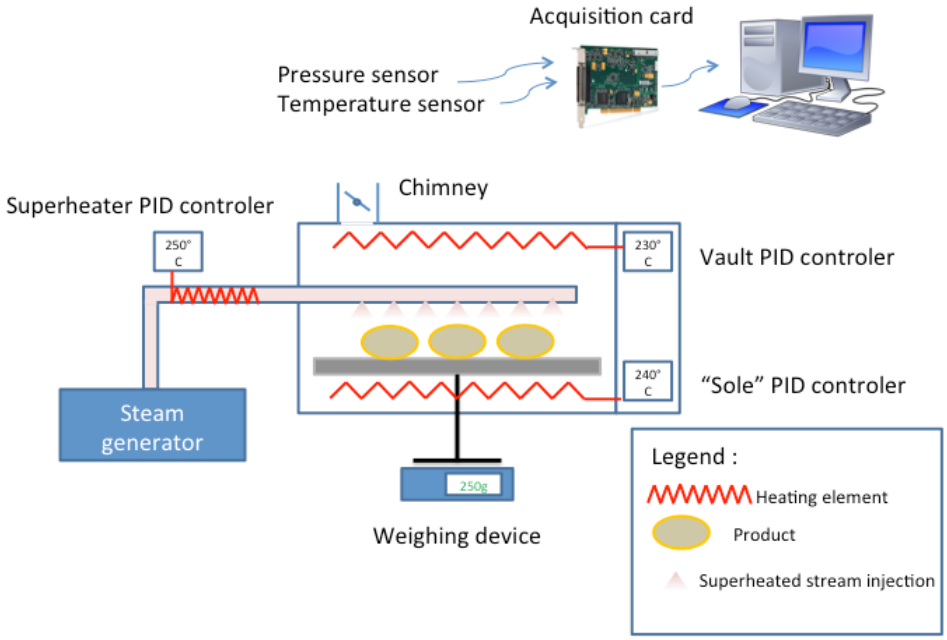

Figure 2 Experimental setup

An electric meter measured the global consumption of the oven, the steam generator and the super heater used in the two baking modes: traditional *vs.* SHS.

Table 1 Example of standard bread baking conditions

Formula	1.5 kg CORDE NOIRE special flour 945 g demineralised water (63%) 37.5 g yeast (2.5%) 17 g salt (added 5min before kneading complete) (1.1%)
Kneading with Fork mixer	4 minutes at speed 1 (40 rpm) 17 minutes at speed 2 (80 rpm)
First rise	20 minutes at 27 °C and 85% RH
Division and moulding	10 minutes. 7 to 10 portions of 250 g
Resting	20 minutes at ambient temperature
Shaping	10 minutes
Fermentation or final proof	1h 30 minutes at 27 °C and 85% RH
Baking	25 minutes (sole 240 °C, vault 230 °C) traditional baking conditions.

RESULTS AND DISCUSSION

In the traditional mode, the bread maker injects steam before or right after loading the product into the oven (the latter strategy is assumed in this study). Steam injection is a key point for the final quality of French bread. Right after loading, the

oven temperature is closed to 250 °C while the dough temperature is close to 27 °C (temperature of the fermentation room). The steam injected in the oven condenses on the surface of the dough pieces, forming a thin film of water. During a short time, this film of water protects the surface of the dough pieces against the effects of heat, delaying the formation of the crust, which is this way reduced in thickness. Meanwhile, starch grains start to swell (water penetrates into the starch granules) due to the combined effects of heat and water content increase near the surface of the product. This swelling leads to a smoother surface and contributes to close the open porosity of the dough (**Figure 3**).

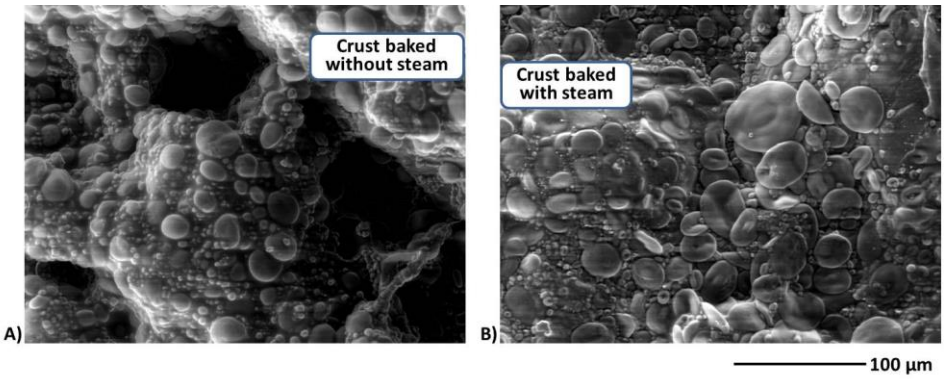

Figure 3 SEM image of bread dough crust (magnification x400); A) Crust baked without steam that shows an open porosity and small starch grains; B) The crust baked with steam injection has a smoother surface and shows bigger starch grains due to swealing (gelatinisation)

The aforementioned starch grain swelling, referred to as gelatinisation, initiates at the surface and then propagates towards the heart of the product and is responsible for the transformation of the dough into crumb. All along this first stage, heat energy is used to increase the temperature of the crust and the crumb and is consumed by the gelatinisation process (**Figure 4**). At the end of this first step (5 to 7 min for the experiments in **Figure 4**), the bread volume reaches its maximum (**Figure 5**) and collapse may occur. The next drying stage gives the product its final water content.

The impact of steam injection upon the relative humidity (RH) of air in the oven yields to a pic during the first minute (**Figure 5**). Then, HR tends to decrease, but increases again after about 5 minutes. This increase is due to the opening of the slit cut into the surface of the bread before loading: the crumb surface in contact with air is augmented and the open porosity of the crumb acts as preferential pathways for water evaporation under heat transfer.

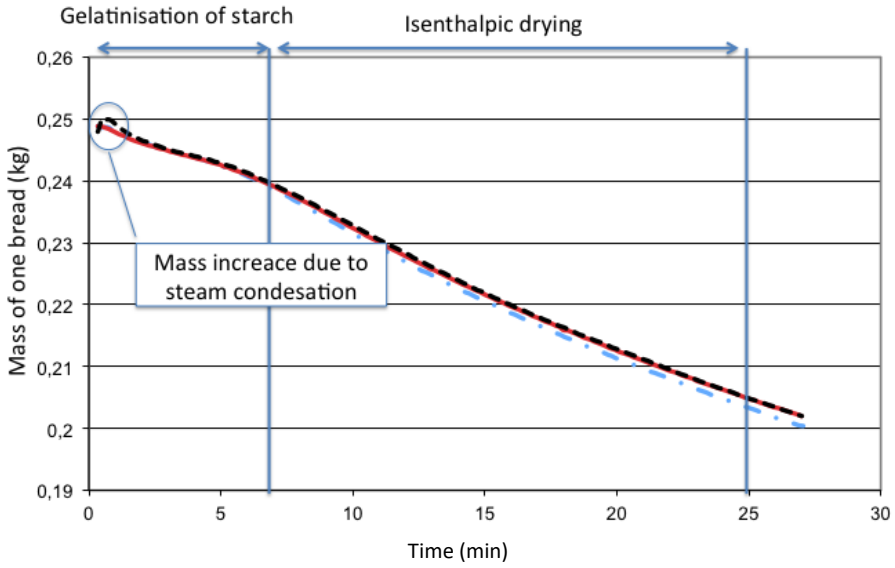

Figure 4 Mass variation during three experiments in traditional baking condition (*T* vault = 230 °C and *T* sole = 240 °C)

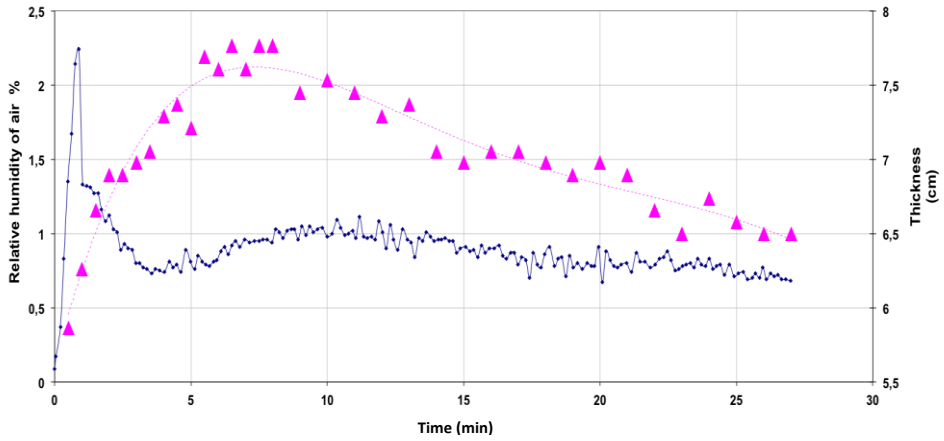

Figure 5 Product thickness and relative humidity of the oven air during a traditional baking process (*T* vault = 230 °C and *T* sole = 240 °C)

Using this knowledge, it becomes obvious that the first (5 to 7) minutes are key for bread swelling. Thus, we waited until the end of this first stage before adding another energy vector. Superheated steam is added during only 3 minutes in open loop (chimmey open after 5 minutes until the end of baking). We also increased the sole temperature (260 °C) to facilitate volume expansion of the dough (**Figure 6**).

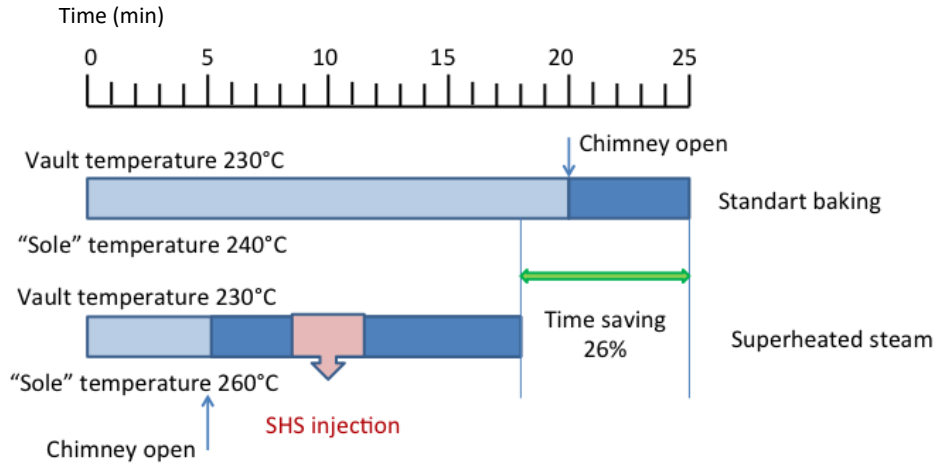

Figure 6 Standard baking and superheated steam cycles

When choosing the SHS baking cycle, volume expansion occurs faster due to the higher sole temperature (**Figure 6**). Superheated steam injection leads to a faster drying process that fixes the shape of the bread. On the other hand, colour kinetic takes less time and the final product is browner (**Figure 7**).

Figure 7 Product baked in traditional mode (left) and with SHS cycle (right)

At last, the traditional baking process requires 2625 kJ to bake a bread while cooking with superheated steam consumes 2310 kJ, or 12% less. In other words, the overconsumption necessary for the production of superheated steam is largely compensated by the reduction of the total cooking time.

A panel of experts evaluated the quality of the bread obtained with SHS and validated the conformity of the shape and colour of the crust, the texture and the taste of the bread obtained with the SHS cycle. The reduction of the cooking time induced moreover an increase in the mass of the loaves after baking (5%), which resulted in better conservation.

CONCLUSIONS

We developed a pilot oven with a dedicated instrumentation in order to understand the interaction between the product (French bread) and the oven. We showed that the bread baking process is twofold: the first phase is the expansion of the dough and the second phase is a drying process leading to the crust formation. Based on this knowledge, the superheated steam was used as an energy vector added to the classical ones (radiative and contact). We demonstrated that superheated steam, when used at certain *key time,* led to a new baking process typified by a baking time reduction (26%) and to a lower energy consumption (12%). The product obtained this way was tested by an expert panel that found the product to match the quality of a traditional product. This work leads to a patent deposit FR2939010.

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PRODUCTION AND QUALITY ANALYSIS OF MALT PRODUCED FROM HULLESS BARLEY

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SUMMARY
In this work, micromalting of two hulless barley samples (lines GZ-186 and GZ-189) was performed. Barley and malt quality control parameters, as well as the concentration of total phenolic compounds, total flavonoids and proteins in barley and malt extracts were analysed. The both lines of hulless barley comprise high protein content (12.3 - 12.9%). Values of extract content from produced malt samples were from 83.92% to 84.46%, fine/coarse extract difference from 7.64% to 8.05%, Kolbach index from 34.1% to 35.2%, viscosity from 1.95 mPas to 2.04 mPas, friability from 33.1% to 41.56%.
It was shown that tested hulless barley samples present rich source of phenolic compounds (364.19 mg_{GAE}/cm^3 and 316.99 mg_{GAE}/cm^3 GZ-186 and GZ-189, respectively), and poor source of total flavonoids (GZ-186: 1.69 mg_{CE}/cm^3 and GZ-189: 1.25 mg_{CE}/cm^3). Consequently, malt samples are characterized with higher phenolic concentration (GZ-186: 408.95 mg_{GAE}/cm^3 and GZ-189: 375.540 mg_{GAE}/cm^3) and lower flavonoids concentration (GZ-186: 1.22 mg_{GAE}/cm^3 and GZ-189: 1.24 mg_{GAE}/cm^3).

Keywords: hulles barley, malt, quality analysis, phenolic compounds

INTRODUCTION

Barley (*Hordeum vulgare* L.) is a highly adaptable cereal grain that is produced from subarctic to subtropical climates. It is the primary cereal used in the production of malt in the world. Malting is defined as the controlled germination of cereals, to ensure specific physical and biochemical changes within the grain, which is then stabilized in the phase of kilning. Three main phases occur during malting: (a) steeping, to ensure good absorption of water by the grain, (b) germination, to maintain embryo growth, enzyme synthesis and a limited endosperm breakdown, and (c) kilning, to ensure malt stability (Gupta et al., 2010).

Hulless barley is the barley without husk. In the Republic of Croatia, it is not traditionally cultivated. However, in China, hulless barley, known as qingke, presents an economical crop widely grown in the highlands with the multiple applications in food industry, such as in the production of low alcohol liquor and noodle, as well as in bakery (Chang and Lv, 2016). It is one of the staple foods for Tibetans and an important livestock feed in the Tibetan Plateau. Cultivated history of hulless barley in Tibetan Plateau dates as far back as 3500 years ago (Zeng et al., 2015).

In the last few years, an interest for the hulless barley production and its application in human nutrition and industrial alteration, *e.g.* in brewing, has been growing worldwide. Some of the recently developed hulless barley cultivars are Roseland (Badea et al., 2017), Ozen (Ergun et al., 2017), and Sawtooth (Bregitzer et al., 2017).

The main advantage of the hulless barley for application in food industry is its use without need to remove the husk after the harvest. The absence of hulls means that the grain has more nutrients and higher energy per unit weight in comparison with hulled barley and therefore it requires less space for storage and transport. In the terms of nutrient composition, hulless barley is comparable with commonly consumed cereals due to high content of proteins, dietary fibres, and various trace elements. Among dietary fibres, *β*-glucans are known in the production of functional food (Šimić et al., 2017). Additionally, hulless barley starch has great potential to be an alternative starch due to its cheap price and wide resource (Chang and Lv, 2016).

In this work, two-rowed winter type hulless barley samples lines GZ-186 and GZ-189, developed at the Agricultural Institute Osijek, were micro-malted. They have good lodging resistance, higher test weight and threshability and are tolerant to most prevalent barley diseases.

Basic analyses on barley and malt samples, regarding brewing quality parameters, are done in this work. Additionally, special attention was given to the analyses of total phenolic compounds, total flavonoids and proteins in both, barley and malt extracts.

The aim of this study was to examine the main brewery characteristics of hulless barley varieties of two diverse genetic origins, while malting was performed to compare the barley grain and its corresponding malt samples for the differences in total phenolic and flavonoid content and to analyse if the two lines of barley could be used in brewing.

MATERIALS AND METHODS

Barley samples

Barley samples (lines GZ-186 and GZ-189) were obtained from the Agricultural Institute Osijek. Samples from the line trials of Agricultural Institute Osijek were collected and analysed during the 2013/2014 season. Barley varieties were grown

under field conditions on location Osijek. The experiments were conducted in randomized block designs (RCBD) with six replications; plot size was 7.56 m^2. Sampling (5 kg per sample) was performed on cleaned and processed barley grains (EBC 3.3.1.) and samples were kept refrigerated in dry containers.

Barley quality analysis

Moisture, hectolitre weight, protein and starch content were determined using Infratec 1241 Grain Analyzer (Foss Tecator AB, Sweden).

Micro-malting

Barley samples were screened over a 2.5 mm sieve prior to malting. 500 g of the sample was malted in an Automated Joe White Malting Systems Micro-malting Unit (Perth, Australia). The malting program consisted of a 37 h interrupted steep program (16 °C, 5 h submerged, 17 °C, 12 h air rest with 100% airflow, 17 °C, 6 h submerged, 18 °C, 12 h air rest with 100% airflow, 17 °C, 2 h submerged), a 96 h germination program (17 °C, 75% airflow, 1.5 turn every 2 h) and a 18 h kilning program (60 °C, 6 h; 65 °C, 3 h; 68 °C, 2 h; 70 °C, 2 h; 80 °C, 2 h; 83 °C, 2 h; 85 °C, 1 h). Rootlets were removed and the finished malt was then stored in plastic containers with caps until analysis.

Malt quality analysis

Malts were ground (particle size 0.2 mm) using a Bühler Universal Laboratory Disc Mill (DLFU type). The malt moisture content (EBC method 4.2) and corresponding extract (EBC method 4.5.1), Kolbach Index (EBC methods 4.3.1 and 4.9.1), viscosity (EBC method 4.8), extract difference between finely and coarsely ground malt (EBC method 4.5.2) and friability (EBC method 4.15) were determined according to European Brewery Convention methods (EBC Analysis Committee, 1998).

Analysis of total phenolic compounds (TP), total flavonoids (TF), and proteins (TP) concentration

Samples were milled to 1 mm particle size (Retsch ZM200). Circa 1.0 g of milled sample was extracted by solvent (50:50, water/ethanol, v/v) with solid/liquid ratio 1:40. Extraction was performed in a water bath at 80 °C (Julabo, SW23, Germany) by shaking (200 rpm) during 120 min. After the extraction, samples were centrifuged at 10,000×g (Multifuge 3 L-R Centrifuge, Heraus, Germany) for 10 min in order to obtain liquid extracts for further analysis.

TP content was estimated by a colorimetric assay using Folin-Ciocalteu methods (Bucić-Kojić et al., 2011) with gallic acid as standard. The absorbance was read at 765 nm (UV-1700 Shimadzu, Japan) and the results were expressed as gallic acid equivalent (GAE). TF content was measured using colorimetric method with aluminium chloride proposed by Marinova et al. (2005). The absorbance was read at 510 nm and the result were expressed as (+)-catechin equivalent (CE). TF content was estimated according to Bucić-Kojić (2009).

Extractable protein concentration was determined by the Bradford method with bovine serum albumin (BSA) as standard, and the absorbance was read at 595 nm.

RESULTS AND DISCUSSION

Barley breeders use malting tests to select malt of good qualities. Basic brewery quality parameters of hulless barley and malt, and total content of phenolics, flavonoids and proteins were analysed.

The results of the content of proteins, moisture, starch, hectolitre mass, as well as mass concentration (*γ*) of total polyphenols (TP), total flavonoids (TF) and proteins (PC) in hulless barley samples are presented in **Table 1**.

Table 1 The content of proteins, moisture, starch, hectolitre mass in barley grains. Mass concentration (*γ*) of total polyphenols (TP), total flavonoids (TF) and proteins (PC) in barley extracts.

Sample	Parameter	Unit	GZ-186	GZ-189
Barley grain	Proteins	[%]	12.90	12.30
	Moisture	[%]	9.80	10.10
	Starch	[%]	58.40	60.10
	Hectolitre mass	kg	72.50	75.20
Barley extracts	Total polyphenols	[mg_{GAE}/cm^3]	364.20	316.99
	Total flavonids	[mg_{CE}/cm^3]	1.69	1.25
	Total extractible proteins	[mg_{BSA}/cm^3]	2.30	2.23

Based on the obtained results it can be concluded that the both hulless barley lines comprise high protein content (12.3 - 12.9%) which is not typical for the brewing barley. The results are compared with the results of the same barley lines produced in different years (2012/2013) using the same cultivation procedure and were as follows: 13.45% and 13.70%, for GZ-186 and GZ-189, respectively (Šimić et al., 2017). It can be concluded that the samples used in this study contained lower protein concentration (12.90% for GZ-186, and 12.30% for GZ-189) in comparison with the barley samples produced in 2012/2013 (Šimić et al., 2017), which can probably be the consequence of the environmental conditions during growing season and harvest time. Starch, the most abundant carbohydrate in barley grain, is an important quality indicator to maltsters and brewers of malt extract content. In the current study the content of starch ranged from 58.4% to 60.1% (**Table 1**). Test weight is a measure of density and is expressed as kilograms per hectolitre (kg/hL). Hulless barley usually has hectolitre weight higher than standard hulled barley, and in this study it ranged from 72.5 kg to 75.2 kg for GZ-186 and GZ-189, respectively.

It was shown that hulless barley samples present rich source of phenolic compounds (364.19 mg_{GAE}/mL and 316.99 mg_{GAE}/mL, for GZ-186 and GZ-189, respectively), and poor source of total flavonoids (1.69 mg_{CE}/mL and 1.25 mg_{CE}/mL

for GZ-186 and GZ-189, respectively). Among cereal grains, barley is known to be naturally high in phenolic compounds, which was proved also here.
Malting is a complex process of barley modifications. The structural changes occur due to the broad enzymatic activities, including enzymatic catalysed release of phenolic compounds bound to the cellular structures of barley, and glycosylation, which lead to the easier extraction of free phenolic acids due to the changes in the matrix in the early phases of kilning (Šimić et al., 2017).
A large number of parameters have been proposed to define malting quality. The general malt quality parameters of the malt produced from hulless barley line GZ-186 and GZ-189 are presented in **Table 2**.

Table 2 Malt quality control parameters

Parameters	Samples	
	GZ-186	**GZ-189**
PC [$\%_{db}$]	13.20	12.80
M [%]	6.59	6.67
E [%]	84.46	83.92
F/C [%]	8.05	7.64
SP [$\%_{db}$]	4.50	4.50
F [%]	41.56	33.10
V [mPa s]	1.95	2.04
IK [%]	34.10	35.20
MC [EBC units]	2.40	2.80

Abbreviations: PC [% db]– protein content per gram of dry basis; M – moisture content; E – extract content; F/C – fine/coarse extract difference; SP – soluble protein content per gram of dry basis; F – friability; V – viscosity; IK – Kolbach's index; MC – malt colour

The most important feature of malt is its behaviour in the mashing process and its potential for producing a wort soluble extract. Hulless barley malts produce significantly higher levels of malt extract than covered barley varieties. Values of extract content from malt samples in this study were from 83.92% to 84.46% while fine/coarse extract difference was from 7.64% to 8.05%, respectively. As it was shown in the previous study (Šimić et al. 2017), results of hulless barley micro-malting showed higher malt extract contents when compared with malting varieties. Edney and Langrell (2004) reported in their study extract values approaching 87% for the hulless variety CDC Dawn in comparison to values less than 81% obtained for the covered variety Harrington. According to the results of Li et al. (2006), who investigated three Canadian hulless barley varieties with micro and pilot malting equipment, all three varieties could be micro malted successfully to produce malt with impressively high malt extract levels, 3 - 5% higher than a covered malting barley control. Their results also indicated that the quality traits of hulless malt, especially malt friability and *β*-glucan and *α*-amylase levels, were

sensitive to acrospire damage during turning and handling and also to harsh kilning conditions.

Friability was lower for both lines analysed in this work, in comparison to the samples from 2012/2013 and consequently, higher F/C difference in both lines were detected in this work. The obtained values are also lower than friability values observed in the Canadian hulless barley (CDC Dawn) that were form 60% to 70% (Edney and Langrell, 2004).

The higher levels of extracts resulted in higher values of wort viscosity. The results of the viscosity were from 1.95 mPas to 2.04 mPas, while friability was from 33.1% to 41.56%, for GZ-186 and GZ-189, respectively.

Kolbach index of the barley sample line GZ-186 was lower in this work in comparison with the previous one, while the IK value for the line GZ-189 did not differ much. Kolbach index represents the degree of protein degradation in malt grain and its values were 34.1% to 35.2%, for GZ-186 and GZ-189, respectively. These results are in accordance with results from quality analysis of malt produced from the three hulless barley varieties in Canada (Li et al., 2006). Edney and Langrell (2004) have noticed in their work Kolbach index values higher than 40%, and even approaching 48% for the hulless variety CDC Dawn when longer germination period was applied.

The results of the mass concentration (γ) of total polyphenols (TP), total flavonoids (TF) and proteins (PC) in hulless malt samples are presented in **Table 3**.

Table 3 The mass concentration (γ) of total polyphenols (TP), total flavonoids (TF) and proteins (PC) in malt samples

Sample	γ_{TP} [mg_{GAE}/cm^3]	γ_{TF} [mg_{CE}/cm^3]	γ_{PC} [mg_{BSA}/cm^3]
GZ-186	408.95	1.22	1.93
GZ-189	375.54	1.24	1.89

According to the results of the mass concentration of total polyphenols (TP), total flavonoids (TF) and proteins (PC) in malt samples (**Table 3**) it can be perceived that malt samples are characterized with high phenolic concentration (408.95 mg_{GAE}/cm^3 and 375.540 mg_{GAE}/cm^3, for GZ-186 and GZ-189, respectively) and low flavonoids concentration (1.22 mg_{GAE}/cm^3 and 1.24 mg_{GAE}/cm^3, for GZ-186 and GZ-189, respectively).

CONCLUSIONS

Hulless barley lines GZ-186 and GZ-189 are characterized with high protein contents. Tested barley samples present rich source of phenolic compounds and poor source of total flavonoids. Malt samples were characterized by higher phenolic concentration and lower flavonoids concentration than barley samples. Generally, malt samples produced from GZ-186 and GZ-189 satisfy the malt quality

in terms of extract content and Kolbach's index and have bright yellow colour, but possess low friability, high viscosity, and high value of F/C difference.

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E – MARKETING FOR THE RECYCLING OF BAKERY PRODUCTS

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SUMMARY
In the last thirty years, people have become aware of our limited resources and the need for their rational use. As the result of changes in the people's global awareness, new scientific disciplines, that focus on the more effective use of the available resources and on the assurance of sustainable development of the society, have emerged. In the context of these thoughts, the problem of waste recycling is becoming increasingly important. Like most other industrial products, the surplus of bakery products, both on the production and the consumption side, needs to be correctly sorted out and appropriately recycled. To accomplish the succesful recycling of bakery products, it is necessary to encourage changes, not only in the industry behaviour, but also in the behaviour of the individual, the consumer. Marketing has the key role in terms of the development of human awareness about the necessity of recycling in general, and also about the recycling of bakery products. But, in line with the technological and social changes, marketing is constantly changing. In the last couple of decades its development has been closely connected with the growth of the information – communication technology, so the new activity principles of marketing are associated with the prefix 'electronic' from which the title 'electronic marketing' or 'e – marketing' has been derived. In the last decade, marketing has acquired a more significant position in the sphere of non-profitable activities, coming from purely profitable sphere of activity. As the result of this activity, the so called 'social marketing" has emerged. Marketing achieves a socially useful activity in different spheres through different actions. From that perspective, it is interesting to look at the specifics of e-Marketing for the recycling of bakery products and to define the conceptual model of social e-Marketing for the recycling of bakery products, as a starting point for the formation of the collective awareness about the need and the necessity for the recycling of bakery products.

Keywords: bakery products, electronic marketing, sustainable development, recycling, social networks

INTRODUCTION

While at first glance the evolution of human society, brought by technical and technological progress to the human community, results with great benefits, these evolutionary shifts have opened up a variety of issues that modern society has to deal with. Thus, on the one hand, the growth of the population, on the other hand, the growth of consumption, the growth of production capacities, which ensured employment and the efficient satisfaction of people's needs. Additionally, the increase in production resulted in the significant increase of the amount of garbage, the increase of greenhouse gases, and thus, the imbalance in the earth's atmosphere, which resulted in the loss of numerous animal and plant species, reduced the stock of essential raw materials and drinking water, pollution of the sea etc. Among other things, when taking into account the positive and negative effects of evolutionary social processes, positive view of the benefits of intensive development of human society becomes questionable.

For this reason, human society has been forced to change its attitude towards the environment and unreasonably overburdened resources, and to focus on optimal exploitation of the available resources through the application of the concept of sustainable development. Product recycling is precisely the task of ensuring more rational use of resources and eliminating the harmful impact of garbage as a negative result of the consumption process as much as possible. Indeed, product recycling defines new and partly renewable sources of raw materials, products and finally energy. Therefore, it is expected that the importance of recycling will continue to grow as product recycling does not grow into a separate industrial branch and does not become a separate scientific discipline. The recycling itself can be done in the sphere of production as well as in the sphere of consumption. Consequently, recycling entities may be industrial plants where product manufacturing is carried out, but also specialised recycling business entities. Also, in the value chain, recycling can be done at every stage of the production cycle, but also in trade as well as in distribution of raw materials, semi-products and products. When it comes to consumption, recycling is mostly done in households. While businesses are motivated by legal measures to recycle, on the one hand and businesses themselves are motivated by recycling due to the potential effects of such behavior on the business result, recycling in households is significantly more difficult to control when there are legal stipulations for this. Hence, the households which are oriented towards recyclers need to be motivated. In this sense marketing plays a very significant role.

Therefore, to motivate households to recycle in general, as well as to recycle bakery products, it is necessary to develop an appropriate marketing strategy and build a marketing model for recycling bakery products in accordance with the marketing strategy. As in the contemporary conditions, an increasingly important communication medium in the relationship with consumers becomes the electronic marketing as the increasingly important means of marketing. In this sense, it is necessary to develop a principle model of electronic marketing of recycled bakery

products in order to provide frames for systematic practical application of this concept.

RESEARCH METHODOLOGY

Marketing was among the first to discover the potential of the new media space, formed by the Internet. At the beginning, marketing used primitive electronic services such as email and chat, but when the World Wide Web was commercialized, marketing recognized the potential of advertising through this medium and used Web sites as a medium to promote both business entities and their products. But as they evolved the possibilities of the World Wide Web, they have also evolved the ways of using the Web, both in marketing and business purposes in general. The use of the Web or the Internet for marketing and business purposes, as well as the use of other digital electronic media, has led to the emergence of the concept of electronic marketing or electronic business. Today, when the current version of the Web is 2.0, marketing greatly utilizes social networking potentials to realize its goals. Therefore, in the modern living conditions, the digital electronic environment potentials for the marketing needs of bakery products recycle (Recycle, n.d.) should be explored and digital technologies that can be used for that purpose should be considered. Accordingly, a structural model of electronic marketing for recycled bakery products should be defined. In accordance with the above, the following hypothesis was defined:

It is possible to define a usable structural model of electronic marketing of recycled bakery products.

Based on the initial hypothesis, the following research goals were defined:

1. Exploring the concept of recycling and looking for the possibility of recycling bakery products
2. Exploring the notion of marketing, and looking for the position and role of marketing in modern business condition
3. Exploring green and electronic marketing concepts and considering their role in raising consumer awareness of the need for recycling bakery products
4. Proposing a structural model of electronic marketing of recycling bakery products

For the purpose of achieving the above-mentioned research goals, the following scientific methods were used: the deduction method, the method of analysis and synthesis, the abstraction method. The method of classification, the method of causative conclusion, the method of descriptive modeling, the historical method and other scientific methods.

RESEARCH RESULTS

American Indians have a saying: 'Treat the earth well: it was not given to you by your parents, it was loaned to you by your children. We do not inherit the Earth from our ancestors, we borrow it from our children.' (McMillan, 2014). Today's

society, as never before in its history, is burdened with this sentiment. The resources available, are, on the one hand, constrained, and on the other hand, increased spending on resources is rising due to the growth of consumerism, both due to the intense population growth (Teitelbaum, n.d.) and the global growth of standards and irrationality in resource spending. Resource limitation is the key factor for further development and survival of the human species. **Figure 1** shows the exponential increase in the number of inhabitants that is happening lately.

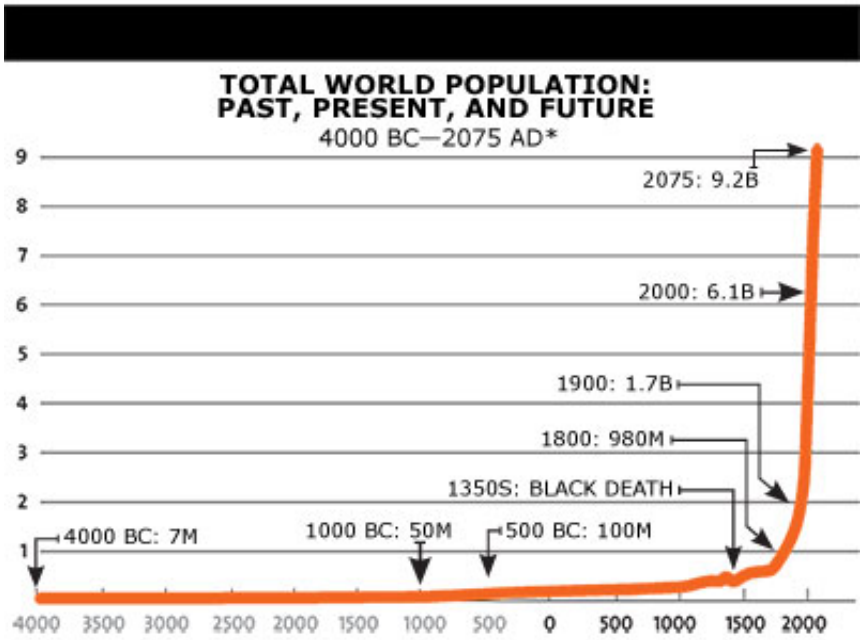

Figure 1 Exponential Growth of the Population on Earth (Whitty, 2010)

Today there are different theories about whether the human population on the earth will continue to increase exponentially, or there will be a stagnation or even decline in the number of people. Today, the problem of the impact of the expansion of the human community on the ecosystem of the country has become evident. In order to reduce the negative impact of human influence on the Earth ecosystem, it is necessary to rationally use the available resources. The problem of better exploitation of the country's resource is nothing new. 'George Knibbs, in his 1928 book The Shadow of the World's Future, suggested that if global population reached 7.8 billion, there would have to be much more efficient use of its surface.' (Cumming, 2016)

One of the solutions that can establish a more rational relationship to available resources is recycling of products. Basically, recycling implies:

- treating or processing used or waste materials so as to make them suitable for reuse [recycling paper to save trees]

- alteration or adaptation for new use without changing the essential form or nature of [The old factory becoming a theater]
- reusage in the original form or with minimal alteration
- causing to pass through a cycle again

One of the views on recycling: 'Recycling is processing used materials (waste) into new, useful products. This is done to reduce the use of raw materials that would have been used. Recycling also uses less energy and and great way of controlling air, water and land pollution. Effective recycling starts with household (or the place where the waste was created). In many serious countries, the authorities help households with bin bags with labels on them. Households then sort out the waste themselves and place them in the right bags for collection. This makes the work less difficult.'(What is Waste Recycling?, n.d.)

This approach to the concept of recycling is interesting because it highlights the role of households being the places of final consumption and places where the individual recycling process begins. Except for the final consumption area, recycling is also present at places of production consumption, i.e. within the distribution and in the market itself. The places where everything can be recycled can be seen in **Figure 2**.

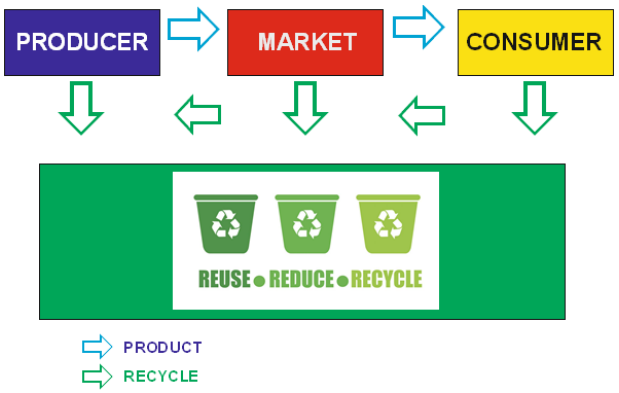

Figure 2 Recycling process sources ((used) What is Waste Recycling?, n.d.)

It should be kept in mind that it is much easier to encourage, monitor or control the recycling process within business entities than in households due to the potential positive effect of recycling on the business result as well as the ease of administrative control of the application of positive legal regulations regarding obligations and recycling methods. When it comes to recycling in households, repressive recycling schemes are ineffective, and therefore insufficient for household recycling to become a mass phenomenon. That is why common practice chooses different approaches. Systems educating and motivating people to affirmative behaviors related to recycling have been proven as effective. In order to motivate people to recycle, it is important to point to problems commonly encountered by the community due to evolutionary social processes and to show

people the benefits of recycling to the society. It should be noted here that: (What is Waste Recycling?, n.d.)

- Recycling helps protect the environment -

This is because the recyclable waste materials would have been burned or ended up in the landfill. Pollution of the air, land, water and soil is reduced.

- Recycling conserves natural resources -

Recycling more waste means that we do not depend too much on raw (natural) resources, which are already massively depleted.

- Recycling saves energy -

It takes more energy to produce items with raw materials than from recycling used materials. This means we are more energy efficient and the prices of products can come down.

- Recycling creates jobs -

People are employed to collect, sort and work in recycling companies. Others also get jobs with businesses that work with these recycling units. There can be a ripple of jobs in the municipality.

Bakery products and other food products are suitable for recycling. **Figure 3** shows the structural elements of recycling of bakery products, within recycling food products in general.

Figure 3 Bakery products, like any other foods, are recyclable (Ackers, n.d.)

Local and regional governments will use marketing to increase people's awareness and motivate them to affirmative behaviours related to recycling, i.e. to increase the amount of recycling and to make it more successful. Accordingly, the question may be what is marketing and why marketing? To put it in a nutshell, marketing is a business philosophy that defines the way of thinking about management. Management based on market research and getting acquainted with consumer needs, defines the production program, selling price and product distribution method as well as the way of promoting the product or the communication of the producer with the consumer. As survival on the market is the universal business purpose of business entities, the primary task of marketing is acomplishing that

purpose. In order for a business entity to survive, it is necessary to realize and accomplish three objectives, from the basic business objectives:

- Growth,
- Efficiency/Effectiveness
- Flexibility (Dukić, 2012).

Companies must be primarily efficient, or have greater impact on the market than consumption, while business entities that do not have the primary function of earning a profit must be effective, that is, produce socially beneficial effects in order to benefit primarily from efficient parts of the business system were willing to give up part of their earnings. In a group of business entities that produce socially beneficial effects, i.e. in a group of effective business entities, there are also regional and local government. While standard marketing applies to business entities which are primarily focused on effective behaviour, it is a social marketing tool that serves the effective parts of the business system, and thus, regional and local government. Therefore, in realizing the affirmation of recycling in a particular community, the regional and local government will use social marketing.

However, it should be emphasized that even marketing as a scientific discipline has recognized the importance of recycling, as well as the survival of the ecosystem of the country, and built on the basis of a rational environmental relationship an approach that is colloquially called green marketing. The main focus of green marketing is shown in **Figure 4**.

Figure 4 The main focus of the green marketing (Thoroughly Green, 2016)

Green marketing refers to the process of selling products and/or services based on their environmental benefits. Such a product or service may be environmentally friendly in itself or produced in an environmentally friendly way, including source (Ward, 2017):

- Being manufactured in a sustainable fashion
- Not containing toxic materials or ozone-depleting substances
- Able to be recycled and/or is produced from recycled materials
- Being made from renewable materials (such as bamboo, etc.)

- Not making use of excessive packaging
- Being designed to be repairable and not "throwaway"

Why Green Marketing?

- Opportunities or competitive advantage
- Corporate social responsibilities (CST)
- Government pressure
- Cost or profit issues

Ward says: 'Green marketing is typically practiced by companies that are committed to sustainable development and corporate social responsibility. More organizations are making an effort to implement sustainable business practices as they recognize that in doing so they can make their products more attractive to consumers and also reduce expenses, including packaging, transportation, energy/water usage, etc. Businesses are increasingly discovering that demonstrating a high level of social responsibility can increase brand loyalty among socially conscious consumers.' (Ward, 2017) The effects of green marketing actions indicate many examples. The 2014 Nielsen Global Survey on Corporate Social Responsibility polled 30,000 consumers from 60 countries to determine statistics on consumer preferences for sustainable purchasing, and found that:

- 55% of consumers were willing to pay extra for products and services from companies committed to positive social and environmental impact (up from 45% in 2011)
- 52% made at least one purchase in the past six months from at least one socially responsible company
- 52% check product packaging to ensure sustainable impact

In today's business conditions, it is important to question how and with which resources should marketing or green marketing work. The reasons for the change in the way and means of action are determined by the emergence of a new age that is the primary product of the activity of information-communication technologies. Technological jumps and the beginning of the new era are shown in **Figure 5**.

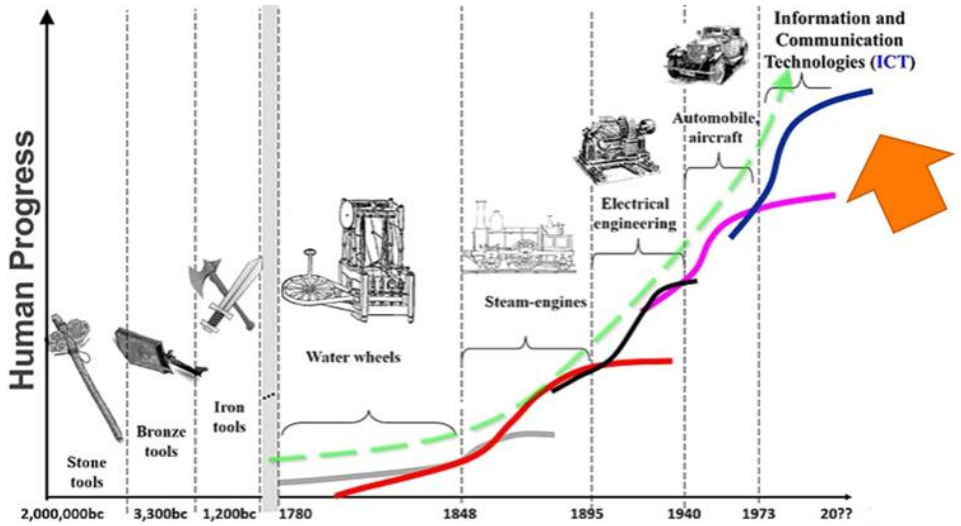

Figure 5 Result of technological leap – Beginning of the informational era (Hilbert, n.d.)

The same evolutionary processes within the information age, or the changes that new information and communication technology brings, is shown in **Figure 6**.

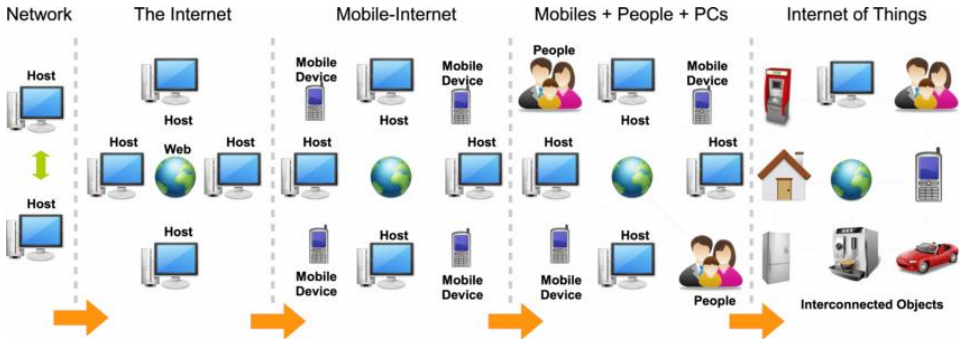

Figure 6 Evolution of ICT-a Technologies which affected the evolutionary processes within the new ICT era (Perera, 2014)

The overall information and communication technology, especially the Internet, has influenced the changes of the modern consumer, which also demands changes of business entities in relation to the contemporary consumer. The contemporary consumer:

- Is Informed
- Has knowledge
- Self-conscious
- Demanding
- Looks for personalised solutions
- Shares experiences with other consumers

- Seeks attention
- Wants to be influential
- Wants a high position in society
- Takes care of personal health
- Seeks alternatives in shopping
- Ready to evolve

The marketing response to the new situation regarding consumer changes is the emergence of a new concept called electronic marketing or e-marketing. One of the e-Marketing definitions states the following: 'E-Marketing (Electronic Marketing) are also known as Internet Marketing, Web Marketing, Digital Marketing, or Online Marketing. E-marketing is the process of marketing a product or service using the Internet. E-marketing not only includes marketing on the Internet, but also includes marketing done via e-mail and wireless media. It uses a range of technologies to help connect businesses to their customers.' (E-Marketing, n.d.). The means that are commonly used by electronic marketing are shown in **Figure 7**.

Figure 7 The means that are commonly used by electronic marketing (Effective E-Marketing, n.d.)

Taking into account all above, it is possible to define the structural model of e-Marketing process in the function of affirmation of recycling of bakery products:

$$eM = eIT + eMmix + eMp + eMk \quad (1)$$

Where:

eIT – stands for - marketing research in virtual surroundings
eMmix – e-Marketing mix
eMp – application of e-Marketing
eMk – e-Marketing control

The important factors of the success of e-Marketing application:

- Two-way communication
- Participation of the consumer in creating the content
- Keeping attention through generating new multimedia contents
- Engagement of the individuals with high social influence
- Content exclusiveness
- Maintaining high level of visibility and social influence

E-Marketing model of recycling baked products:

$$eMp(\text{thl}) = m(\text{transf}(\min(\text{Web1.0}) \rightarrow \text{Web 3.0}) + max(\text{Web2.0}) + HR_{vi} + W\text{metrix} + BI_{su} + \text{CRM2.0} + SEO + GEO) \quad (2)$$

Where:

m - stands for - mobility

transf(min(Web1.0)→ Web 3.0) - transformation of Web 1.0 into Web 3.0 with minimising the content created by the consumer

max(Web2.0) - increase visibility on social networks

*W*metrix - usage of services (ex. Cloud) which measure user influence on community (Social Index or index of a person's social nfluence – indicating how much a certain individual publishes, follows, is followed on all platforms)

HR_{vi} - personal utilisation of people with high social index

BI_{su} - usage of personal tools of business intelligence in measuring social index of individuals as well as the whole organisations online

SEO - Search Engine Optimisation -search engine optimisation (also in Web 3.0)

GEO - ambient intelligence utilisation (ex. FourSquare)

CONCLUSIONS

Growth in the volume of consumption is a result of the growth in the number of people and the increase in consumption due to population growth. It has a profound implication on the Earth's ecological system. In order to, at least, reduce the amount of waste, and in order to exploit raw materials that provide waste, and also reduce the energy needed, it is necessary to carry out product recycling more extensively and efficiently. Bakery products like other products can be efficiently recycled, but in order to recycle successfully and comprehensively, recycling needs to be encouraged by educating and motivating those who have the opportunity to recycle bakery products. Recycling can be carried out in all spheres of human activity, from business spheres where surpluses of raw materials, semi-products and products are recycled, to the sphere of personal consumption where recycling of products is carried out. Appealing to human consciousness and pointing out the necessity of recycling as well as motivating people to carry out recycling, can significantly help marketing. Indeed, marketing as a scientific paradigm has

revealed the importance of recycling through the concept of green marketing. However, in modern living conditions defining information and communication technology, especially the Internet, significant changes have occurred in the properties and behavior of consumers, hence classical media and marketing media become questionable. In such circumstances, marketing has evolved into a new developmental stage in the so-called 'electronic' or 'e-marketing' where modern information and communication technology play the key role as marketing tools. In this respect, it is important to choose the right marketing means for the purpose of affirming recycling of bakery products. Analyzing the marketing of available digital technologies and providing logical testing of their usability and functionality in the function of e-marketing recycling of bakery products, a structural elementary model of e-Marketing of bakery product recycling was defined.

The model itself represents the starting point and the systemic framework within which the appropriate content, that can help to develop the awareness of end consumers about the necessity of recycling bakery products, should be created. Therefore, the results of this research should be the basis for building a comprehensive e-marketing of bakery products. The approach to build such a model requires interdisciplinarity, that is, the minimal cooperation of bakery technology know-how with marketers and experts from the domain of information science. Without the application of such models it is difficult to believe that a comprehensive and efficient recycling of bakery products will be achieved, thereby significantly contributing to the preservation of the ecological system in which contemporary society exists.

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CEREAL FOOD WASTE – A REVIEW

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SUMMARY
Food waste represents a significant portion in the process we call food chain. In developing countries food chain is understood predominantly as a part of production and storage processes while in developed countries it is used for food products ready for consumption. This tendency is present in terms of the cereal food chain covering staple crops. The increasing emphasis is put on reducing food worldwide, including tasks of raising awareness, production and processing technology. Cereals are a processed food manufactured from grain. The most commonly used grains are corn, wheat, oats, rice and barley. Cereals are the most important food source for human consumption. Of the approximately 2.3 billion tonnes of cereals currently produced, roughly 1 billion tonnes are destined for food use, 750 million tonnes is employed as animal feed, and the remaining 500 million tonnes is processed for industrial use (FAO, 2009). In the present article the major findings about cereal food waste are summed up from the literature of the field.

Keywords: cereal, food waste, food supply chain

INTRODUCTION

In recent years, food waste has become an increasing global issue. According to the Food and Agriculture Organisation of the United Nations (FAO), food loss is defined as 'the decrease in quantity or quality of food'. Food waste is part of food loss and refers to discarding or alternative use of food that is safe and nutritious for human consumption (FAO, 2015). Approximately 1.3 billion tonnes of food produced in the world for human consumption is wasted annually, with cereals accounting for 30%. The amount of food lost or wasted every year is equivalent to more than a half of the world's annual cereals crop (2.3 billion tonnes in 2009/2010) (FAO, 2015). Over the next four decades, the world's population is estimated to increase by 2 billion people to exceed 9 billion people by 2050. Recent FAO figures indicate that to meet the projected food demand, global agricultural

production will have to increase by 60% from its 2005–2007 levels (FAO, 2009). A reduction in food waste would increase the amount of food available for human consumption and enhance global food security to meet the demand of a rapidly increasing global population.

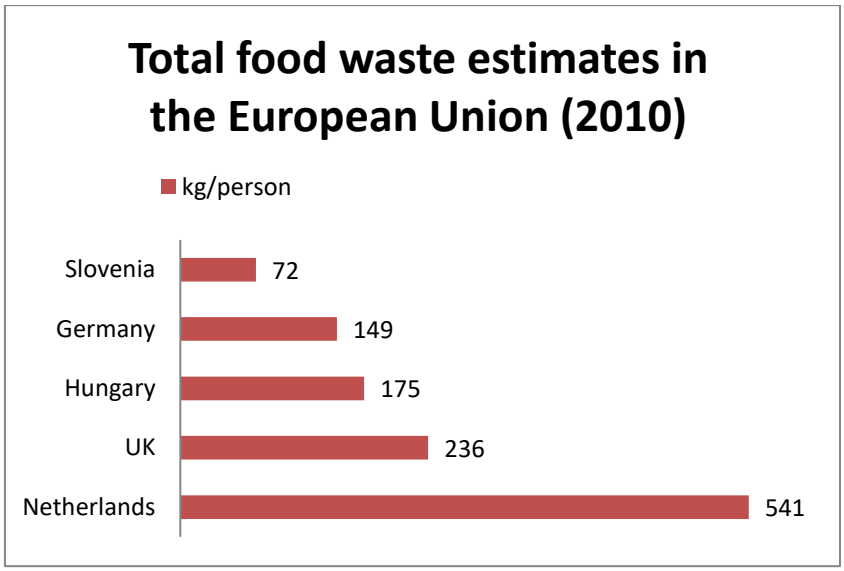

Figure 1 Estimated amount of food waste in EU countries (EP, 2017)

DISCUSSION

Definitions

The definition of food waste is a contended subject, it can vary in many ways and it is often defined on a situational basis. Food waste occurs at different points in the food supply chain, although it is most readily defined at the retail and consumer stages, where outputs of the agricultural system are self-evidently 'food' for human consumption (Parfitt et al., 2010). According to Food and Agriculture Organization of the United Nations, food waste is wholesome edible material intended for human consumption, arising at any point in the food supply chain that is instead discarded, lost, degraded or consumed by pests (FAO, 1981). Another, broader definition includes edible material that is intentionally fed to animals or is a by-product of food processing diverted away from the human food in addition to the above description (Sturat, 2009). In its widest sense, food waste is defined as in two above mentioned definitions and completed by over-nutrition — the gap between the energy value of consumed food per capita and the energy value of food needed per capita (Smil, 2004).

Wherever possible, the distinction is made between three classifications of household food waste and these are: 'avoidable', 'possibly avoidable' and 'unavoidable'. Avoidable refers to thrown food and drink that was, at some point

prior to disposal, edible in the vast majority of situations (cooked, prepared or served too much or not used in time). Possibly avoidable food and drink is the one that some people eat and others do not (e.g. bread crusts), or that can be eaten when a food is prepared in one way but not in another (e.g. potato skins). Unavoidable waste is defined as waste arising from food preparation that is not, and has not been, edible under normal circumstances (Parfitt et al., 2010).

Point of views

The issue of cereal food waste can be approached from different viewpoints: ethical, economic and environmental perspective should be considered.

The imbalance of food waste and the available food resources has led to an ethical discussion of the issue. The food waste in the global food supply chain is reviewed in relation to the prospects for feeding a population of nine billion by 2050 (FAO, 2001). Better management and distribution of food resources could be beneficial to the least privileged societies. The amount of food waste is affected by rural-to-urban migration. 50 per cent of the world's population now lives in urban environments. This proportion is expected to rise to 70 per cent by 2050 (UN, 2008). Rapid urbanization has created the need for extended food supply chains to feed urban populations. For these to be efficient, countries need improvements in roads, transportation and marketing infrastructure to keep food affordable for lower income groups. How these extended supply chains develop has implications on food waste globally, now and in the future (Parfitt et al., 2010).

In terms of economic factors, food waste implies a considerable loss of money. Better management of food resources and distribution would lead to substantial savings that could be diverted to other purposes. For example, 5 % of the USA's yearly food waste equals one day's food for 4 million people (Parfitt et al., 2010). The demand for an economic paradigm change is indicated by the increasing number of publications on the concept of circular economy including the practice and theory of circular agriculture. Notable literature in this field are, among others, *Opportunities for Agriculture and Forestry in the Circular Economy* published by the European Commission and *Rethinking the innovation model in agriculture: challenges and opportunities* by the Forum for the Future of Agriculture (EC, 2015), (EC, 2015), (Forum for the Future of Agriculture, 2016), (Trendov et al., 2017), (Tang et al., 2006), (Vollaro et al., 2016), Brod et al., 2015), (Vong et al., 2017). These works range from situation analysis to describing the possible solutions with scientific results.

Apart from ethical and economic issues, environmental concerns about food waste are being raised, such as biodegradation of food that releases methane, a greenhouse gas that is 20 times more damaging to the environment than carbon dioxide (CO_2) as it adsorbs 23 times as much heat as CO_2. Biodegradation in low-oxygen conditions, also called 'anaerobic digestion', produces biogas, a natural gas which is made up of 60% methane and 40% CO_2. If this process takes place in an open landfill, the released biogas makes an extremely negative contribution as a

greenhouse gas emission, but if it occurs in a controlled environment (such as in a biogas power plant), this form of biogas conversion offers a renewable source of fuel. In this way, organic matter such as food waste could be used to generate energy in an environmentally friendly manner and as an alternative to using fossil fuels for the same purpose (EGE, 2008).

Losses in the food supply chain

Food waste occurs at each stage of the food supply chain from harvesting to consumption. In low income countries storage and transportation losses are dominant while in high income countries waste is the highest in retail and at the consumers' end (Forum for the Future of Agriculture, 2016). A food supply chain refers to the processes that describe how food from a farm ends up on our tables. Grains undergo several operations such as cleaning, drying, storage, processing and transportation. In the food supply chain, the crop is lost due to several factors, such as improper handling, inefficient processing facilities and spoilage due to microorganisms.

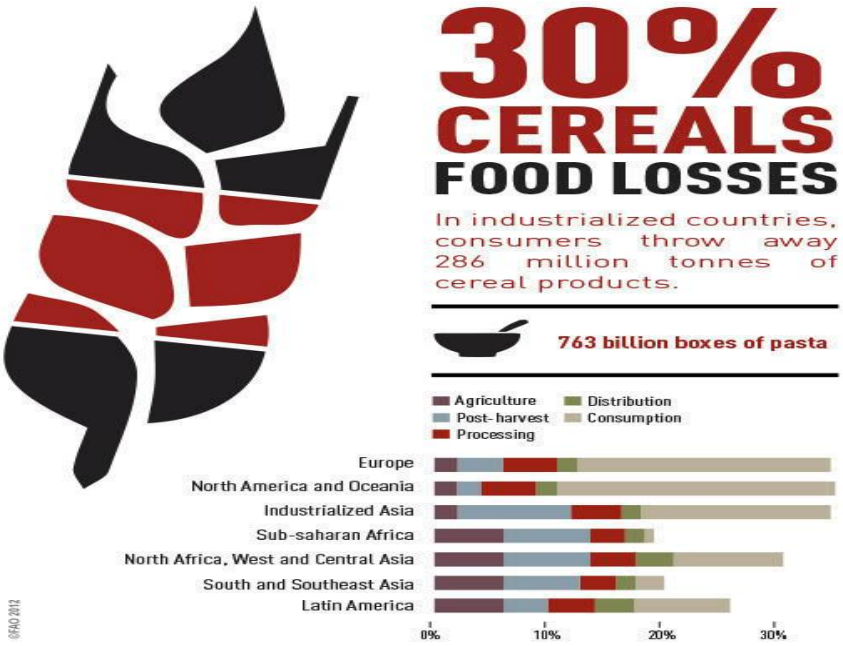

Figure 2 Infographic showing cereal food loss in different continents at different stages of the food supply chain (FAO, 2008)

Food loss begins right at the beginning of the food supply chain, at harvesting. Timing and method of harvesting are two important factors which affect cereal losses during the harvesting operations. A large amount of losses occurs before or during the harvesting operations if it is not performed at the required crop maturity and moisture content. Harvesting a crop too early at high moisture

content increases the drying cost, making it susceptible to mould growth, insect infestation and resulting in a high amount of broken grains and low milling yields. However, leaving the crop unharvested leaves the grains susceptible to bird and rodent attacks and losses due to weather. In developing countries, harvesting is performed manually which is labor intensive and time consuming. During the peak of harvesting season, labor shortages can cause delays in harvesting and result in losses (Parfitt et al., 2010).

The next stage where cereal can be lost is the stage of threshing, cleaning and drying. The purpose of the threshing process is to detach the grain from the panicles. Grain spillage, incomplete separation of the grain from chaff and grain breakage are some of the major reasons for losses during the threshing process. Delay in threshing after harvesting of crops results in significant quantity and quality loss, as the crop is exposed to rodents, birds and insect attack. Lack of mechanization is the major reason for this delay. After the threshing process, the grain is cleaned. Grains which are not properly cleaned can increase the risk of insect infestation and mould growth during the storage, they can add unwanted taste and colour and damage the processing equipment. A large amount of grains are lost as spillage during this step. Grains are usually harvested at high moisture content to minimize the shattering losses in the field. The safe moisture content for long-term storage of crops is considered below 13%. Drying can be performed naturally or using mechanical dryers. Inadequate drying can result in mold growth and significant losses during the storage and milling. Drying is an important step to maintain crop quality and reduce losses (Parfitt et al., 2010).

Losses can occur during the storage as well. Crops are grown seasonally and after harvesting, grains are stored for short or long periods of time either as food reserves or as seeds for the next season. The majority of food losses occur during the storage of crops mainly due to the lack of adequate infrastructure. Studies report that in developing countries, such as India, about 50 - 60% of grains are stored in traditional structures. These structures are made from locally available materials without any scientific design which guarantees the protection of crops. Storage losses can be direct, due to a physical loss of produce, or indirect, due to a loss in quality. Storage losses are affected by several factors such as insects, pests, rodents, fungi, temperature and rain. Mycotoxin contamination is a major factor which makes the grain unsuitable for human consumption. A large amount (25 - 40%) of cereal grains is contaminated by the mycotoxins produced by storage fungi world-wide. Moulds and mycotoxins affect the quality of the grain and are a food safety hazard (Parfitt et al., 2010).

Transportation losses are relatively low in developed countries due to modern road infrastructure and specialized equipment used to load and unload produce onto vehicles. However, this is not the case in developing countries. A lack of adequate transportation infrastructure results in damaged food products through bruising and losses due to spillage. Grains are usually transported in bags from the field processing facilities using carts, bicycles, small vehicles or open trucks. Poor road

infrastructure along with such modes of transportation results in large spillage and high contamination (Parfitt et al., 2010).

CONCLUSIONS

It is clear that there is an absence of information detailing why, where and how much cereal food waste is produced at each stage of the food supply chain. Grain waste studies have mainly focused on developing countries, with very few studies reporting grain waste in developed countries. A small number of studies conducted in the USA have only investigated grain waste in the retail and consumer stages of the food supply chain (Buzby et al., 2012). There is a clear need for further research to identify cereal waste so government bodies and stakeholders can develop effective waste utilization and management practices.

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SOCIAL MEDIA IN BAKERY PRODUCT E-PROMOTION

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SUMMARY
Marketing could be seen as a dominant business philosophy today, oriented on satisfying the needs of consumers. A marketing driven business process starts with a market research, and a marketing program is defined after that, based on the acquired information about consumer needs, with a task to answer questions about which product to produce, how to determine the price, how to deliver the product to the consumer, and how to inform the consumer about the product. The answer to these questions is provided by so-called marketing mix, which in the standardized form consists of the product, the price, the place and the promotion. From the time it originates, the middle of the last century, marketing has probably used all available media to inform the consumer, in the part where it interacts with the consumer, especially in the promotion part, so lately, after the Internet was invented, especially the World Wide Web environment, marketing has used this media space more and more intensively for promotion purposes, so one can talk about the existence of electronic promotion, i.e. e-Promotion. However, whether it is physical or electronic media, the practical experiences show that the word-of-mouth marketing, i. e. personal contact and sharing of personal experiences from one consumer to another, is the most efficient form of product promotion. Because of this, social networks play an increasingly important role in sharing the personal experiences of consumers in a virtual environment, within the e-Promotion environment. Beside that, social networks also offer significantly greater opportunities than personal contact, as they enable the multilateral (network) exchange of information. For this reason, it is important for the bakery industry to investigate and define the model of social networking for the purpose of electronic promotion of bakery products.

Keywords: internet, e-Marketing, e-Promotion, social media, bakery production promotion

INTRODUCTION

Organized and massive cereal production as the basis of human nutrition was the first major milestone in the history of mankind. The first civilizations emerged from the moment when man replaced the nomadic way of life with a stationary way of life, precisely, for the production of cereals. But in order to establish a productive cereal production, it was necessary to discover and adopt a whole range of new knowledge and technologies, from metallurgy, that is, the production of metal tools for the processing of soil, to the calendars and writing. Because of the importance of the acquired knowledge and the new technologies taught by the man of that time, that period is known as the time of the first major technological revolution. The effect of new knowledge and new technologies has resulted in the emergence of a civilized way of life and the establishment of a classical social order that has not changed significantly until today. The first big leap took place approximately 5 to 6 thousand years ago. Although the human society has permanently adopted new knowledge from that time, and many significant and great scientific discoveries have occurred, especially with the beginning and the evolution of the industrial age, not one leap that has occurred in the meantime had such a significant implication as the first major technological leap, to the one that happened during the Second World War.

Namely, during the Second World War the two technologies that will definitely change human history were discovered and began to develop. These are the space technology, that will enable the colonization of the universe in the future, as well as the digital information and communication technology that is already forming a new global virtual world. While space technology is still in its infancy, the virtual world that was formed by information and communication technology is the reality that led to the beginning of a new era, the characteristics of which will be the rapid flow of information, the integration and systematization of knowledge in the function of even faster social progress, and wisdom in making decisions. For this reason, the new age, depending on the author who deals with the changes that are taking place in society, is called information age, age of knowledge, age of wisdom, but also electronic age, digital age, virtual age, and so on. Regardless of the name of the new era, the importance of that era is global connectivity, large and fast information flow, fast access to well-organized knowledge, large and fast changes, the establishment of electronic forms of business, and more. Thus, almost everything that can be digitized, thanks to the virtualization provided by modern information and communication technology today, transitions from the domain of the physical world to the domain of the virtual world. Marketing, in particular its promotional part, was among the first to recognize the values of the virtual era and it formed new concepts such as electronic marketing (e-marketing), electronic distribution (e-distribution), electronic promotion (e-promotion) and more (Dukić, 2012).

Today, even the oldest human activities, which can not be completely switched to the virtual world, use benefits from this world. The production of bread, that is, the

production of bakery products, should be counted among such activities. Although bread, as a physical product can not be produced and distributed in a virtual environment, information and communication technology is involved in business processes related to the production of bread, that is, bakery products, from production management, through the control of production and business processes up to the establishing and managing relationships that take place on the market. Among a number of processes related to business processes involved in bread production, for the success of bread production, one of the more important roles is promotion i.e., in the virtual environment, electronic promotion. As electronic promotion is constantly changing or evolves under the influence of the evolution of information and communication technologies, it is essential to constantly identify models of optimal product promotion based on the opportunities offered by the current development version of the information and communication technology. Given that there are specificities in the promotion of different types of products, it is important to scientifically explore and define the promotion model for each of them, and thus to identify the model for optimal electronic promotion of bakery products.

MATERIALS AND METHODS

As one of the elements of marketing-mix promotion is the key factor in the successful application of marketing of a product. Until the beginning of this century, promotion was generally understood as a one-way means of communication between a business entity and its consumers, and the purpose of the promotion was to familiarize the consumer with the business entity and the features of its product by sending messages. In the new century, by moving the promotion into a virtual environment, the promotion gets a new meaning where a one-way form of communication is replaced by the two-way communication, that is, the permanent exchange of information between the business entity and the consumer. Although bakery products, as basic food products, were rarely promoted because the baking industry itself was oriented to mass production or craft small-sized production, changes in the behavior and nutritional habits of people that are happening from the end of the past and the beginning of this century, will force the bakery industry to accept the principles of marketing and to approach the problem of promoting bakery products systematically. In this regard, it is necessary to define the basic model of the process of electronic promotion of bakery products, in order to enable business entities from the bakery industry to build applied promotional models for the virtual environment. In accordance with the above, the following hypothesis is defined:

It is possible to define the basic model of electronic promotion of bakery products that uses the current potentials of information and communication technologies, especially social networks.

Based on the defined hypothesis, the following research goals could be defined:

1. Explore the term of promotion, with particular reference to features of electronic promotion.
2. Explore the development position of information and communication technology and overview the relevance and importance of social networks.
3. Examine the reasons for applying the marketing philosophy to the products in bakery industry and their promotion.
4. Introduce the model of electronic promotion of bakery products.

Overall, the following scientific methods have been used in this research: deductive method, analysis and synthesis method, desk research method, historical method, proof and disproof scientific method, causal reasoning method, abstraction method, classification method, generalization method, descriptive modelling method. The listed methods are used along with some other methods.

RESULTS AND DISCUSSION

Marketing is, acoording to American Marketing Association (AMA) defined in the following way: „Marketing is the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large." (Definition of Marketing, n.d.). In principle, marketing is often seen as a business philosophy that emerged in the middle of the last century as a response to the inability of the sales concept to cope with the situation that led to/ caused overproduction. Generally, mass production produced products regardless of the needs of consumers, which led to market surpluses that were almost impossible to sell. In order to solve this problem, it is important to start from the idea that instead of putting the production in the center of the business process, it is necessary to set the consumer, that is his needs, and then define the production programme based on the knowledge of customers needs. In this sense, it is predicted that every business process starts with market research, that is, a research that results in knowledge of customers needs. This is why marketing was often referred to as a concept aimed at profitably satisfying the needs of customers. From that time, marketing has evolved significantly, so marketing today also works in a non-profit sector where the primary goal is not profit but meeting the general social needs of consumers. Therefore, marketing is commonly seen as a managerial philosophy at the present time, in which the management business is done in a way to ensure at the same time the survival of the business entity and the efficient fulfillment of consumer needs (Meler et al., 1997).

The undertaken research in marketing, that is the market research, results in information that provides answers not only to product-related issues, but also answers to questions about potential price, distribution and promotion of products. These answers are the basis for creating a marketing plan or a marketing programme. Defining the production programme, selling prices, the way of distribution and product promotion, a so-called marketing-mix is defined. Accordingly: „A marketing mix is a way to make important decisions about how to

execute a successful marketing plan. The term 'marketing mix' was coined in 1953 by American Marketing Association president Neil Borden, and has been used from then until today, with changes being made to account for current technology and other aspects of marketing that have changed over time." (Lake, 2017).

Because of its great and wide role, promotion is probably the most complex element of marketing-mix. When referring to promotion, i.e. business promotion, Ward states the following: „Business promotion is communicating with the public in an attempt to influence them toward buying your products and/or services. You might communicate in person through direct selling or in a retail store, via the internet through a website or social media platform, electronically through email or text messaging (SMS marketing), just to name a few of the more popular business communication channels, but it's the intention to influence the consumer that defines promotion and sets it apart from other communication with customers and/or clients (Ward, n.d.). The same author differentiates promotion and advertising: „The words promotion and advertising are often used interchangeably, but they're not the same thing. Advertising is one specific action you could take to promote your product or service. It's one type of promotion. (…) Promotion, as a general term, includes all the ways available to make a product and/or service known to and available to purchase by customers.The word promotion is also used specifically to refer to a particular activity that is intended to promote the business, product or service. A store might advertise that it is having a big promotion on certain items, for instance, or a business person may refer to an ad as a promotion. Businesses also often create or buy promotional merchandise, products that often have been branded with a company's logo, to give away at events such as trade shows or as thank yous to customers." (Ward, n.d.). Promotion is comprised of various elements like:

- Sales Organization
- Public Relations
- Advertising
- Sales Promotion (The Marketing Mix, n.d.).

Promotional elements in the literature are commonly defined by the promotion mix shown in **Figure 1**.

Figure 1 Promotion mix (Source: Promotion Mix, n.d.)

In order to create a successful product promotion strategy, including the strategy for bakery products, it is important to answer the following questions:

- How can you send marketing messages to your potential buyers?
- When is the best time to promote your product?
- Will you reach your potential audience and buyers through television ads?
- Is it best to use the social media in promoting the product?
- What is the promotion strategy of your competitors? (The Marketing Mix, n.d.).

Promotion could also be seen as an information-communication process and in that part the promotion matches the concept of communication with the market. However, communication with the market is a wider term because it is used not only for promotion purposes but also for market research. Today, modern digital information and communication tools enable permanent and immediate two-way communication of a business entity with its consumers. For this reason, the modern promotion which uses information and communication technologies is usually named the electronic promotion. According to the above mentioned, electronic promotion could be simply defined as a promotion that is carried out in an electronic or virtual environment. However, the traditional promotion and electronic promotion, although fully matched in their purpose, are not exactly the same in the way they work. Due to changes in the environment, electronic promotion changes and the principles of its action in the sense that communication is no longer prevalent in one direction, i.e. by using one-way mass communication media through standardized and globalized messages that are visible to all and intended for larger groups of consumers, but there is a use of potential of modern information-communication technologies that enable bidirectional, individualized and personalized communication with a focused consumer. Accordingly, the promotion used by the information-communication technology that operates in the virtual environment is a special form of promotional activity that is focused and accurate, and the content of the communication is unique and tailored to each consumer according to his needs and preferences. Digital marketing channels used by e-promotion are shown in **Figure 2**.

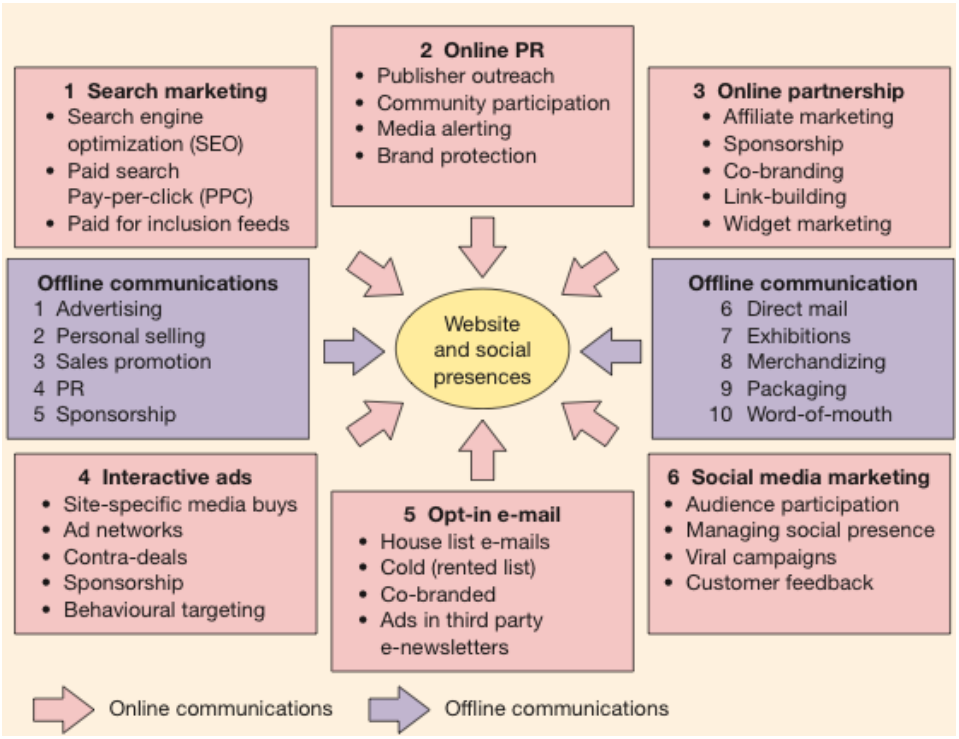

Figure 2 Digital marketing channels (Digital marketing channels, n.d.)

Information and communication technologies at the beginning of the 21st century become a key factor in marketing and thus promotional activities. The reason for this should be found in the fact that the Internet is becoming the key communication medium used in all spheres of human activity and hence for business purposes**. Figure 3** shows the widespread distribution, and thus the impact and power of information and communication technology, which shows the expected increase in the volume of Internet connectivity by 2020.

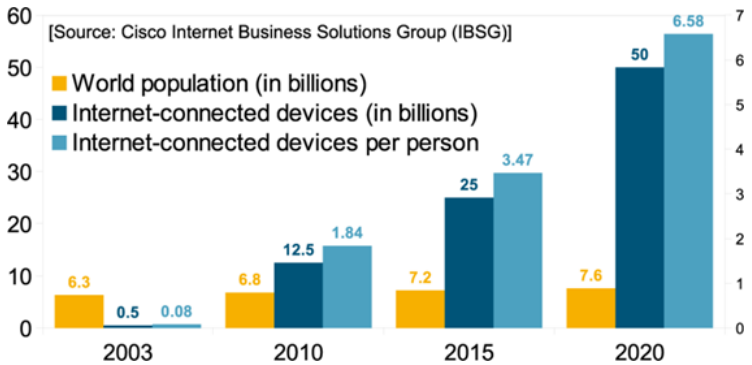

Figure 3 Growth in Internet-Connected Devices/Objects by 2020 (Perera et al., 2014)

The World Wide Web (Web) was imposed as the primary internet service in the mid-nineties of the last century. Today, as shown in **Figure 4**, the Web is at the heart of modern marketing activities that take place in the virtual environment created by the Internet. **Figure 4** shows the evolutionary processes of the Web.

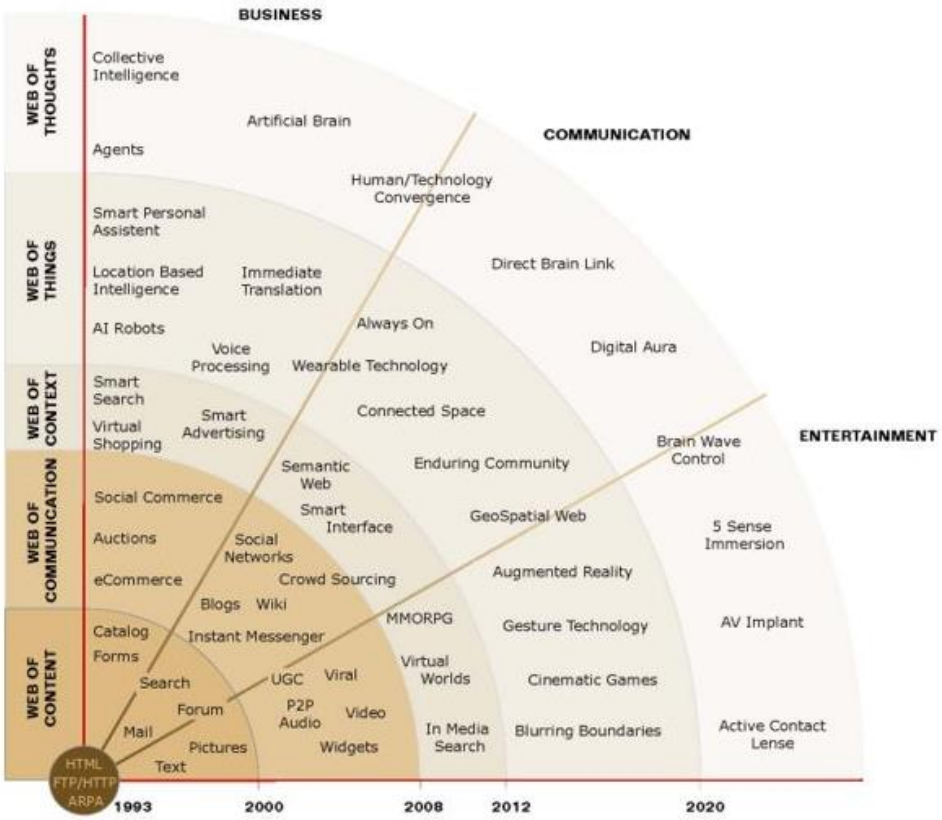

Figure 4 The evolution of the World Wide Web (Flat World Business, n.d.)

Nowadays, in a promotional sense, the Web has a special significance as a communication medium, that is, the communication part of the web that refers to social networks. **Figure 5** shows the development versions of the Web, that is, the position of the social web, or social networks as a development stage in the evolution of the Web (Difference between Web 1.0 and Web 2.0, 2012).

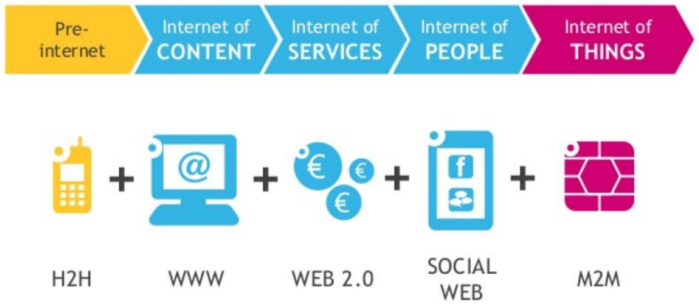

Figure 5 The evolution of the Web and the position of social Web in the evolutionary process (Nagar, 2015)

Although social networks are the only one of the media channels used by e-promotion, due to their importance and popularity among Internet users, as well as the opportunities arising from the direct multilateral communication they enable, social networks have been positioned as the means with the largest marketing and hence promotional potential. The promotional potential of social networks stems primarily from their ability to exponentially expand and the ability to stimulate chain reactions within consumers, where the consumer in the second step becomes the interpreter and the promoter of the information received, or a spokesman for the business entity and the representative of the product. Thus, it can be concluded that social networks provide the most effective promotion through so-called word-of-mouth marketing. With regard to the importance, popularity and potential of word-of-mouth marketing, Hubijar states that in 2005 WOMMA (Word of Mouth Marketing Association) was formed, which defined the following terms:

- Word of mouth communication:
  Consumer activity in terms of providing information to other consumers.
- Word of mouth Marketing:
  Giving people the reason to talk about products and services, and facilitating such communication. It is the art and science of building active, mutually beneficial communications on consumer-consumer and consumer-marketer relations.
- WOM episode:
  Conducting mouth-to-mouth communication involving participants, actions, mouth-to-mouth communication units (WOMunits), places (venues) and outcomes (Hubljar, 2011).

When it comes to the application of social networks in the electronic promotion of products and therefore bakery products, it is important to pay attention to the following facts:

- Social networks imply a two-way character of communication.
- On social networks, the primary content creator is a consumer rather than a provider.

- The consumer is applied on the social network and his attention is kept because of content, quality, relevance, exclusivity and attractiveness.
- The contemporary consumer is oriented to multimedia dynamic content.
- Consumers with a high score of the public opinion (opinion makers) are diamond consumers who are bound by a large number of followers or fans and therefore cause stronger and deeper chain reactions.
- Processes on social networks can and must be managed in order not to lose control over the chain reaction.
- Social network presence needs to be accessed professionally and systematically with the involvement of social managers.

However, the desire of a business entity for their presence on social networks opens up a whole series of problems:

- Too many social networks are available and it is not possible to be on each one of them and to be able to control everything.
- The enormous breadth and depth of each social network, the high-speed changes with permanent work hours (24 hours / 365 days a year) endanger the exclusivity of the content and threaten to lose control over the social networking event.
- Global transparency of social networks where everyone has information about each and every one can produce disinformation that is difficult to monitor and control, and the potential negative triggers could be deprived only with the permanent presence.
- Loyalty of consumers can only be sustained with the huge involvement of social managers who keep permanent communication with consumers on an individual level, paying attention to new and attractive content.

With regard to the above-mentioned, the first step in terms of electronic promotion is the choice of a platform, i.e. a social network in which to build presence and to realize promotional activities. Considering the above- mentioned, it is good to keep track and know the popularity of certain social networks, and to use popularity information as a key factor in choosing a social network or a few of them. **Figure 6** shows the popularity of the most important social networks.

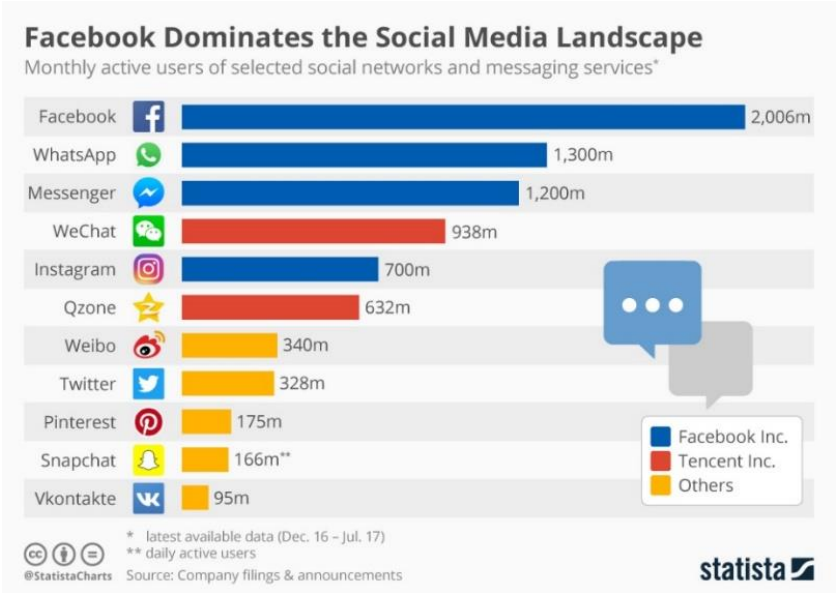

Figure 6 The popularity of the most important social networks (Richter, 2017)

As with other industries, so when building a model of electronic promotion of bakery products, the specificities of the bakery industry should be taken into account. First of all, it is an industry whose products belongs to a group of fundamental nutritional products that are subjected to permanent re-evaluations of nutritional value as an essential factor in the contemporary understanding of the quality of life and the importance of nutrition for quality life. The focus of content in terms of promotional activity on social networks should therefore go in the direction of emphasizing the proportional relationship between quality of life and proper consumption of bakery products in daily diet. As it is a two-way communication process happening on social networks, it is urgent to respond promptly to the consumer's remarks and suggestions, and to respect them if they are acceptable, or to provide exhaustive explanations if consumer objections and suggestions can not be taken into account. Therefore, the promotion of bakery products on social networks should be systematically accessed, in the first place, to develop and adopt a strategy for electronic promotion of bakery products on social networks, which will contain, besides the technical details related to the promotion, also the content dimensions of the promotion activities as well as promotion techniques for individual products in certain situations. The general model of approach to the electronic promotion of bakery products on social networks is shown in **Figure 7**.

Figure 7 The general model of approach to the electronic promotion of bakery products on social networks

Finally, the model of electronic promotion of bakery products through social networks is shown in **Figure 8**.

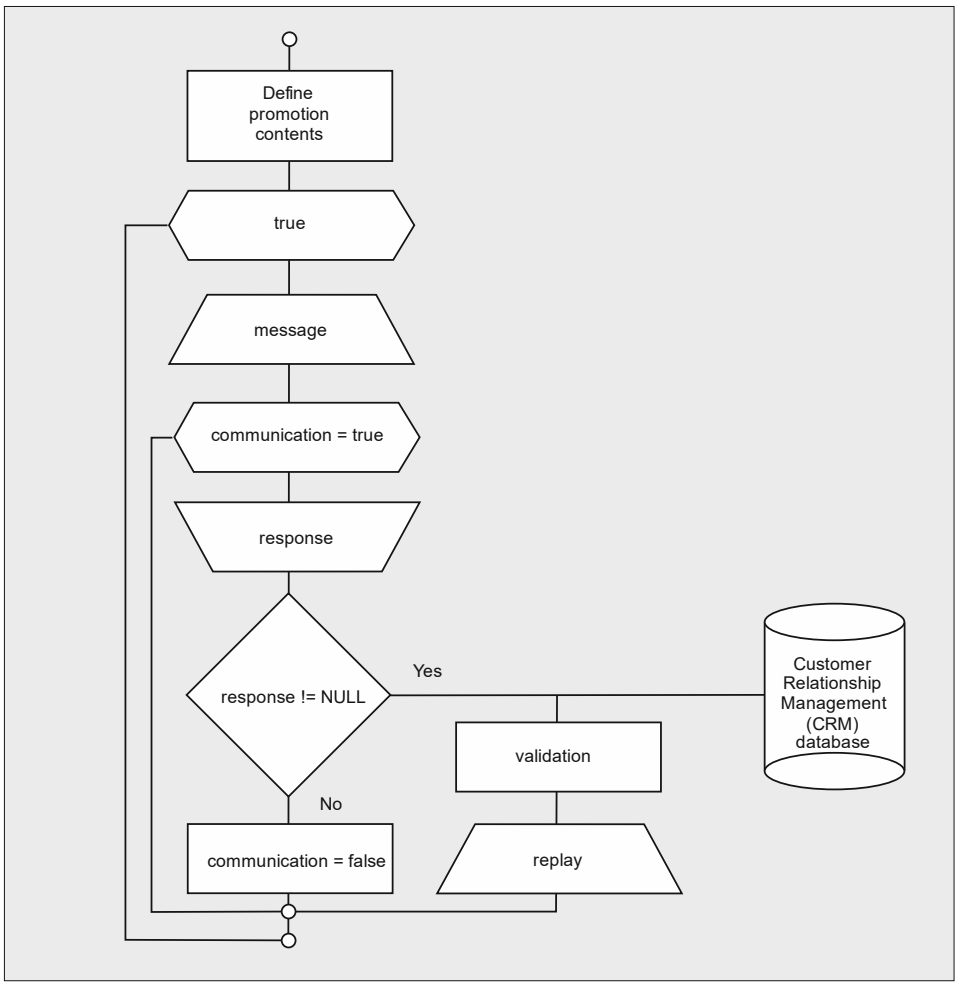

Figure 8 The model of electronic promotion of bakery products on social networks

As it is evident from **Figure 8**, the process of electronic promotion of bakery products through social networks is a continuous circular process that takes place as long as the consumer is willing to participate in the process. Unlike formalized forms of consumer interaction with business entities that take place through typed forms and formalized issues, where the process of filling in databases is automated, communication through social networks is, and thus the promotion through social networks, unstructured communication, so the presence of social networks managers who will lead the communication process is necessary, and the essential elements of communication process are recorded through the customer relationship management system (CRM). Promotion on social networks is happening on a personal level, therefore it has the features of the most effective form of promotion, namely "mouth-to-mouth" promotion, that is promotion based on personal recommendations and trust established between the sender and the recipient of the message. Given the changes that are taking place in the modern world and given the importance of social networks in the lives of modern people, it is realistic to expect that e-Promotion through social networks will become the most efficient form of bakery products promotion.

CONCLUSIONS

Bakery products belong to a group of basic nutritional products whose life spans with the time of discovery of the first cereals and as such into the group of products with the longest life expectancy. The long life expectancy of bakery products indicates not only the importance of these products in human nutrition, but also the relative stability of their consumption. However, regardless of the current market position and the recent non-elasticity of bakery products when it comes to their consumption, the bakery industry must not ignore or neglect the importance of marketing, especially promotional activities. Among many reasons in favour of the fact that the bakery industry should turn to marketing and promotional activities is the fact that with the growth of the purchasing power of the population, people are more and more inclined to a better quality and more expensive diet, especially in developed countries, which reduces the need for consuming bakery products.

The new era, aside from the increased consumer purchasing power, due to the influence of information and communication technology, has recently influenced the increase of the level of information and knowledge of consumers. Furthermore, a modern consumer, not only knows more and pays more attention to quality of life, but he also changes habits of behaviour and consumption. For this reason, modern bakery manufacturers should follow the needs of consumers and monitor changes in consumer spending habits. Social networks are a powerful tool in this respect, and enable bakery products manufacturers to develop a relationship of cooperation with consumers. Although social networks are powerful promotional tools for bakery products, they also carry a range of potential hazards, so the use of social networks for the purpose of promoting bakery products should be

systematically modelled, as this powerful promotional tool would not turn against the manufacturer. In this regard, the algorithm for the implementation of electronic promotion of bakery products on social networks has been developed.
The model itself is universally applicable, but every manufacturer, especially with regard to the specificity of the market, should approach the correction and adaptation of the model. In this regard, the results of this research represent the starting point for building specific models of electronic promotion of bakery products on social networks.

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THE INFLUENCE OF FIBRE FROM DIFFERENT LINSEED SOURCES ON WHEAT FLOUR AND CEREAL PRODUCT CHARACTERISTICS

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SUMMARY
Wheat flour was fortified by 2.5, 5.0 and 10% wt. of linseed fibre, gained from seeds of golden flax varieties Amon and Raciol (granulation 500-700 μm, prepared from 2015 flax harvest). Technological quality of the tested flour composites was described by Falling Number and Zeleny sedimentation test. Both screening methods sustained a little impact on amylases activity and protein quality, respectively. Rheological tests included the farinograph, the extensograph and the Rapid Visco Analyser (RVA) proofs. Internal laboratory procedures were used for the preparation of bread and cookies. The addition of brown and yellow flax fibre significantly increased farinograph water absorption and shortened dough stability, somewhat stronger by the addition of brown linseed fibre. Extensograph features depended on dough proof resting time. Linseed fibre supported dough extensibility, and energy as the area under curve significantly decreased about 7 - 18%. In general, fibre is characterised as hydrophilic material, which was confirmed by pasting profiles of flour composites. During dough leavening, dough resistance and optimal leavening time of wheat-linseed fibre dough was shorter than wheat control. Regardless of the described modifications in dough machinability, specific volumes of bread buns were similar through the whole sample set. A weak worsening of buns vaulting reflected a partial dilution of dough gluten skeleton. Cut-off biscuits were characterised by gradually lowering spread ratio, in line with the elevated dough elasticity. All cereal products were found to have acceptable sensory profiles. PCA method verified partial lowering of protein quality and pointed at differentiation of the tested sample according to the amount of the linseed added.

Keywords: brown and golden linseed fibre, dough rheology, bread, biscuits, PCA

INTRODUCTION

Flax (*Linum usitatissimum* L.) is a utility crop used for the production of thread and seeds, or raw material for the production of linseed oil and linseed fibre. Wild flax can be found in Asia, and its seeds are naturally brown in colour; the yellow (gold)

variant is cultivated by humans. As in case of other seeds, their cover layers are built from polysaccharides; specific heteropolysaccharides forming 7 - 12% of cover weight (Kaewmanee et al., 2014) are described by high water absorption capacity (up to 1 200%), similarl to chia or basil. Gel formed in excess of water at room temperature is called mucilage.

After oil extraction, linseed press cake is milled and sieved, producing food supplement known as linseed fibre. One of the world's producers is the Functional Whole Foods New Zealand Ltd. (earlier Walramcom Ltd.), offering linseed fibre from both brown and gold seeds. They declare content of dietary fibre equal to 45%. Within the Czech Republic, the company Agritec Šumperk occupies with linseed breading and planting, and they rendered seeds of two golden linseed variants Amon and Raciol for this study (total dietary fibre contents over 50%). During farinograph testing, ability of huge water absorption was confirmed by Koca and Anil (2007). Linseed flour replaced from 5% to 20% of wheat one, and significant increase of water absorption was registered (from 63.7% up to 65.6%, respectively). Flax non-gluten proteins weakened dough during kneading as expected. Besides bread recipe enhancement, linseed fibre has a potential to be used in formulas of muffins (Lee et al., 2004), cookies (Hrušková and Švec, 2016) and pasta Kishk et al. (2011) with improved nutritional score.

The aim of this study was to determine a baking potential of wheat-linseed fibre composite flour samples and to compare influence of two types of the non-traditional material on analytical features of flour, rheological behaviour of composite flour and quality of bread prepared in a laboratory scale.

MATERIALS AND METHODS

Semi-bright wheat flour (WF) was delivered by the industrial mill Delta Prague. It was characterized by protein content 11.2%, Falling number 432 s and Zeleny value 39 ml. Linseed fibre characterised by granulation range 500-700 μm was produced in laboratory conditions (mill Stephan UM/SK 5, Stephan Machinery, Germany; vibration laboratory sieving apparature, Stavební strojírenství n.p. Brno, Czechoslovakia), treating seeds from golden varieties Amon and Raciol, harvested in year 2015. In tested composites, linseed fibre replaced either 2.5, 5.0 or 10% wt. of wheat flour. Samples' abbreviations combined the amount of the added linseed fibre and the name of linseed variety (2.5Amon, 5.0Amon, 10.0Amon, 2.5Raciol, 5.0Raciol, 10.0Raciol).

Technological features of WF and flour composites were described by Zeleny test (ISO 5529), Falling number (ISO 3093) and total dietary fibre content (TDF, AOAC 985.29). Non-fermented dough properties were determined with the help of farinograph and extensograph apparatures (Brabender, Germany), following the international norms (ISO 5530-1 and 5530-2, respectively). Due to bread fermentation, which lasted for 50 min, extensograph data collected after dough resting, which lasted for 60 min, were only take into the account. Behaviour of

flour-water suspensions was recorded on the Amylograph (Brabender, Germany; ICC method 126/1) and on the RVA 4500 equipment (Perten Instruments, Sweden; AACC method 76 - 21). The former traditional test takes 45 min, while the latter novel machine collects similar data in 16 min only. According to the internal procedure of the Cereal laboratory of the UCT Prague, wheat and wheat-linseed composite bread was prepared and assessed in terms of consumer's quality (Hrušková et al., 2006).

Statistical analysis of the obtained data combined two-way ANOVA and principal component analysis. Considered factors were linseed type and the added amount. For the latter analysis, matrix of 23 features was reduced to 16 representative ones (e.g. extensograph test is represented by elasticity-to-extensibility ratio and energy), based on correlations to bread characteristics.

RESULTS AND DISCUSSION

Analytical features of flour composites

As is documented in **Table 1**, linseed fibre partially lowered the Falling number value of the control, but the observed positive decrease was not verifiable with respect to the measurement accuracy (± 25 s). In protein quality, similar trend was registered, but lowering the Zeleny value under 35 mL may already have influenced volume of baked goods negatively. Addition of 5.0% golden linseed fibre from the New Zealand affected the Zeleny value similarly – it meant decrease from 37 to 23 ml (Hrušková and Švec, 2016). Positive effect of linseed fibre was measured in total content of dietary fibre; from the nutritional point of view, 10% enhancement should be recommended (double increase compared to WF).

Table 1 The influence of golden linseed fibre on basic analytical features of wheat flour (WF)

Composite flour	Addition (%)	Falling number (s)	Zeleny value (mL)	Total dietary fibre (%)
WF	0	432^{a}	39^{bc}	3.40^{a}
WF+Amon	2.5	362^{a}	40^{c}	4.61^{ab}
	5.0	387^{a}	37^{b}	5.83^{bc}
	10.0	399^{a}	30^{a}	8.25^{d}
WF+Raciol	2.5	386^{a}	40^{c}	4.64^{b}
	5.0	384^{a}	38^{bc}	5.88^{c}
	10.0	384^{a}	32^{a}	8.37^{d}
Repeatability		*25*	*1*	*0.22*

Rheological behaviour of flour composites

The RVA test offers a detailed description of a pasting process, but main variation was recognized in curve points Peak viscosity, Hold viscosity and especially in Final viscosity (signs "+" in **Figure 1**). With exception of 2.5% addition, Peak viscosities of composites containing Amon fibre were almost comparable to WF control. In Hold and Final viscosities, both linseed fibre types caused a significant thickening of composite suspensions (increase from 9% to 55%; data not shown). Linseed fibre from the New Zealand demonstrated the same character – the viscosity points were about 11%, 27% and 21% higher than WF control, respectively (Hrušková and Švec, 2016).

Tested fibre influenced rheological properties of non-fermented dough – the lowest addition supported dough elasticity in three-time higher extent than extensibility. Higher fibre ratios in recipe lessened the elasticity to values comparable to WF; in the same comparison, the extensibility fell up to about 16% (data were presented on poster). Differences in dough machinability were confirmed by Koca and Anil (2007) for linseed/wheat composite flours with 5 - 20% of the non-traditional material. The same authors also mentioned that additions higher than 10% may worsen volumes of the leavened bread.

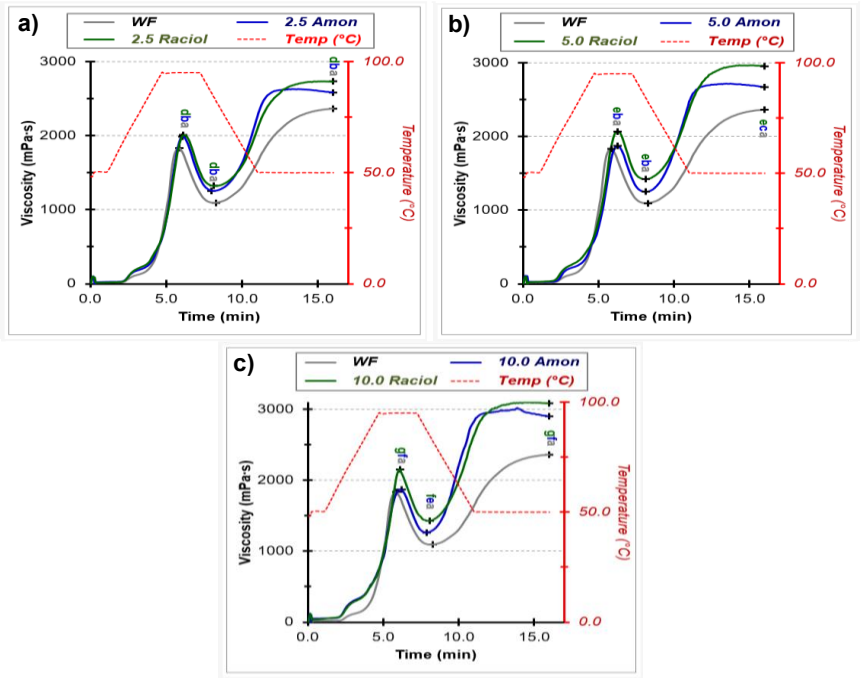

Figure 1 (a, b, c) Influence of 2.5, 5.0 or 10% golden linseed fibre on pasting behaviour of wheat flour (WF). Amon, Raciol – golden linseed varieties. From left to right, signs "+" identify pasting curve points Peak, Hold and Final viscosity. a-g: values of pasting points on single RVA curves described by the same letter are not statistically different (p = 95%)

Baking test results

Golden linseed fibre influenced the water addition in recipe positively; its amount has risen from 59.0% (WF control) up to 65.0% and 69.0% for samples 10.0Amon and 10.0Raciol (data not shown). Both lower enhancement levels improved bread quality at least, while 10% addition lowered specific volume, as well as varied bread shape (height-to-diameter ratio; **Figure 2**). Crumb firmness, defined as penetration depth, corresponded with the size of bread buns – value 14.9 mm was elevated over 20 mm by 2.5 and 5.0% linseed fibre, while 10% of the alternative raw material lowered penetration to 12.9 mm and 9.9 mm (data not shown). Sensory profiles of all tested variants fell into "acceptable" or "acceptable with minor objection" category, related to harder chewiness and partial stickiness of mouthful in case of most fortified samples.

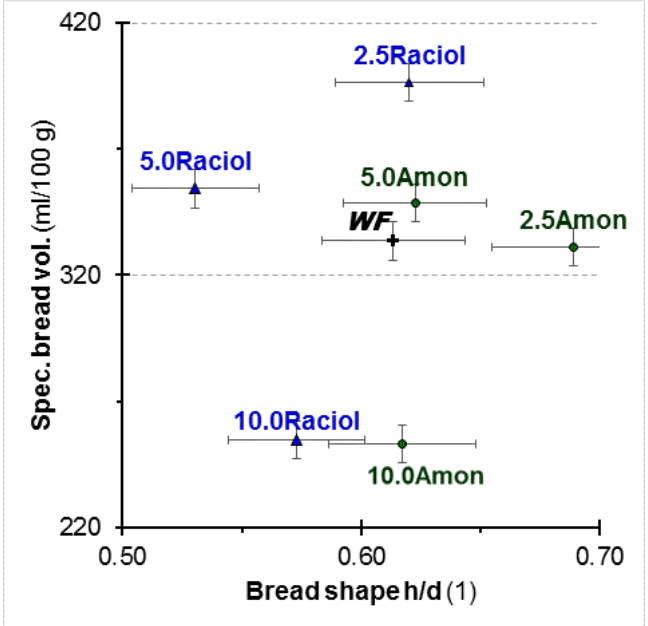

Figure 2 The influence of 2.5, 5.0 or 10% golden linseed fibre on quality of wheat bread (WF). Amon, Raciol – linseed varieties; 5.0Raciol – composite flour from wheat one and linseed fibre 95:5 wt. %

Multivariate statistics (PCA)

Within the area of the first two components (PC), data scatter was explained from 74%, i.e. from 52% by PC1 and from 22% by PC2 (**Figure 3**). In the mentioned plot, presumed connections between dough rheological characteristics and bread quality features were verified. For example, specific bread volume and crumb penetration reflect properties of proteins (Zeleny value ZT, extensograph energy EEN), or bread sensory profile connection to Falling number (FN) and mixing tolerance index (MTI). Interesting binding was revealed between amylograph maximum (AMA) and RVA curve points Peak and Final viscosity; within the flour

composite group, the last mentioned parameter had the greatest capacity to differentiate the tested material.

Samples location in PC1xPC2 plane corresponds to their overall technological potential, i.e. influence of 2.5% or 5.0% linseed fibre from Raciol variety could be regarded as improving.

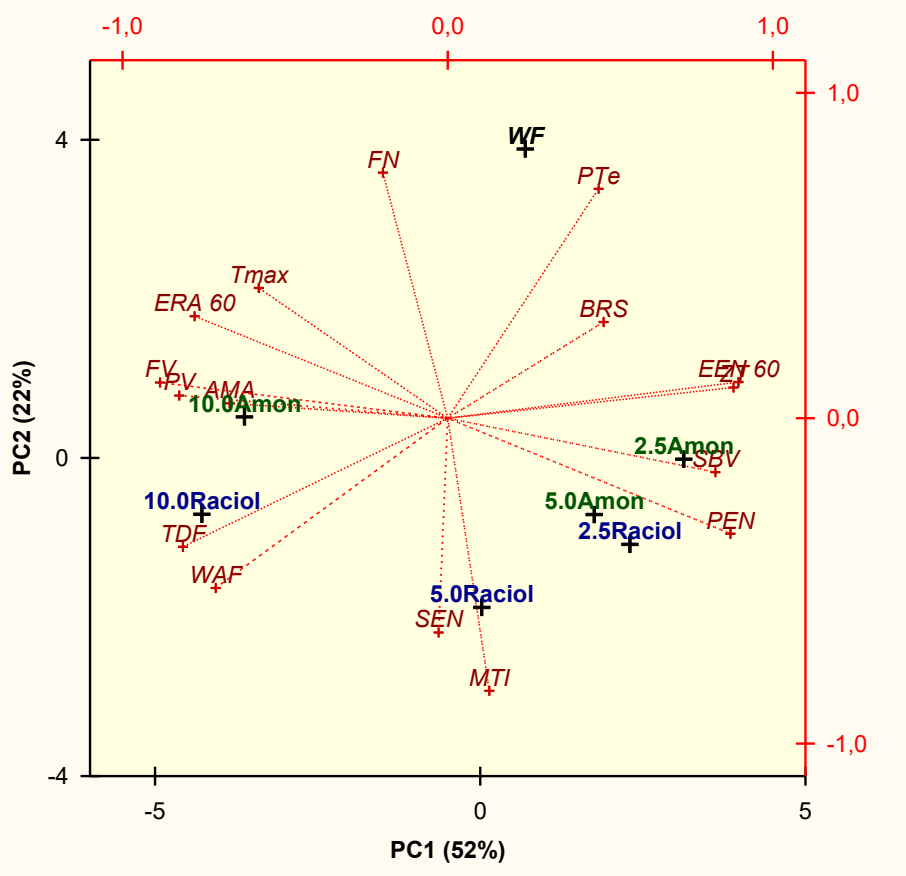

Figure 3 Principal component biplot of loadings and scores. Variables: FN – Falling number, ZT – Zeleny test, TDF total dietary fibre content, WAF – farinograph water absorption, MTI – mixing tolerance index (dough softening degree); ERA 60, EEN 60 – extensograph elasticity-to-extensibility ratio and energy; AMA, *T*max – amylograph viscosity maximum and proper temperature; PV, PTe, FV – Peak viscosity, Peak temperature and Final viscosity on RVA curve, SBV – specific bread volume, BRS – bread shape (height-to-diameter ratio), PEN – crumb penetration depth, SEN – bread sensory profile

CONCLUSIONS

Replacement of wheat flour by golden linseed fibre brought an expected decrease in protein quality, i.e. in dough machinability, resulting in lowered specific bread volume and elevated crumb hardness. Differences betweentwo tested fibre types, gained from Amon and Raciol varieties, were recorded considering the effect on pasting behaviour of flour mixtures and quality parameters of composite bread. As a compromise between satisfying technological quality and nutritional benefit, enhancement at the level of 5% on wheat flour base could be recommended.

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SENSORY ANALYSIS OF BISCUITS FROM EINKORN FLOUR, BARLEY FLOUR, EINKORN FLAKES AND WHEAT FLOUR IN DIFFERENT PROPORTIONS AND DIFFERENT SUGARS

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SUMMARY
Sensory assessment has an irreplaceable role in developing a new product. Sensory senses can help to determine whether the product is acceptable for consumption or not. Biscuits are products which are consumed by groups of people from different ages. When producing biscuits, wheat flour is usually used as one of the main raw materials for their production and sucrose is used as sweetener. The aim of this study is to determine the sensory characteristics of new kinds of biscuits produced by using different types of flour (barley flour, einkorn flour and einkorn flakes) and different sweeteners (sucrose and glucose solution).
The sensory assessment was made by implementing the method of scoring. With the help of weighted scores, biscuits are categorized in the certain category of quality. 48 different types of wheat flour biscuits, barley flour, einkorn flour and einkorn flakes in different proportions (30:70, 50:50, 70:30 and 100) were analyzed. Sucrose and glucose solution were used as sweeteners. The sensory analysis was made by 15 people at the University of Ruse Angel Kanchev branch Razgrad, Bulgaria. The achieved results were statistically elaborated. The completed sensory analysis showed that majority of produced biscuits belong to the category of very good quality (3.5 – 4.5). The statistic elaboration of data showed that different types of flour and different types of sugar had influence on the sensory characteristics of produced biscuits ($p<0.05$).
Considering the achieved results it can be concluded that using other types of flour (barley flour, einkorn flour and einkorn flakes) and other sweeteners (sucrose and glucose solution) can produce new types of biscuits, which will have good sensory characteristics and satisfying sensory quality.

Keywords: biscuits, sensory analysis, barley flour, einkorn flour, einkorn flakes

INTRODUCTION

Sensory assessment is a science discipline which is used to evoke, measure, analyze and interpret human reactions to products based on the senses (Lawless and Heymann, 1988). Good taste, together with other characteristics, is one of the most important criteria for choosing the food product (Heiniő et al., 2016). Sensory analysis deals with problems related to the evaluation of products offering a science approach which leads to complete and appropriate information about sensory quality of the products (Mandić and Perl, 2006). Eating is a dynamic process: ingredients change over time, i.e. changes in food occur during chewing (Heiniő et al., 2016). Food with cereals like biscuits, crackers or muesli is one of the largest sources of energy in human nutrition, especially for children (Simpson et al., 2012). One of the biggest nutritive problems nowadays is consuming large amounts of sugar, which causes serious health problems (Zoulias et al., 2002).

Biscuits are one of the most often consumed baking products (Nakov et al., 2016a), they can be distinguished by a specific structure (Zoulias et al., 2002) and are made from flour, oil, sugar (Zoulias et al., 2002; Popov-Raljić et al., 2013) and other components, and are characterized by a long shelf-life(Nakov et al., 2016; Mousa and Mousa, 2014). The main disadvantage of biscuits is that they harm balanced diet. Nowadays, in order to solve this problem, lots ofbiscuits made from different types of grains (barley, buckwheat, oat etc.) are offered on the market (Izembaeva et al., 2013). Flour, necessary for producing baked products, has to be of optimum quality appropriate for the certain product (Belitz et al., 2009).

White wheat flour is the flour which is usually used in baking industry. Wheat flour for making biscuits has to contain 9 - 10% proteins and a small amount of gluten (Dabija and Paius, 2015). Einkorn wheat *(Triticum monococcum* L.*)* is one of the oldest grains suitable for organic farming. The benefit of the einkorn wheat is notably smaller compared to other types of wheat. Because of the low gluten of this type of wheat, its flour is used for making biscuits (Nakov et al., 2016b). Barley is the fourth cultivated grain in the world. It is usually grown for producing malt and as animal feed. It is used very little in human nutrition. Researches have shown that barley contains a large amount of dietary fibres, especially soluble dietary fibres *β*-glucans (Gupta et al., 2011). Flakes are made in Europe from many different cereals such as rye, barley etc. Einkorn flakes can be used for making breakfast, bread and biscuits (Bartolucci, 2015).

Sucrose is generally used as a sweetener. Sucrose, known as "common sugar" is one of the most important food sugars (Coultate, 2009). Sucrose is a standard for the intensity and quality of sweetness and all other sweet substances are compared to it (BeMiller, 2011). Tendency of constant increase of using different sweeteners as a substitute for sucrose has been noticed all over the world. Sweeteners as substitute for sucrose include: glucose, fructose, sugar alcohols

(sorbitol, mannitol, xylitol), honey etc. Glucose is a simple sugar or monosaccharide and it is a main source of energy. Glucose provides 4 calories per gram and is responsible for the sweetness of baked products. In baking industry, glucose is used mainly for improving the flavour i.e. as a sweetener. Secondary functions of glucose include imparting moisture and tenderness to baked goods (Internet source - glucose).

MATERIALS AND METHODS

Sensory assessment is made according to a method presented by Popov- Raljić et al. (2005), according to which appearance (surface, shape and crashes of biscuits) is assessed, and there is a visual assessment of structure, chewing, odour and taste of biscuits. According to this type of assessment, every characteristic is assessed with one grade from 1 to 5. Lack of this type of assessment is compensated by the importance quotient (importance factor). Weighted grades are calculated with the help of this equation (1), which is used to calculate the total quality of the product.

$$weighted\ grades = grade \cdot importance\ factor \quad (1)$$

German standards (Deutsche Landwirtschafts-Gesellschaft) for sensory assessment (**Table 1**) are based on calculating the achieved average quality number (2):

$$\frac{\sum weighted\ grades}{\sum importance\ factors} = quality\ number \quad (2)$$

All parameters are assessed with grades from 1 to 5, 1 being the lowest grade and 5 being the highest with the method of scoring (grading). The total amount of importance factors is 20, and according to the European Organization for Quality Control, frame method is the only method for grading all food products (Primorac, 2006). Sensory analysis of produced biscuits has been made by 15 people who were previously appropriately trained for sensory assessment. Sensory assessment has been conducted at the University of Ruse "Angel Kanchev" branch, Razgrad Bulgaria. According to the DLG method, the analyzed products can be classified in several groups.

Table 1 Product categorization according to DLG method

Quality category	Average weighted grades limits
Excellent quality	4.5 – 5.0
Very good quality	3.5 - 4.5
Good quality	2.5 – 3.5
Not meet requirements regarding quality	< 2.5

Statistical analysis

Statistical analysis of calculated weighted grades has been made with the help of *XLSTAT* 2017 and *Microsoft Office Excel* 2013 programs. During processing, the results in *XLSTAT* 2017 program, analysis of variance (*ANOVA*) and Fisher`s Least Significant Difference test (LSD) with an importance factor (significance) of 95% (p<0.05) have been used.

RESULTS AND DISCUSSION

Sensory assessment is a science discipline which helps analyze the composition of food (appearance, odour, texture and taste) by assessing human reactions (Internet source: Food – a fact of life).

Sensory properties are first, and often the only parameters according to which most customers assess the food quality. Sensory or organoleptic properties of food as an aspect of quality are connected to the sense of tastiness which food gives when consuming it, and include all properties which can be perceived through the senses of eyesight, odour, taste, touch, and even hearing (Koprivnjak, 2014).

Table 2 Weighted grades from the sensory assessment of biscuits with glucose solution and sucrose sweeteners and total quality number of analyzed biscuits

Appearance assessment (surface, shape and crashes)	Visual assessment of the structure	Chewing	Odour and taste assessment	Quality number	Sample
14.60	18.67	16.27	39.60	4.46	100%WF
13.80	18.13	16.00	33.00	4.05	30%WF+70%B
13.60	16.00	16.27	32.40	3.91	50%WF+50%B
13.60	17.60	16.80	33.60	4.08	70%WF+30%B
13.40	16.27	16.53	39.00	4.26	100%B
9.20	16.80	15.47	36.00	3.87	30%B+70%E
10.60	15.20	15.47	38.40	3.98	50%B+50%E
11.80	15.20	15.47	36.60	3.95	70%B+30%E
13.40	17.47	16.27	35.40	4.03	30%WF+70%E
12.60	17.87	16.53	34.20	4.06	50%WF+50%E
10.60	15.20	14.67	37.80	3.91	70WF+30%E
9.40	16.53	16.27	37.20	3.97	100%E
11.00	16.00	16.27	37.80	4.05	30%E+70%EF
12.00	16.00	16.00	35.40	3.97	50%E+50%EF
11.80	15.47	17.33	41.40	4.30	70%E+30%EF
10.40	16.80	16.27	32.40	3.79	100%EF

**WF-Wheat flour; B-Barley flour; E-Einkorn flour; EF- Einkorn flakes*

***average value of weighted grades from 15 assessors*

According to product categorization shown in **Table 2**, it can be concluded that all 16 different types of biscuits which have glucose and sucrose in their production belong to the group of very good products. Biscuits from 100% wheat flour have the largest quality number (4.46), whereas biscuits from 100% einkorn flakes have the lowest quality number (3.79).

Table 3 Weighted grades from the sensory assessment of biscuits with glucose solution sweetener, and total quality number of analyzed biscuits

Appearance assessment (surface, shape and crashes)	Visual assessment of the structure	Chewing	Odour and taste assessment	Quality number	Sample
12.00	15.71	14.57	26.36	3.43	100%WF
10.20	14.13	13.60	26.40	3.22	30%WF+70%B
10.00	13.60	14.13	26.40	3.21	50%WF+50%B
11.00	16.27	14.40	25.80	3.37	70%WF+30%B
11.00	10.40	13.87	25.20	3.02	100%B
11.60	14.67	15.20	33.60	3.75	30%B+70%E
12.80	16.00	14.40	26.40	3.48	50%B+50%E
10.00	13.87	15.20	35.40	3.72	70%B+30%E
11.20	14.93	15.47	34.80	3.82	30%WF+70%E
12.00	16.00	13.87	29.40	3.56	50%WF+50%E
10.60	14.93	14.40	30.60	3.53	70WF+30%E
13.40	14.13	15.47	33.60	3.83	100%E
12.00	15.20	15.73	31.20	3.71	30%E+70%EF
11.60	16.53	15.73	32.40	3.81	50%E+50%EF
10.40	14.13	15.73	32.40	3.63	70%E+30%EF
11.40	14.40	15.20	33.60	3.73	100%EF

**WF-Wheat flour; B-Barley flour; E-Einkorn flour; EF- Einkorn flakes*
***average value of weighted grades from 15 assessors*

According to the quality numbers of biscuits with glucose as a sweetener shown in **Table 3**, the results showed that biscuits made from barley flour and einkorn flour (30:70; 70:30), wheat flour and einkorn flour (30:70; 50:50; 70:30), 100% einkorn flour, 100% einkorn flakes, as well as biscuits made from einkorn flour and einkorn flakes (30:70; 50:50; 70:30) belong to the group of products with a very good quality. Other products belong to the group of good quality.

Table 4 Weighted grades from the sensory assessment of biscuits with sucrose sweetener and total quality number of analyzed biscuits

Appearance assessment (surface, shape and crashes)	Visual assessment of the structure	Chewing	Odour and taste assessment	Quality number	Sample
13.80	18.67	16.80	33.00	4.11	100%WF
11.80	13.60	16.00	30.60	3.60	30%WF+70%B
11.20	14.67	14.67	36.60	3.86	50%WF+50%B
12.00	15.73	16.00	32.40	3.81	70%WF+30%B
12.80	17.33	15.47	37.20	4.14	100%B
10.20	17.87	16.00	39.60	4.18	30%B+70%E
10.80	13.87	16.00	42.00	4.13	50%B+50%E
10.80	17.60	16.80	40.20	4.27	70%B+30%E
8.40	12.80	14.93	32.40	3.43	30%WF+70%E
11.40	16.80	16.80	37.20	4.11	50%WF+50%E
11.20	17.07	12.53	32.40	3.66	70WF+30%E
8.80	11.20	11.20	25.20	2.82	100%E
9.20	13.87	15.73	30.00	3.44	30%E+70%EF
9.00	12.27	13.33	30.60	3.26	50%E+50%EF
8.60	14.40	16.00	32.40	3.57	70%E+30%EF
12.00	16.27	16.53	39.00	4.19	100%EF

**WF-Wheat flour; B-Barley flour; E-Einkorn flour; EF- Einkorn flakes*
***average value of weighted grades from 15 assessors*

In order to determine the category of quality in which products can be divided regarding biscuits with only sucrose as a sweetener, only biscuits made from 100% einkorn flour and 50% einkorn flour, and 50% einkorn flakes are classified in the group of good products, while the others are classified in the group of very good products (**Table 4**).

During statistical data processing, firstly it has been determined whether there is a statistical difference between samples. The results from the same are shown in **Table 5**.

From **Table 5** it can be seen that regarding different mixtures of flour, there is a statistically significant difference ($p<0.05$), and the same is true for sugars i.e. different types of flour and different types of sugar influence the sensory assessment of biscuits.

Table 5 Results of the statistical data analysis

	Mixtures of flour	**Sugars**
Lambda	0.854	0.893
F (Observed values)	4.068	10.290
DF1	28	8
DF2	2551	1414
F (Critical value)	1.481	1.945
***p*-value**	< 0.05	< 0.05

Results from the analyses of variance are shown in **Table 6** in order to present the statistically significant difference between biscuits made from different categories of flours and mixtures ($p<0.05$).

Table 6 Analysis of the differences between categories with a confidence interval of 95% for all parameters of different flour mixtures

Category	Appearance assessment (surface, shape and crashes)	Visual assessment of the structure	Chewing	Odour and taste assessment
White flour	13.800 ± 0.47^{a}	18.022 ± 0.61^{a}	16.089 ± 0.57^{a}	33.800 ± 1.42^{abc}
Barley flour	12.400 ± 0.47^{b}	$14.668\pm0.61b^{c}$	15.289 ± 0.57^{ab}	33.800 ± 1.42^{abc}
White flour: Barley flour	11.911 ± 0.27^{bc}	15.526 ± 0.35^{b}	15.319 ± 0.33^{ab}	30.800 ± 0.82^{c}
White flour: Einkorn flour	11.267 ± 0.27^{cd}	15.674 ± 0.35^{b}	15.052 ± 0.33^{ab}	33.800 ± 0.82^{abc}
Einkorn flakes	11.267 ± 0.47^{cd}	15.822 ± 0.612^{b}	16.000 ± 0.57^{a}	35.000 ± 1.42^{ab}
Barley flour: Einkorn flour	10.867 ± 0.27^{cd}	15.674 ± 0.35^{b}	15.556 ± 0.33^{ab}	36.467 ± 0.82^{a}
Einkorn flour: Einkorn flakes	10.622 ± 0.27^{d}	14.874 ± 0.35^{bc}	15.763 ± 0.33^{a}	33.733 ± 0.82^{abc}
Einkorn flour	10.533 ± 0.47^{d}	13.956 ± 0.61^{c}	14.311 ± 0.57^{b}	32.000 ± 1.42^{bc}

**Values in the same column with different exponents (a-d) have statistically significant difference (p<0.05) ANOVA, Fisher`s LSD.*

Statistically significant results regarding the appearance assessment (surface, shape and crashes) can be seen in **Table 6** and it can be concluded that results from wheat flour, barley and einkorn flour together with a mixture of einkorn flour and einkorn flakes are statistically significant i.e. different ($p<0.05$). During visual assessment of the structure, it can be noted that biscuits from wheat flour are statistically significant regarding all other types of biscuits. Statistical processing of the results for chewing has shown that only biscuits from wheat flour and einkorn flour are statistically different. Biscuits made from the mixture of white flour and

barley flour are statistically different from biscuits made from barley flour and einkorn flour regarding the odour and taste.

Table 7 Analysis of the differences between categories with a confidence interval of 95% for all parameters of different sugars

Type of Sugar	Appearance assessment (surface, shape and crashes)	Visual assessment of the structure	Chewing	Odour and taste assessment
Sucrose and glucose solution	12.196[a]	16.495[a]	16.117[a]	36.250[a]
Glucose solution	11.533[b]	15.357[b]	15.350[b]	34.600[a]
Sucrose	11.021[b]	14.728[b]	14.800[b]	30.175[b]
Values in the same column with different exponents (a-b) are statistically significantly different (p<0.05) ANOVA, Fisher`s LSD.				

Results showed that regarding appearance assessment (surface, shape and crashes), visual assessment of the structure and chewing, there has been statistically significant difference between biscuits with the sucrose and glycose syrup mixture and biscuits with individual sweeteners. Regarding odour and taste, biscuits with sucrose as a sweetener have been statistically different from biscuits with other types of sweeteners. Statistically significant difference is determined in biscuits with sucrose as a sweetener.

CONCLUSIONS

From the conducted analysis, it has been determined that the highest weighted grades had biscuits from 100% wheat flour. If biscuits are examined according to the type of sweetener separately, it can be concluded that biscuits with 100% wheat flour and mixture of sucrose and glucose as a sweetener, have the highest quality number, but together with other biscuits from this group, belong to the group of very good products.

The lowest quality grades have been noticed in the group of biscuits with glucose as a sweetener and part of these biscuits belong to the group of good products, while others belong to the group of very good products. In this group, biscuits from 100% einkorn flour are the products with the highest quality grades (3.83).

With biscuits with only sucrose as a sweetener, almost all types of biscuits belong to the category of very good products (except biscuits from 100% einkorn flour (2.82) and biscuits from 50% einkorn flour and 50% einkorn flakes)).

From the results of statistical analysis, it has been concluded that regarding sensory parameters: appearance assessment (surface, shape and crashes), visual

assessment of the structure and chewing, biscuits with sucrose and glucose syrup as sweeteners are significantly different. When determining the influence of different mixtures of flour on the sensory assessment, it has been determined that according to sensory parameters: appearance assessment (surface, shape and crashes), visual assessment of the structure and chewing, biscuits made from wheat flour are statistically different from the biscuits made from others flours or mixtures.

We consider that all types of biscuits have satisfying quality as it has been shown from the sensory analysis. The use of barley flour, einkorn flour and einkorn flakes in biscuit production can contribute to the production of new types of biscuits with characteristics of functional food.

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VOJVODINA BREAD, PASTRY AND CAKE OFFER AMONGS THE SPECIFIC TYPES OF RESTAURANTS, INNS AND FARMS

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SUMMARY
Bakery and pastry products represent an important part of the total tourismand gastronomic offer of the country, region, city and the individual facilities. Due to a high quality offer, the satisfied tourists have the long and nice memories of the flavour from the countries they have visited. Moreover, they share experiences amongst their friends, wishing to repeat the visit sometimes. Vojvodina regional kitchen could be described by an authentic bakery-pastry products such asstrudel, pumpkin pastry, pastry rolls with fat and other specialties which have been preserved by many generations.
Vojvodina is one of the most interesting and hospitableplaces in Serbia, in regards to the agricultural diversity. Also, it is the multicultural area populated with many different nationalities. Any of them possess their own culture and tradition, contributing to the colourful picture of this place. This paper provides an analysis of the Vojvodina bread, pastry and cake offer in 10 specific restaurants, namely, fish restaurants and farm type objects. The main objective is to highlight the importance of Vojvodina bread, pastry and cake offer in inns and farms, throughout theoretical and practical analysis.

Keywords: bread, pastry, cake, Vojvodina, restaurants

INTRODUCTION

Vojvodina cuisine is different from the other parts of Serbia, due to medieval influence. It was formed as the result of complex circumstances of living, geographical characteristics: natural conditions and social interactions in this area. In the territory of Vojvodina there aremultiple different cuisines, thus, the big variety of products could be found (Ivkov-Cigurski and Blešić, 2009).
Food and dish preparation in Vojvodina, was massively influenced by the arrival of Germans, since they brought dishes, customs, winter food preparation, wines, fruit

and grape planting. Therefore, Vojvodina citizens adapted lots of dishes and methods of the food preparation. Likewise, in Vojvodina an abundance culinary skills and mutual influence of Hungarian, Romanian and Slovakian cuisine is present, and lots of dishes are derived from other cuisines from the neighbours (Ivkov-Cigurski and Blešić, 2009; Kalenjuk et al., 2011).

Vojvodina cuisine originates from the period of Turkish expatriation in Europe from medieval time, and the large migrations of various nations of different ethnical origin, i.e. during the liberation wars against Ottoman Empire, starting from the occupation of Wien, until the liberation of Belgrade.

Vojvodina is traditionally an important food manufacturing area in Serbia and the whole region (Tesanović et al., 2013), considering geographical position, ground, climate, and cultural heritage. Thus, the large number of well-known, authentic dishes, food and beverage products which are manufactured in the industry, are served in hospitality objects as well as citizen food and for export.

In many countries in the world food industry also plays an important role in tourism, since degustations are organized and the dishes are put in menus and food cards of hospitality objects. Moreover, domestic regional dishes are particularly marked, their origin is protected, and museums which affirm gastronomic, cultural heritage are created. Also, tourist cooking schools and gastronomic manifestations are organized which gather millions of people and take serious actions which affirm their food and beverage, by developing gastronomic tourism (Kalenjuk et al., 2012b).

Farms and river inns are an authentic gastronomy tourist objects which are placed in rural areas and households, and are now part of the growing trend in Vojvodina. The owners of farms invest their funds in order to evoke former appearance and ambient. Thus, farms are close to become the tourist attraction and place which should be visited if you are the tourist.

Certainly, it is not the case every time. There are lots of old authentic farms, whose owners, during the transition period because of the money deficiency, did not have the possibility to show their tourist potential (http://www.salas.org.rs/).

Inn (csarda) is the restaurant with the folklore ambiance. Previously, river inns were bars placed out of the village, intended to be visited by the passengers. During the 19th century, it was the place where the Hungarian haiduks (robbers) stopped by. Nowadays, some of them, jealously keep gastronomy secrets, by providing the guests not just with good food and beverages, but also the romance of the past days.

Word Csarda (River inn) originates from Persian language and literary refers to eaves placed at four pillars. River inns were placed, from medieval times, across the roads and by the rivers, and were the perfect shelters for vacation and rest. Inns across the roads have lost their earlier importance, because of the travelling speed. However, the inns at the river became even more attractive, like the onese at the Danube. It is also worth mentioning that the word csarda is used only in Hungarian and Serbian language (Gergely, 2010).

The subject of this paper is a representation and offer of Vojvodina types of bread, pastry and cakes in authentic restaurants such as inns and farms. The significance of these products in traditional offer of ethnic restaurants will be distinguished throughout this work.

The aim of this paper is to point out the significance of Vojvodina bread, pastry and cake offer in inns and farms through the theoretical and practical analysis. The goal of this work is to show the current offer of Vojvodina bread, pastry and cakes, and to think of the method for the improvement of offer in inns and farms, and also to determine the most frequent dish presented in ethnic food restaurants.

MATERIALS AND METHODS

This research included 10 river inns and farms, which belong to the territory of Vojvodina. Their menus were used for the purpose of this paper, so it could be seen which bread, pastry or sweets they offer to their visitors.

The content and modus of the research were determined by the application of appropriate methods. Results of research were obtained through the:

- application of professional domestic and foreign literature sources;
- market research and the data collecting;
- statistical analysis of the collected data and their visual presentation.

Methods of work were the cabinet and field research. Furthermore, the comparative method was used for the comparison of data of the restaurants' offer, followed by the statistical and graphical method by the help of which certain facts throughout figures could be shown, which was also used as the method of criticism while making certain conclusions.

RESULTS AND DISCUSSION

The analysis of Vojvodina cakes, pastry and bread refers to the complete analysis of the inns' and farms' offer considering traditional products. The comparison was conducted between every single object in order to determine the most frequent dish, found in inns and farms.

Frequency of Vojvodina bread, pastry and cake presence in inns and farm menus are shown in **Figure 1**.

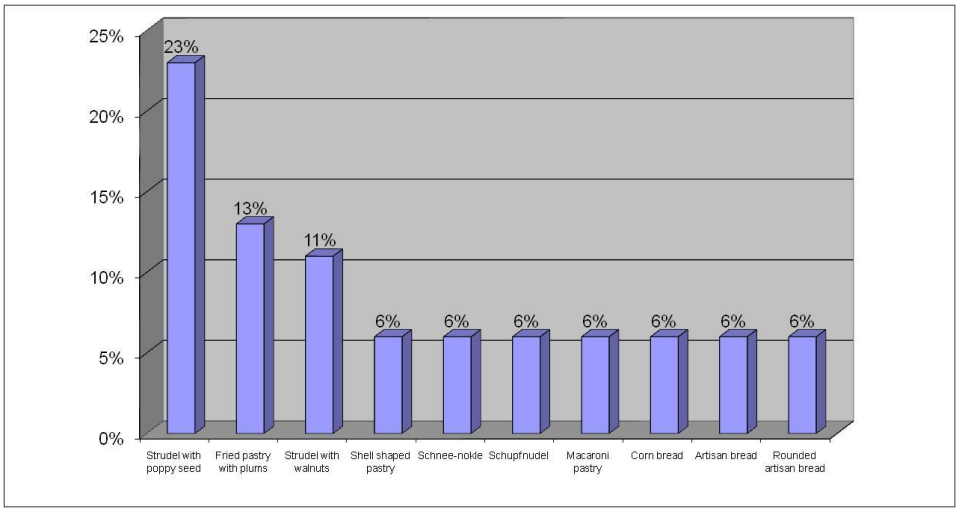

Figure 1 Frequency of Vojvodina bread, pastry and cake presence in inns and farm menus

By analyzing this offer (**Figure 1**), it was concluded that strudel with poppy seed has been dominating in menus (23%), in comparison to other dishes. The second most frequent dish was fried pastry with plums (13%). Slightly lower percentage had strudel with walnuts (11%). The less frequent represented dishes were shell shaped pastry, Schnee-nokle, Schupfnudel, macaroni pastry, corn bread and artisan bread (6%).

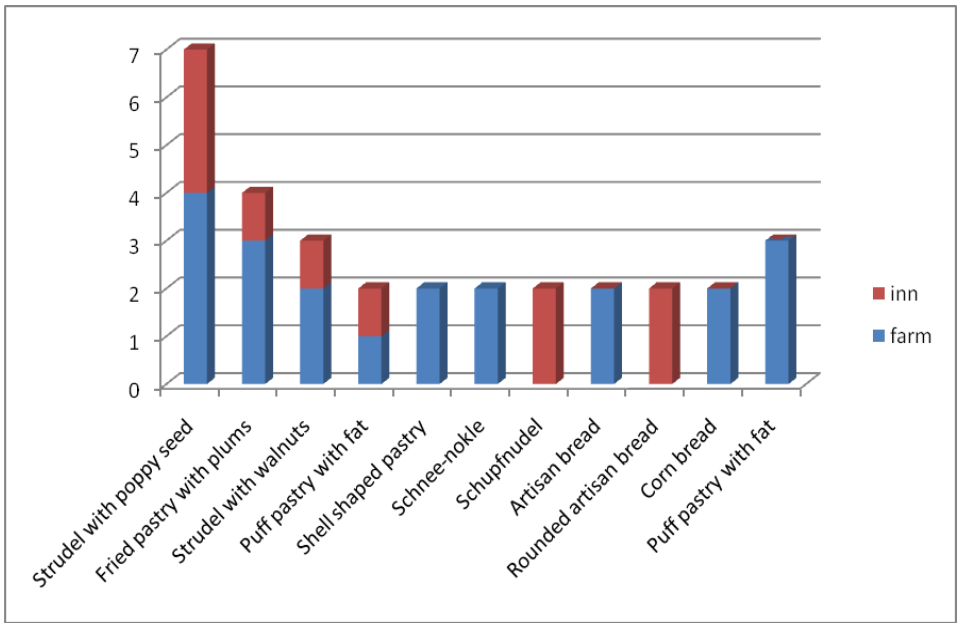

Figure 2 Distribution of some authentic Vojvodina food products in farms and inns

By observing the partial distribution of dishes in farms/inns (**Figure 2**), it could be seen that the strudel with poppy seed can be found in seven restaurants, out ofwhich four of them belong to the type of farms, and three to the type of inn. The fried pastry with plums were spotted in four specific restaurants. They could be found in the offer of three farms and one inn. Strudel with walnuts can be found in three of the ten objects in which this survey was conducted. Considering the type of restaurant, strudel with walnuts is offered in two farms and one inn. Puff pastry with fat is placed inside the offer of three restaurants, and they all belong to the type of farm. Other Vojvodina cakes, pastries and breads are present in two of the ten examined objects. Rounded artisan bread and macaroni pastry are in the offer of two inns, while artisan bread, corn bread, Schupfnudel and Schnee-nokle are in the offer of two farms. Schell shaped pastries are also present in the offer of only two restaurants; one of them belonging to the inn and the other to the farm.

CONCLUSIONS

By observing results of the conducted research, considering Vojvodina cakes, pastries and bread offer in specific restaurants (farms and inns), it could be concluded that:

- The most common product is the strudel with poppy seed, since it presents 23% of the total supply of Vojvodina pastry products in the examined restaurants;
- Second in the presence frequency is fried pastry with plums. They contribute with 13% of the total products' offer;
- Strudel with walnuts was present in ethnic restaurants with 11%;
- Shell shaped pastry, Schnee-nokle, Schupfnudeland macaroni pastry are rare to find in ethnic restaurants with a possibility of 6%.

Itis obvious that traditional pastry and confectionery offer presented in Serbian ethnic restaurant did not meet author's expectations. Geographical domestic food products are the base of the tourist gastronomic offer, therefore, should be in focus while planning the menu. The lackn of some traditional pastry products in inns/farms should alarm the gastronomic society to provide the proper education and influence the restaurant owners in order to improve a total gastronomic offer of the country.

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THE EFFECT OF DIFFERENT COMMERCIAL SOURDOUGHS ON THE QUALITY OF GLUTEN FREE BREADS

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SUMMARY
The search for solutions to alleviate technological and nutritional defects in gluten free (GF) breads is a major research topic in the area of food technology. Up to now, the strategies used only contemplated the design of complex matrices by adding ingredients and additives, raising the cost of these products. Nevertheless, the strategy of exploiting the sourdough benefits has been scarcely explored. The possible influence of sourdough on bread quality might reduce the need for additives. In this study, the impact of different commercial sourdough on the structural and quality behaviour of rice wholemeal breads. Breads obtained did not show significant differences in relation to specific volume, moisture and water activity. The addition of sourdough resulted in more acidic bread crumbs and the consequent increase in titratable acidity (TTA), resulting in harder crumbs and irregular crumb grain of the sourdough breads. On the other hand, there were no significant differences in the nutritional composition of the breads. Overall, commercial sourdoughs changed the textural characteristics of the GF breads, without affecting the specific volume.

Keywords: gluten free, sourdough, bread, quality, staling

INTRODUCTION

Nowadays, the presence of gluten-free products (GF) in the market is growing due to the increasing demand, not only for people with medical needs, but also consumers who include this type of products as part of their lifestyle. This trend has led to the search for GF products with similar sensory and nutritional characteristics to traditional cereal based products. Nevertheless, the development of good quality GF products continues to be a challenge for food scientists and technologists. In fact, GF products, currently available on the market, still have low technological and nutritional quality (Mariotti et al., 2013). Specifically, GF bakery products have lower texture, lower volume, poor colour and short shelf-life

(Gallagher et al., 2004; Matos and Rosell, 2012), as well as poor nutritional composition (Matos and Rosell, 2011).

Different studies focused on improving the technological and sensory quality of GF breads describe complex formulations needed to overcome the negative impact of the absence of gluten (Matos and Rosell, 2011). These formulations combine diverse additives in order to mimic the viscoelastic properties of gluten (Masure et al., 2016). However, the addition of these ingredients supposes an increase of the final product. In addition, the current trend of consumers is directed towards healthy products with good aroma and taste, good texture and a long shelf-life, made in a "natural" way without the addition of artificial additives. In this sense, the use of sourdough has a long tradition associated with artisan baking. Nevertheless, the use of sourdoughs, beyond market trends, plays an important role in the preparation of breads, improving the technological, nutritional, organoleptic and maintenance shelf-life properties of breads (Moroni et al., 2009). Thus, the positive influence of the sourdough could be exploited to reduce the need for additives.

The aim of this research was to evaluate the effect of different commercial sourdoughs on the technological and nutritional properties of GF breads. For that purpose, four GF sourdoughs, obtained from different raw sources, were tested. Breads obtained were evaluated regarding physicochemical analysis, hydration properties, crumb microstructure, crumb texture, and nutritional analysis.

MATERIALS AND METHODS

Materials

Four commercially dehydrated available sourdoughs, coming from different flour origin, were used in this study. Corn (MM1), rice (MM2), buckwheat - organic quality (MM3) and quinoa – organic quality (MM4) sourdoughs were obtained from Böcker (Minden, Germany); rice flour was purchased from La Meta (Lerida, Spain); bran rice was provided by Arrocera Antonio Tomás; dry yeast by DHW Europa; salt by local market; and hydroxypropylmethylcellulose (HPMC) Methocel K4M by Dow Wolf Cellulosics GmbH, USA.

Baking procedure

Control breads (PC) were prepared using 90% rice flour and 10% rice bran, 110% water, 1.5% salt, 3% yeast and 1% HPMC. The samples were prepared by adding 5% sourdough. To keep a constant flour/bran ratio, the percentage of added sourdough to the samples was replaced by the equal amount of flour/bran mixture in control dough formulation. Mixing was carried out in a Vimar 18 - 2 spiral kneader (Barcelona, Spain) at speed 1 for 5 minutes. The batter was scaled to 100 g into baking tins and placed into a proofer (Lezo, Spain) for 30 min at 35 °C and a relative humidity of 85%. The breads were baked for 35 min at 180 °C in a Eurofours oven (Gommegnies, France), injecting steam for the first 5 seconds. After

baking, bread loaves were removed from the tins and cooled at room temperature for 1 h. Baking was performed on 2 different days (2 independent trials) and 3 loaves were prepared for each bread type at each baking trial.

Bread physicochemical analysis

Bread moisture content was determined following the ICC Standard Methods 110/1 (ICC, 1994). Weight loss during baking was assessed by weighing the pans before and after baking. Bread volume was determined by the rapeseed displacement method. The specific volume was calculated as the ratio between the volume of the bread and its weight. Water activity of samples was measured using an Aqua Lab Series 3 (Decagon Devices, Pullman, USA) at 22 °C. The pH of the crumbs was measured using a suspension of crumb according to a standard method (Getreideforschung, 1954). The total titratable acidity (TTA) of bread samples was also determined. A suspension of 10 g of sample in 90 mL of water was homogenized together using a Polytron Ultraturrax homogenizer IKA-T18 (IKA works, Wilmington, USA) for 0.5 min at 14,000 rpm and titrated with 0.1 N NaOH to pH 8.5. These measurements were carried out in three breads of each batch.

The coulor of the bread crumbs was measured at three diverse locations by using a Minolta colourimeter (Chromameter CR-400/410. Konica Minolta. Japan) after standardization with a white calibration plate (L^* = 96:9; a^* = -0.04; b^* = 1.84). The colour was recorded using CIE-$L^*a^*b^*$ uniform color space (CIE-Lab) where L^* indicates lightness, a^* indicates hue on a green (-) to red (+) axis, and b^* indicates hue on a blue (-) to yellow (+) axis. Data from three slices per bread were averaged.

An image analysis system was used to analyze the bread crumb structure. Images of the GF bread slice (10-mm thick) were captured using a flatbed scanner equipped with the software HP PrecisoScan Pro version 3.1 (HP scanjet G3110, Hewlett–Packard, USA). The images were scanned full scale at 600 pixels per inch, analyzed in levels of gray (eight bits, readout 0 – 255) and captured in tiff format for each measurement. A 15 x 15 mm square field of view (FOV) was evaluated for each image. This FOV captured the majority of the crumb area of each slice. The image analysis was carried out using Image J software (UTHSCSA Image Tool software). Threshold was assessed applying the Otsu's algorithm according to Gonzales-Barron and Butler (2006). Data derived from the crumb structure analysis included: number of cells or alveoli, average cells area and cell circularity, and were used for comparing purposes among different samples.

Crumb hardness, chewiness, cohesiveness, springiness and resilience were evaluated using a Texture Profile Analyser (TA.XT.Plus Stable Microsistems, UK) with a 5 kg load cell, which compresses the bread crumb with a 25 mm aluminum cylindrical probe. Bread samples were sliced into 10 mm slices and analyzed with a test speed of 2 mm/s and a trigger force of 5 g to compress the middle of the bread crumb to 50% of its original height at a crosshead speed of 1 mm/s and applying 30 s gap between compressions. The measurement with the various parameters was conducted on the day of baking.

Chemical composition

The chemical composition of the samples was determined according to ICC corresponding standard methods (ICC, 1994) namely, fat (ICC 136), proteins (N x 6.25) (ICC 105/2) and ash (ICC 104/1). Total carbohydrates were determined by difference from 100 g minus the sum of moisture content, protein, ash and fat expressed in grams/100 g FAO (2003). For the estimation of dietary fibre, samples were finally powdered to pass through a sieve of 250 µm. Total dietary fibre (TDF), insoluble dietary fibre (IDF) and soluble dietary fibre (SDF) contents were determined following the AACC method (AACC.32-07, 1995). Determinations were done in duplicate for obtaining mean values.

Statistical analysis

The data reported are the mean of replicates and expressed as a mean ± standard deviation. Statistical analyses were carried out with Fisher's least significant differences test with a significance level of 0.05. Pearson correlation coefficient (r) and p-value were used to indicate correlations and their significance using Statgraphics Centurion XV software (Bitstream, Cambridge, N). The correlation coefficient was classified in different levels of correlation: perfect ($|r| = 1.0$), strong ($0.80 \leq |r| \leq 1.0$), moderate ($0.50 \leq |r| \leq 0.80$), weak ($0.10 \leq |r| \leq 0.50$), and very weak (almost none) correlation ($|r| \leq 0.10$).

RESULTS AND DISCUSSION

The effect of sourdough on the quality parameters of gluten free breads based on rice flour

To determine the role of the different sourdoughs in GF breads, several commercial dehydrated sourdoughs from different sources were selected and a 90:10 mixture of rice flour: rice bran was used as the formulation bases.

The statistical analysis indicated that the sourdough addition significantly influenced the weight loss of breads (p <0.001), but did not prompt a significant effect on the specific volume and water activity parameters (**Table 1**). GF samples displayed specific volume values that ranged from 1.47 to 1.78 mL/g. These results are in agreement with literature (Gujral and Rosell, 2004a). The moisture content values obtained for control and sourdough samples showed values of 41.16 – 43.64%. The moisture content values obtained in this study are rather high compared to those found in different commercial GF breads marketed in Spain (Matos and Rosell, 2011). Similar trend was observed in water activity parameter. Likely, the moisture retention, as well as the high water activity might be attributed to the high water holding capacity of the incorporated hydrocolloids and the addition of rice bran to the formulation, as suggested by Wang et al. (2002) and Guarda et al. (2004). The incorporation of sourdough significantly affected the weight loss parameter. Samples MM3 and MM4 did not show a significant

difference with the PC bread, while MM1 and MM2 samples had a significantly lower weight loss than PC.

As expected, sourdough addition resulted in more acidic crumbs and an increase in TTA value (Table 1), showing a strong negative correlation between both parameters (r = -08444, p = 0.0021). Control bread displayed the highest pH followed by bread obtained from MM4> MM1 and MM3> MM2. The highest TTA value was noted in the MM2 bread followed by MM3, MM1, MM4 and PC bread. These results confirm the formation of different proportions of metabolites in the different sourdough used (Arendt et al., 2007).

Results from the crumb colour parameters are presented in **Table 1**. The a^* and b^* values for crumb colour showed significant (p < 0.05) differences among the different sourdough added breads, but no difference was observed for L^* value. Nevertheless, lightness of bread crumbs was higher than those reported in the literature for rice flour GF breads, likely due to the rice bran added (Phimolsiripol et al., 2012). Regarding a^* and b^* values, all samples showed positive values, indicating hue on red and yellow axis for all samples evaluated. The obtained results were similar to those reported in the literature for GF breads based on rice flour with bran rice added (Phimolsiripol et al., 2012). In addition, great variation derived from the different sourdough added in each formulation was observed. An increased of a^* value was observed in all samples, except in the case of MM1 sample. b^* parameter also maintained a similar pattern, while it remained constant for MM3 and MM4 samples. The results suggest that developed colour was the result of the interaction of ingredients, the addition of 5% of sourdough being enough to influence these parameters.

Table 1 Different quality characteristics of the control and sourdough samples

	Specific Volume (mL/g)	Weight loss (g)	Moisture (%)	Water activity	pH	TTA (mL)	L*	a*	b*
PC	1.72 ± 0.06	29.09 ± 0.08^{c}	41.16 ± 1.15	0.968 ± 0.000	6.09 ± 0.03^{d}	3.90 ± 0.05^{a}	73.30 ± 1.63	0.44 ± 0,04^{b}	19.09 ± 0.26^{a}
MM1	1.47 ± 0.16	25.88 ± 1.28^{ab}	43.64 ± 0.28	0.970 ± 0.001	5.70 ± 0.04^{b}	4.97 ± 0.05^{b}	71.95 ± 0.53	0.25 ± 0,01^{a}	19.35 ± 0.36a^{b}
MM2	1.67 ± 0.01	25.31 ± 0.99^{a}	42.58 ± 0.24	0.968 ± 0.002	5.43 ± 0.02^{a}	6.30 ± 0.14^{c}	70.75 ± 0.36	0.56 ± 0,01^{c}	18.89 ± 0.34^{a}
MM3	1.58 ± 0.00	27.38 ± 0.44^{bc}	42.20 ± 0.21	0.968 ± 0.002	5.64 ± 0.01^{b}	6.37 ± 0.14^{c}	70.17 ± 2.30	1.44 ± 0,06^{e}	20.02 ± 0.18^{bc}
MM4	1.78 ± 0.09	28.97 ± 0.33^{c}	42.84 ± 1.07	0.969 ± 0.007	5.92 ± 0.02^{c}	4.77 ± 0.24^{b}	72.53 ± 1.38	0.74 ± 0,06^{d}	20.65 ± 0.53^{c}
P-value MM	0.0848	0.0128	0.1284	0.9784	0.0000	0.0000	0.3076	0.0000	0.0196

Parameters from the image analysis of the control and sourdough bread crumbs (**Figure 1**) displayed a large variability among crumb bread structures (**Table 2**). PC, MM3 and MM4 samples exhibited similar cells or alveoli number value, whereas lower values for alveoli number were seen for MM1 and MM2. Moore et al. (2006) reported values of this parameter in GF breads ranged from 15 to 20 cells/cm^2. Nevertheless, our results showed high values for this parameter. McCarthy et al. (2005) observed that the number of cells/cm^2 increases as HPMC and water increase. In this study, no direct correlation between the cell number and bread moisture was found. However, the weight loss displayed a strong positive correlation with this parameter (r = 0.9977, p = 0.0432). In contrast, samples MM1 and MM2 showed lower average cell area (mm^2) than the other samples, likely due

to the coalescence of many gas cells into one large cell. No significant differences were observed for circularity values. Sample crumbs had circularity values ranging from 0.60 to 0.65, indicating a fairly uniform shape.

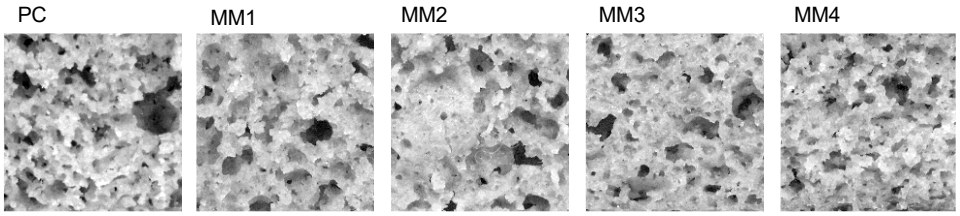

Figure 1 Digital images of control and sourdough bread crumb samples (15 x 15 mm field of view of breads)

Crumb hardness, chewiness, cohesiveness, springiness and resilience parameters determine the bread acceptability in consumers (Matos and Rosell, 2011). Sourdough addition had a significant effect on hardness and chewiness parameters (**Table 2**), but not on the cohesiveness, springiness and resilience parameters. The hardness obtained for control sample showed values of 4.88 ± 0.34 N. GF products are mainly composed of carbohydrates, resulting in crumbs with a high hardness. Matos and Rosell (2012) reported hardness values of GFB crumb higher than 10N. However, the hardness values observed for the control sample in this study showed lower values that those reported in the literature. Likely, low hardness might be ascribed to rice bran added, as suggested by Phimolsiripol et al. (2012). This value was significantly increased after the MM1 and MM2 sourdough addition. Hayman et al. (1998) related the coalescence of gas cells during the early stages of cooking with excessive hardening of cell walls. On the other hand, Moroni et al. (2011) observed a strengthening of the starch gel after the acidification of the buckwheat doughs. The pH results obtained, as well as the image analysis of the crumbs suggest that both phenomena could be occurring in MM1 and MM2 samples, which could explain the increase in hardness of the crumbs.

Table 2 Analysis of crumb microstructure and texture Analysis of crumb microstructure and texture

	Number of alveoli/cm ^{2}	Total area alveoli mm^2/cm^2	Hardness (N)	Springiness	Chewiness (N)	Cohesiveness	Resilience
PC	32 ± 5 ^{c}	0.900 ± 0. 128 ^{a}	4.88 ± 0.34^{a}	0.92 ± 0.01	3.13 ± 0.23 ^{a}	0.71 ± 0.02	0.33 ± 0.01
MM1	24 ± 6 ^{ab}	1.127 ± 0. 156 ^{b}	8.47 ± 0.4 6^{c}	0.95 ± 0.01	5.47 ± 0.27 ^{c}	0.68 ± 0.01	0.33 ± 0.01
MM2	21 ± 3 ^{a}	1.189 ± 0. 086 ^{b}	7.56 ± 0.38 ^{bc}	0.94 ± 0.02	5.08 ± 0.19 ^{c}	0.71 ± 0.02	0.34 ± 0.02
MM3	29 ± 3 ^{bc}	0.818 ± 0. 077 ^{a}	7.20 ± 1.26 $^{a-c}$	0.96 ± 0.01	4.82 ± 0.72 ^{bc}	0.69 ± 0.01	0.34 ± 0.01
MM4	28 ± 6 $^{a-c}$	0.830 ± 0.036 ^{a}	5.40 ± 0.82^{ab}	0.97 ± 0.01	3.71 ± 0.28^{ab}	0.72 ± 0.05	0.37 ± 0.04
***P*-value MM**	0.0400	0.0064	0.0388	0.4011	0.0388	0.4961	0.4327

Chewiness characterizes the time required masticating a bread piece prior to swallow. Low chewing values means easy break of the bread in the mouth (Matos and Rosell, 2011). Chewiness varied from 3.13 to 5.47 N, observing a significant effect with the sourdough addition. Following the trends displayed up to the

moment, PC and MM4 followed by MM3 samples displayed the lowest values for this parameter, while MM2 and MM1 showed the highest one (**Table 2**).
Regarding cohesiveness, springiness and resilience, no significant difference was observed. The extent to which a material can be deformed before it ruptures, reflecting the internal cohesion of the material is cohesiveness. High cohesiveness is desirable in breads because it forms a bolus rather than disintegrates during mastication, while low cohesiveness means bread has an increased susceptibility to fracture or crumble (Onyango et al., 2011). A 0.70 value for this parameter was observed for all the samples (**Table 2**). Similar results about the impact of sourdough on buckwheat breads were reported by Moroni et al. (2011) in their study. In agreement with data reported in the literature (Matos and Rosell, 2012), samples showed springiness values around 0.95. The low springiness value indicates brittleness and reflects the tendency of bread to crumble when sliced (McCarthy et al., 2005). The resilience is related to the capacity of the crumb to adapt to the compression and recovery. The results obtained in this study were 0.33 for this parameter.

The effect of sourdough on the chemical composition of gluten free breads based on rice flour

The chemical composition of control and sourdough breads is summarized in **Table 3**. No significant difference in chemical composition between control and sourdough breads ($p > 0.05$) was observed, with the exception of dietary fibre values (**Table 3**). As expected, the major component of the different samples were carbohydrates (Matos and Rosell, 2011), while the minor component were the minerals. The results suggest that sourdough did not significantly influence the nutritional composition parameters. However, GF breads obtained showed higher nutritional contribution than GF breads with complex formulations (Matos and Rosell, 2011). A plausible explanation for the high nutritional contribution would be the rice bran used in the recipe. De Delahaye and Peña (2009) reported that the rice bran added in wheat-based formulations provides a contribution of 16% protein, 8.5% minerals and 20% fat.

Table 3 Chemical composition, expressed as g/100 g of wet matter, of the control and sourdough breads

	Protein (%)	*Ash (%)*	*Fat (%)*	*Carbohydrate (%)*	*Total dietary fibre (%)*	*Insoluble dietary fibre (%)*	*Soluble dietary fibre (%)*
PC	5.33 ± 0.10	1.02 ± 0.02	1.38 ± 0.22	51.09 ± 0.78	0.70 ± 0.11^{a}	0.21 ± 0.09	0.49 ± 0.02^{a}
MM1	5.17 ± 0.05	1.06 ± 0.01	1.16 ± 0.18	48.94 ± 0.53	2.19 ± 0.13^{c}	0.67 ± 0.15	1.53 ± 0.02^{d}
MM2	5.21 ± 0.03	1.07 ± 0.01	1.22 ± 0.27	49.77 ± 0.02	1.74 ± 0.19^{b}	0.53 ± 0.14	1.21 ± 0.05^{c}
MM3	5.42 ± 0.03	1.01 ± 0.01	1.31 ± 0.09	50.13 ± 0.16	1.66 ± 0.15^{b}	0.59 ± 0.21	1.07 ± 0.06^{b}
MM4	5.33 ± 0.19	1.04 ± 0.02	1.19 ± 0.03	49.62 ± 0.82	1.23 ± 0.10^{b}	0.51 ± 0.17	0.72 ± 0.07^{b}
P*-value *MM	0.2387	0.0642	0.7400	0.0844	0.0014	0.1798	0.0000

The fibre composition of the different breads revealed the influence of the addition of the different sourdoughs (**Table 3**). TDF ranged from 0.70 to 2.19 g/100 g,

showing that sourdough breads contained more of dietary fibre than PC bread. That effect was due to the SDF content, which resulted in an increase of the TDF content. In general, all bread samples showed higher amount of SDF than IDF fraction. A direct correlation was observed with the composition of the sourdoughs described by the supplier's datasheets. Thus, the commercial sourdoughs contain SDF in their composition, which might improve the content of SDF, contributing to the increase in the level of TDF.

CONCLUSIONS

The results obtained allow concluding that the technological characteristics and nutritional properties of GF breads are notably influenced by the sourdough addition. The commercial sourdough addition decreased the pH of the crumb of the breads and this effect was dependent on the flour used in the manufacture of the sourdough. The highest acidification was obtained with MM2 obtained from rice flour. The texture of the bread crumbs was affected after the commercial sourdough addition, observing an increase in hardness caused by the addition of MM1 and MM2 (both from cereal flours). Nutritionally, the sourdoughs did not modify the chemical composition of the GF breads, except for the soluble fibre content that increased with the presence of sourdough, and consequently the amount of total fibre. This increase was attributed to the possible presence of compounds in the sourdough with soluble fibre functionality.

The overall analysis of the results showed a remarkable discrimination between the control and sourdough samples. The greater effect was caused by MM2 sourdough from rice flour. Therefore, commercial sourdoughs are a suitable alternative to modify the technological characteristics of GF breads, obtaining more acidic products and modified crumb textures. The commercial sourdoughs studied contributed to increase the soluble and total fibre content of the GF breads.

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INVESTIGATION OF LONG TERM QUALITY STABILITY IN TWO WINTER WHEAT VARIETIES (JUBILEJNAJA 50 AND GK ÖTHALOM) IN HUNGARY

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SUMMARY
The quality of winter wheat means different things; growers generally look at the yield, while millers look at the other quality indicators. And quality stability is a very important parameter for millers.
Therefore, during the qualifying stage, we need varieties to which we can later relate, taking both yields and quality parameters into account. At the same time, it is not insignificant how the quality in each crop year varies.
Our aim was to observe the quality stability of two genotypes of winter wheat (GK Öthalom and Jubilejnaja 50) at different locations, between 1978 and 2009 in Hungary. Nine cultivation years were observed as the basis for this study. For the comparison purposes, the parameters we examined were valorigraphic value, water absorption, gluten content, and falling number, the quality parameters that were available during each year. The following tools were used for the statistical analysis: statistical program SPSS 22.0, histogram, boxplot, and analysis of variance. The statistical analysis has shown a significant effect on the examined quality parameters, which is probably influenced by the weather conditions of the crop year.

Keywords: winter wheat, stability, quality parameters

INTRODUCTION

Winter wheat is used in food industry, but also great amounts of winter wheat are used as fodder in Hungary. Study of bread making quality of winter wheat and the interpretation of the results have been in the focus in the last decades for researchers and other specialists, too. Namely, all of the participant of the product of wheat path are interested in good and stable quality, but not the same way (Kent, 1994; Pepó et al., 2006; Sipos et al., 2007; Tanács, 2007; Varga et al., 2007; Diósi et al., 2015). Nowadays, farmers are increasingly focusing on fullfilling the specific quality needs of users, in addition the quantitative parameters.

We can state that the bread making quality is a genetically determined attribution of the given variety. Bread making quality depends on environmental conditions (especially the amount of precipitation and the temperature) and the agricultural techniques (Győri, 2008; Pepó, 2010). However, we can not improve the quality parameters significantly (Szentpétery et al., 1995). So apart from extreme cases, three factors have influence on the baking quality of winter wheat as follows: variety 21%, ecological conditions 32% and agricultural technology 47% (Pepó and Győri, 1997).

Quality of wheat which is defined through the factors that influence the flour-factory and bakery quality are mostly determined by the habitat's features (Ágoston, 2006). Stability of quality of winter wheat is one of the most important factors for baking and milling industry too. Both of them require constant quality. Stability of quality may vary from environment to environment, but genotypes with a small contribution to the genotype by environment variance are more stable than those with a larger contribution (Becker and Leon, 1988; Baric et al., 2004). So genotypes, environment and their interaction have influence on the stability of quality and different quality traits. Stability of a genotype is very important, it should not change the mean values of the traits. Thus, the most important goal for breeders and end-users is to find the genotype with stable and good quality (Baric et al., 2004).

MATERIALS AND METHODS

The winter wheat samples used for the investigations were from several experimental sites and years, presented in **Table 1**.

Over the last few decades, we have examined numerous varieties, out of which the results of two varieties are presented in this paper, GK Öthalom and Jubilejnaja 50. These varieties have been cultivated for several years and in cultivated areas for more reliable impacts. We examined nineteen different experimental sites, as can be seen in **Table 1**.

These wheat samples were mostly taken from arable land where agrotechnical experiments were carried out to determine the quantitative and qualitative parameters of winter wheat by different sites.

Laboratory analysis were carried out in the Central Laboratory of the University of Debrecen, Centre of Agricultural Sciences. Flour was produced by a laboratory mill QC:109 Labor MIM (Budapest, Hungary) according to the MSZ 6367-9:1989. The examined parameters were baking value, determined by Farinograph (according to the MSZ ISO 5530-1:2003 and MSZ 6369-6:1988) and water absorption (AACC 54-21), falling number (MSZ ISO 3093:1995) and wet gluten content (MSZ ISO 5531:1993).

Statistical analyses of experimental results were made using statistical program package SPSS 22.0.

Table 1 Presentation of the cropping year, variety and experimental site

Year	Winter wheat variety	Experimental site	Year	Winter wheat variety	Experimental sites
1978	Jubilejnaja 50	Tiszaföldvár	2003	Jubilejnaja 50	Táplánszentkereszt, Siófok, Szeged, Mezőhegyes, Székkutas, Kompolt, Tordas, Mosonmagyaróvár, Bóly, Karcag
1981	Jubilejnaja 50	Tiszaföldvár	2004	GK Öthalom	Nádudvar, Röjtökmuzsaj, Gyöngyös, Felsőszentiván, Mezőhegyes, Abaújszántó, Debrecen
1982	Jubilejnaja 50	Tiszaföldvár	2004	Jubilejnaja 50	Röjtökmuzsaj, Gyöngyös, Felsőszentiván, Mezőhegyes, Dalmand, Abaújszántó, Bábolna, Debrecen
1983	Jubilejnaja 50	Tiszaföldvár	2005	GK Öthalom	Nádudvar
1984	Jubilejnaja 50	Tiszaföldvár	2006	GK Öthalom	Nádudvar
1986	GK Öthalom and Jubilejnaja 50	Tiszaföldvár	2007	GK Öthalom	Nádudvar
1988	GK Öthalom and Jubilejnaja 50	Tiszaföldvár	2008	GK Öthalom	Nádudvar
2003	GK Öthalom	Nádudvar	2009	GK Öthalom	Nádudvar

RESULTS AND DISCUSSION

The baking value (determined by Farinograph) is a complex quality indicator, which provides possibility to analyze the protein's quantity, quality and the protein fractions altogether (Balogh et al., 2006). In Hungary, the evaluation of the farinograph diagram is not the same as in the international qualification standards. In Hungary, one of the evaluated parameters is the baking value, which is calculated from the area between the maximum resistance line and the midline (Sipos, 2013).

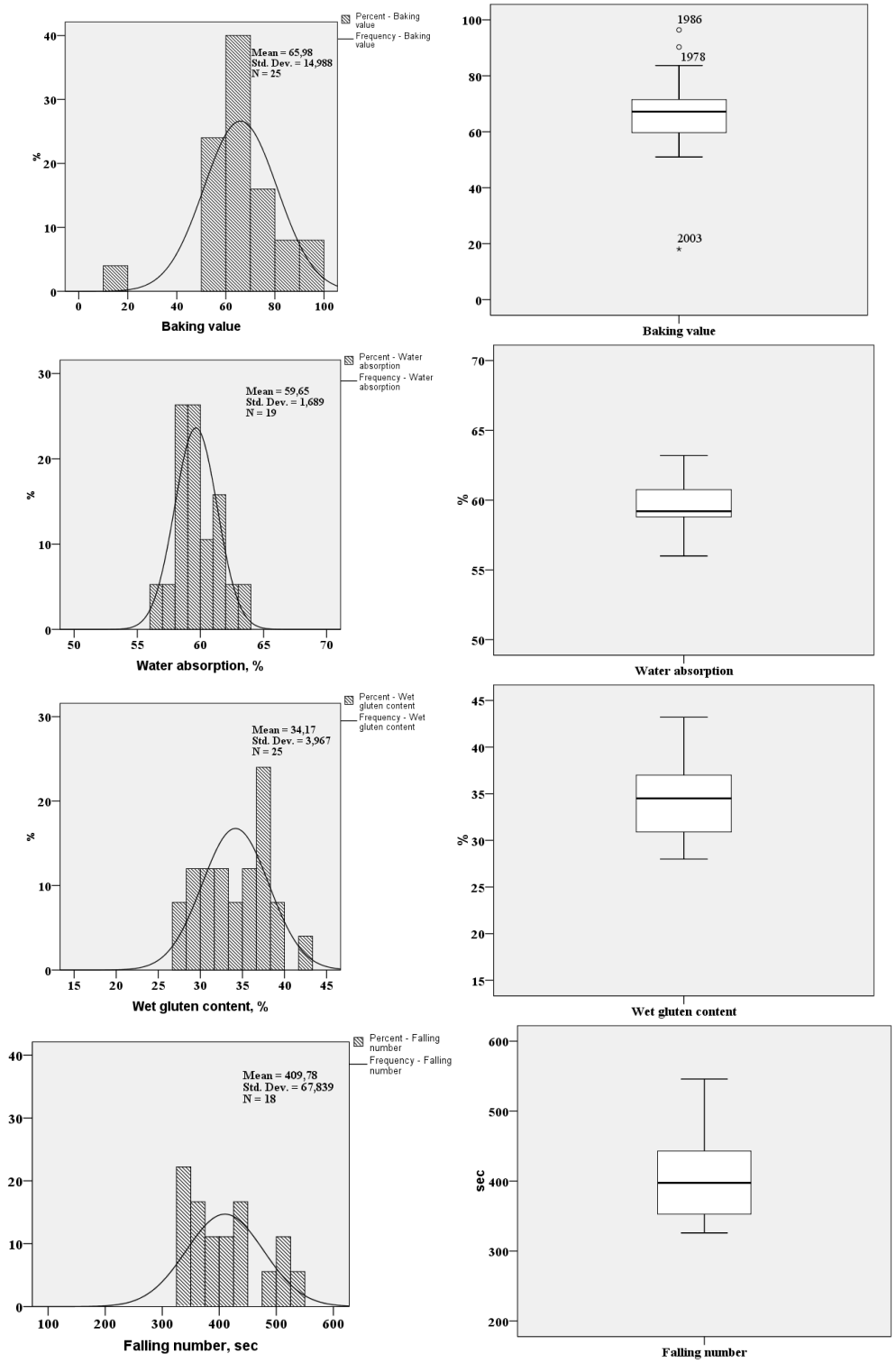

Figure 1 The results of the examined quality parameters by Jubilejnaja 50 variety

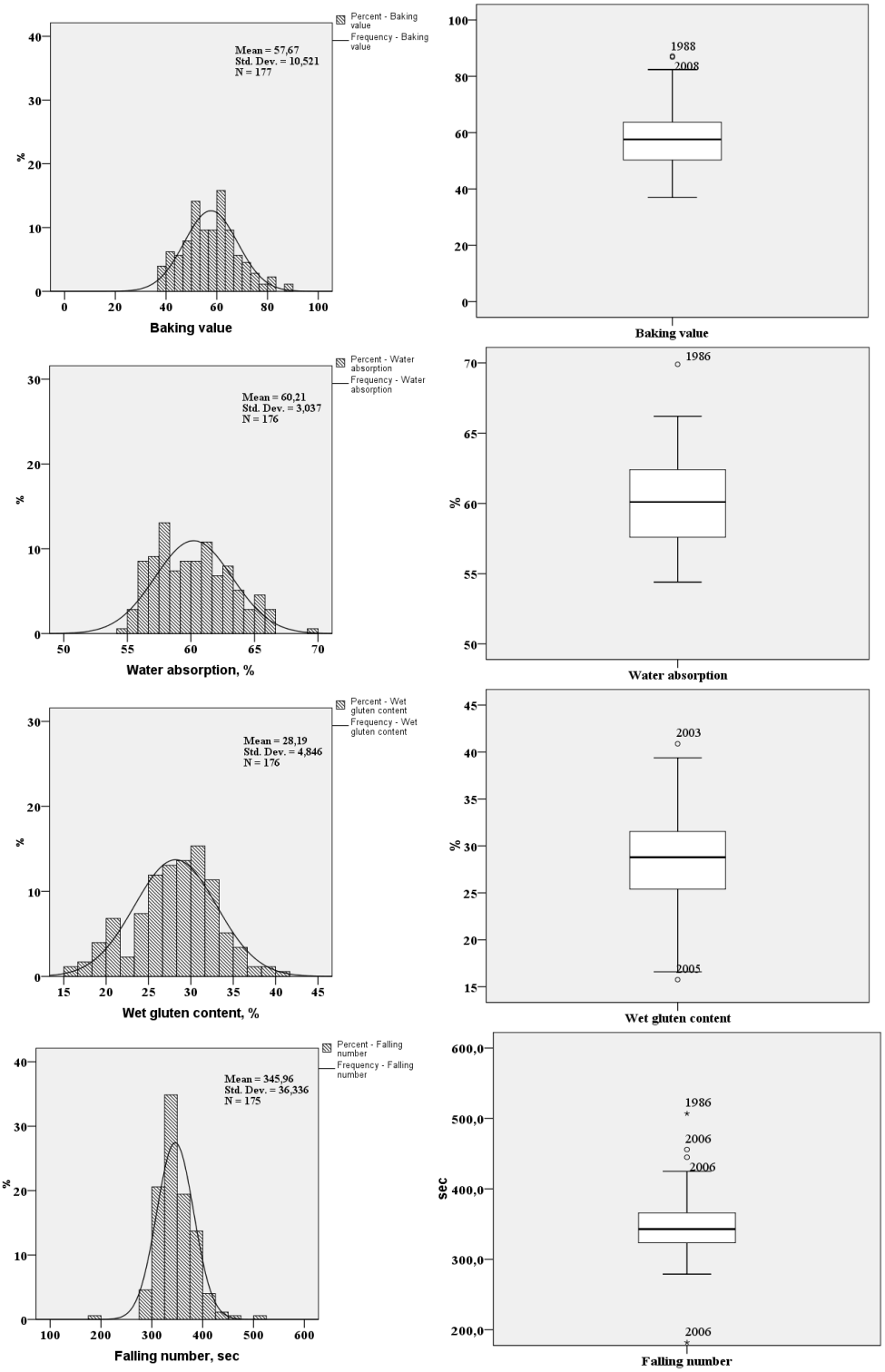

Figure 2 The results of the examined quality parameters by GK Öthalom variety

Based on the comparison of the study results, the average baking value (determined by Farinograph) of the Jubilejnaja 50 varieties was 65.98 ± 14.99, and GK Öthalom 57.67 ± 10.52 in the examined years (**Figures 1** and **2**). Previous variety, as shown by the boxplot, three outliers in 1978, 1986 and 2003 and in the case for the latter variety, two outliers in 1988 and 2008 were observed, which is most likely to be attributed to the weather conditions. Apart from that, our test results follow a normal distribution as shown on the histogram.

In the examined period, the average water absorption was 60.21 ± 3.04%, by GK Öthalom and 59.65 ± 1.69%, by the Jubilejnaja 50 variety (**Figure 1** and **2**). Outliers were found in one case in the GK Öthalom variety in 1986. The test results are also normally distributed in this case.

The wet gluten content is one of the most important quality parameters of winter wheat; in the examined years, the average wet gluten content of GK Öthalom variety was 28.19 ± 4.85%, and 34.17 ± 3.97% by the other variety, which reached a premium category, compared to the Hungarian wheat standard (MSZ 6383:2012) (**Figures 1** and **2**). Examining the results of the boxplot for this latter variety, no outlier could be determined, while in the case of GK Öthalom, the 2003 and 2005 values are already as outliers on the chart.

From the value of the falling number, the quality of flour products can be inferred. The value of falling number gives us information about the activity of *α*-amylase enzyme. It is determined by the wheat variety, but basically the weather conditions at harvest determine its value. High falling number indicates flours with a low *α*-amylase activity. For the GK Öthalom variety, 345.96 sec ± 36.34 sec, and for Jubilejnaja 50 varieties 409.78 sec ± 67.84 sec values were determined in the average of the examined years. Looking at the boxplot, outliers and extreme outstanding values can be observed for GK Öthalom in 1986 and 2006 (**Figure 1** and **2**).

The single-factor analysis of variance revealed that the crop year had a significant effect on each of the four characteristic parameters examined for the winter wheat variety GK Öthalom. The results of the variance analysis proved significant difference (p = 0.1%), while in the other examined variety, Jubilejnaja 50, the crop year effect was significant in the case of baking value (determined by Farinograph) and falling number. In the case of the previous, quality parameters were found at the p = 5% level, while for the falling number significant differences at the p = 1% level were found.

CONCLUSIONS

The quality of winter wheat means different things for different users, but we can conclude that quality stability is equally important for all of them.

This study assessed the performance of a set of winter wheat genotypes (GK Öthalom and Jubilejnaja 50) at different sites in Hungary with regard to quality traits. Nine vegetation years were studied from 1978 to 2009. The analyzed quality

parameters were the baking value (determined by Farinograph), water absorption, wet gluten content and falling number.

Based on the statistical analysis, we can state that some years show outstanding values of the examined quality parameters. In the case of Jubilejnana 50, outliers were observed only in the baking values. The other analyzed quality parameters show no outliers. Examining the results of the GK Öthalom, there were outliers and outstanding values for each of the examined parameters, but in different years. The data show normal distribution in each year.

Observing the single-factor analysis of variance we come to the conclusion that the crop year had significant effect on the examined quality traits.

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QUALITY ASSURANCE OF BREAD AND BAKERY PASTRIES IN PUBLIC INSTITUTIONS ACCORDING TO THE LAW ON PUBLIC PROCUREMENT

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SUMMARY
Public institutions, such as kindergartens, are committed to ordering food according to the Slovenian Law on public procurement (ZJN-3), which is compliant with EU legislation. There are many bread manufacturers in the market, therefore contracting authority have the challenging task to provide a diverse and high-quality bread and bakery pastries through the process of public procurement. Each buyer has the option of ordering food through the so-called "short chain", which allows the ordering of locally produced cereals, bread from the organic and integrated production. The Ministry of Health of the Republic of Slovenia issued a "Guide to Quality Standards of Food in Public Ordering for Educational Institutions" which supports the ordering process. In addition to quality requirements, the buyer divides the tender documentation into several groups and subgroups (e.g. Bread, Bakery pastries and Bread of organic production). The bakery industry is aware that in kindergartens a high-quality bread and bakery pastries are required, therefore they already offer products with reduced salt, sugars, fats, products without trans-fatty acids and gluten. Taking into account the appropriate purchasing specifications and good knowledge of legislation, with respect to public procurement law-related orders, children in kindergartens can be provided with a high-quality bread and bakery pastries.

Keywords: high quality bread and bakery pastries, public institutions, public procurement, quality assurance, quality schemes

INTRODUCTION

Balanced, recommended healthy nutrition, eating habits and lifestyle are important factors that have a strong impact on the child's health and well-being. A well-planned and organized diet in educational institutions, such as in kindergartens, is crucial for educating children about the importance of eating in the life of an individual. Nourishment of children in most kindergartens includes four meals a

day, breakfast, a morning snack, lunch and an afternoon snack, which cover over 70% of their whole-day needs for the energy input. The menus are always assembled to include foods that are diverse in colour, their shape and texture encourage children to enjoy their food.

Bread and bakery pastries are main sources of carbohydrates included daily in the children's menu. Daily, at least two different types of bread or bakery pastries are offered to children. Kindergartens serve a very wide selection of different types of bread and bakery pastries.

According to the available data from the Chamber of Agricultural and Food Companies at the Chamber of Commerce and Industry of Slovenia, about 332 companies deal with bakery, there are around 800 more companies, including craftsmen and sole proprietors, also taking into account those who have bakery activity listed as a secondary activity, which puts the number at around 1600. Due to the wide range of the baked goods in the market, the contracting authorities have a demanding task to set precise quality criteria for each type of bread and bakery pastry.

On the state lavel, public institutions, such as schools, kindrergartens and hospitals, together with the rest of the public sector, are important consumers and spend more than 120 milions EUR per year on food products. They spend as much as 120 million EUR per year on food.

DISCUSSION

Educational institutions, such as public institutes, are obliged to order food by the Law on public procurement (ZJN-3), which is compliant with the European legislation. The law states that the contracting authority may file an order on the basis of the lowest price or the most economically advantageous offer, using the criteria of food quality schemes. The order must also be in compliance with the Regulation on Public Green Food Procurement (ZJN-3 91/2015).

Law on public procurement (ZJN-3) requires a preliminary market check. Public procurement usually starts with the decision to initiate the procedure. The source and amount of funds intended for the execution of a public procurement must be indicated. Direct and indirect budget users must comply with the rules governing public finances in connection with the initiation and execution of the procurement procedure and the execution of a public procurement. The contracting authority may appoint an expert commission to carry out all, or a part of the procedure. For the execution or a decision-making process in public procurement procedures, another contracting authority may be authorized.

There is also the possibility of the so-called short-chains, which have many advantages for producers, farmers and consumers, such as ordering locally-produced cereals and bread from organically-produced flour types. There is a decree within the Law on public procurement (ZJN-3), which determines the ordering of a minimum proportion of organic foods, so those produced in Slovenia

are favoured. Among them are grain and cereal products, as well as organic bread and bakery pastries.

The contracting authority must, if possible and economically acceptable, divide the public procurement into smaller segments. The contracting authority has the option of ordering under the so-called short chains and may award a public procurement for individual segments without applying the procedures of this Act if the estimated value of the excluded segments is less than EUR 80000 without VAT, and the total value of excluded goods may not exceed 20% of the total value of all segments. The contracting authority chooses the best offer according to the set criteria, which are determined on the basis of: offer value, requirements according to the quality scheme, organic bread and bakery pastries and packaging (ZJN-3 91/2015).

The contracting authority has the opportunity to include food that is in the Quality Scheme. The scheme includes foods produced in an integrated way, seasonal food and ecologically produced food, farm goodies, guaranteed traditional specialities, food with designated origin and designated geographical indication. The quality schemes are defined in the Agriculture Act.

European quality schemes are regulated with in the European decree. A product that is produced according to the principles of a particular quality scheme has a special character, which is determined by the method of production, the influence of the geographical area in which the product is produced or processed, and also by the traditional production methods. Quality schemes are available to all manufacturers. Anyone involved in the quality scheme must comply with clearly defined conditions, which are set by the law. They are in the form of the production (organic production, delicacies from our farms and an integrated production) or in the product specification (designation of origin, geographical indication, guaranteed traditional specialty and higher quality).

As an additional requirement, we usually also require quality signs such as:

- QUALITY SCHEMES IN THE REPUBLIC OF SLOVENIA: guaranteed traditional specialty, geographical indication, integrated production, designation of origin, ecological sign, higher quality, natural mineral water;
- QUALITY SCHEMES IN THE EU: guaranteed traditional specialty, geographical indication, designation of origin.

Figure 1 Quality signs in the republic of Slovenia (web 2)

Protected designation of origin - all stages of the production and processing of the agricultural product must be carried out in a specific geographical area.
Protected geographical indication - at least one production phase of the agricultural product must be carried out in a specific geographical area.
Guaranteed traditional specialty - production is not limited to a specific geographical area, which means that products produced according to the specification can be produced throughout the territory of the Republic of Slovenia and the EU (in case of the European protection). These products are produced either in the traditional way, from traditional raw materials or following a traditional recipe.
Higher quality - the agricultural produce or foodstuff differs positively in its characteristics from other similar agricultural products and foodstuffs.
Organic production - agricultural produce or food is produced and processed according to natural methods and procedures.
Integrated production - the agricultural product is produced with methods that use the regulated authorized agro-technical measures.
Goodies from our farms - agricultural products and foodstuffs are produced or processed on the farm according to recipes typical of farm products and using the bulk of their own raw materials or materials from the local environment.
The Ministry of the Environment has appointed three certification bodies, namely:

- Bureau Veritas d.o.o.;
- Institute for Control and Certification in Agriculture and Forestry (KON-CERT);
- Institute for Control and Certification of the University of Maribor (IKC UM).

In all three bodies, the contracting authority has the option of verifying the suitability of the certificate required for the selection of the higher quality bread.
For the successful implementation of the public procurement, the contracting authorities in educational institutions also have a "Guide with quality criteria for food in Educational Institutions" issued by the Ministry of Health of the Republic of Slovenia (web 1).

Example of the quality requirements are bread and bakery pastries. The bread is made from flour of various types, water, yeast and salt. As defined by the rules, the additional ingredients for bread, such as other food and additives, may also be added. All products must be labelled in accordance with the regulations. The loaves must have the correct shape. Bread must be properly baked, with a nicely baked crust and not burned. The taste and smell must be pleasant and typical for each type of bread, and the texture must also be appropriate. Since bread, pastries and other types of bakery products are the most important source of salt in the diet of Slovenians, it is necessary to choose less salty products.

WHITE BREAD

Table 1 Basic description: White wheat bread (web 1)

Quality requirements:	Made from wheat white flour with ash from 0.45% to 0.55%, a portion of wheat flour can be replaced by the flour of other cereals according to a percentage permitted by the rulebook; basic and additional raw materials, the content of additives must comply with the requirements of the Regulation; preservatives are not allowed; appearance, taste, smell, colour and consistency must be typical for white wheat bread.
Packaging and quantity:	Packed in an appropriate packaging (foil) according to customer's requirements.
Storage and transport of the product:	No special transport needed, protected from external influences.

BREAD, WITH POTATOES

Table 2 Basic description: Bread with potatoes (web 1)

Quality requirements:	Made from wheat or other flours and with the addition of a minimum of 8% potato flour or potato flakes. All basic and additional raw materials, the content of additives, must comply with the requirements of the Regulation; preservatives are not allowed; appearance, taste, smell, colour and consistency must betypical for bread with potatoes.
Packaging and quantity:	Packed in an appropriate packaging (foil) according to customer's requirements.
Storage and transport of the product:	No special transport needed, protected from external influences.

BREAD ROLL, WHOLEGRAIN

Table 3 Basic description: Wheat wholegrain bakery (web 1)

Quality requirements:	Made from whole wheat flour or whole grain wheat groats with ash up to 2%. It can contain up to 20% of other flour; all basic and additional raw materials, the content of additives must comply with the requirements of the Regulation; preservatives are not allowed; appearance, taste, smell, colour and consistency must be typical for whole grain bakery.
Packaging and quantity:	Packed in an appropriate packaging (foil) according to customer's requirements
Storage and transport of the product:	No special transport needed, protected from external influences.

Contracting authority in the kindergarten provides foodof a high quality in such a way that the contents of the tender documentation are divided into several groups and subgroups. Bread and bakery pastries are a large group. Organically produced bread and bakery pastries represent a special group.
Example: ECO WHOLEGRAIN WHEAT BREAD Rich in fibre; Ingredients: wheat wholegrain flour*, wheat flour*, water, sunflower oil*, yeast, salt* from the organic production. The content of insoluble fibres is 6.4%, content soluble fibre 1% Produced by: Bakery XY, address of the bakery Net weight: 700 gr Use before: day, month, year SI-EKO-001 EU agriculture/outside the EU.

There are many types of bread in the BREAD group (wheat bread, black bread, wheat mixed, wheat wholegrain, corn bread, oat bread, soybean bread, buckwheat bread, buckwheat bread with walnuts, rye bread, rice bread, mixed bread, bread with potatoes, bread with the addition of turmeric, bread with the addition of activated carbon, bread with the addition of red beet, bread with the addition of barley) and an additional demand is that the bread is already sliced to suitable thickness and packed. In the same way, the PASTRIES group, describing the requirements for different types of flour, different shapes and grams of pastries, is defined.

Table 4 Example from the tender documentation (web 1)
1. GROUP BREAD AND PASTRIES
Name of the provider:

NUM.	TYPE OF GOODS	ASSESSD QUANTITY	UNIT OF MEASURE	PRICE FOR UNIT WITHOUT VAT (EUR)	VALUE FOR EVALUATED QUANTITY WITHOUT VAT (EUR)	AMOUNT OF VAT (EUR)	VALUE FOR EVALUATED QUANTITY WITH VAT (EUR)	NUM. OF FOODS IN THE QUALITY SCHEME	NUM. OF FOODS BY THE MEASURE "MULTIPLE ECOLOGICAL FOODSTUFFS"
1	2	3	4	6	7 = 3 x 6	8 = 7 x VAT rate	9 = 7 + 8	10	11
1	Wheat semi - white bread (T - 850), 0.7 to 1.0 kg, cut and packaged				0.00	0.00	0.00		
2	Wheat white bread (T -500), 0.7 to 1.0 kg, cut and packaged				0.00	0.00	0.00		
3	Wheat mixed bread without additives, 0.7 to 1.0 kg, cut and packaged				0.00	0.00	0.00		
4	Corn mixed bread without additives, 0.7 to 1.0 kg, cut and packaged				0.00	0.00	0.00		
	TOTAL VALUE OF THE CONCLUSION				0.00	0.00	0.00		
	GROUP PASTRIES								
NUM.	**TYPE OF GOODS**	**ASSESSD QUANTITY**	**UNIT OF MEASURE**	**PRICE FOR UNIT WITHOUT VAT (EUR)**	**VALUE FOR EVALUATED QUANTITY WITHOUT VAT (EUR)**	**AMOUNT OF VAT (EUR)**	**VALUE FOR EVALUATED QUANTITY WITH VAT (EUR)**	**NUM. OF FOODS IN THE QUALITY SCHEME**	**NUM. OF FOODS BY THE MEASURE "MULTIPLE ECOLOGICAL FOODSTUFFS"**
	1	2	3	4	6	7 = 3 x 6	8 = 7 x VAT rate	9 = 7 + 8	10
5	Wheat white bakery with different shapes (rolls, bombets, ...), 30 to 50 g / pc				0.00	0.00	0.00		
6	Corn mixed bakery of different shapes (rolls, buns, ...), 60 to 70 g / pcs,				0.00	0.00	0.00		
	TOTAL VALUE OF THE CONCLUSION				0.00	0.00	0.00		

Since bread is the most important source of salt in the nutrition of Slovenians, contracting authorities order bread with less salt. The bakeries responded to this demand. They also offer bread and bakery pastries without the added additives, with less fat, without trans-fat acids, less sugar, and no gluten.
In kindergartens, there are more and more children with allergies to nuts, soya, eggs and milk. When reading the declarations, it can be found that there are still many bakeries that use these foods as additional ingredients, and therefore they are often listed as allergens.

Mostly, considering its chemical composition, structure, physical and thermal properties, food represents a heterogeneous system. In such an environment, additives enter numerous interactions with other food ingredients, so special attention is paid to allergens in bread and bakery pastries.

All ingredients contained in foodstuff causing allergies or hypersensitivity are included in the list of substances or products in Annex II of the Regulation 1169/2011 (EC 1169/2011). On the list of allergenic substances, there are cereals containing gluten, eggs, peanuts, soya beans, milk, nuts (almonds, hazelnuts, walnuts, Indian nuts, American nuts, Brazilian nuts, pistachio, macadamia, sesame seeds).

Educational institutions have a Catalogue of allergens, prepared in accordance with the Regulation (EC) No. 1169/2011 on the provision of information on allergenic food to consumers (EC 1169/2011).

Table 5 Allergenic substances present in bread of the chosen producer

The name of the bread	Gluten	Eggs and egg products	Soy and soy products	Milk and milk products, lactose	Nuts	Sesame
Buckwheat bread	WHEAT	*	*	*	WALNUTS, HAZELNUTS ALMONDS	*
Buckwheat bun	WHEAT	*	*	*	WALNUTS	*
White bread	WHEAT	*	*	*	WALNUTS, HAZELNUTS ALMONDS	*

Contracting authorities, influence the industry with their expertise and with a good description of bakery products, in order for it to focus on new modern technological procedures that reduce the use of unwanted additives, contain less salt, sugars, preservatives and are free from trans-fatty acids.

The bakery industry has therefore repeatedly introduced changes in the technological processes of producing bakery products, which has led to the need to control biochemical, chemical and physical processes. For this purpose, the use of individual additives or combinations of various additives has been established (Mikuš et al., 2012). Many additives with a different chemical structure have different applications in the preparation of various bakery products: they facilitate mechanical processing, affect the sensory properties of the bakery products, contribute to preserving freshness and extend the shelf-life.

In technological processes, various emulsifiers, hydrocolloids, lifting agents, flour treatment agents, organic acids, additives for the microbiological stabilization of products or preservatives are often used. The texture properties of bakery products are influenced by the addition of hydrocolloids, which have been increasingly used in the baking industry in recent years (Kohajdová et al., 2009).

The lifting agents provide an appropriate volume and structure of products in technologies where yeast is not used. Flour treatment agents improve the baking characteristics of the flour, increase the elasticity of gluten, and thus help achieve the desired properties and structure of various products. The spoiling of baked products with prolonged shelf-lifeis a major problem due to the development of mould, which is associated with high costs. Traditionally it is prevented by the addition of chemical preservatives, in particular with salts of weak organic acids (Marin et al., 2003).

Sweeteners are also unwanted. In the Regulation (EC) No. 1169/2011 there is a list of sweeteners and food to which sweeteners can be added.

Emulsifiers, which contribute to the improved properties of the dough during treatment and improved sensory properties of the finished product, such as texture properties, core softness, greater volume and prolonged freshness (Požrl and Mondic, 2017; De Leyn, 2006) are also used in the processes. DATEM (diacetyl ester tartrate monoglyceride tartrate mono- and diacetyl esters and mono- and diglycerides of fatty acids) is a very important emulsifier used in the baking industry. It is also one of the most commonly used emulsifiers (Požrl and Mondic, 2017; De Leyn, 2006).

Lecithins, which are usually a mixture of different phospholipids, which are otherwise found in yolk, unrefined oils and elsewhere, are also used as emulsifiers. Soya is the most important commercially used source of lecithin. But since it contains genetically modified organisms and allergens, sunflower or rapeseed lecithin is increasingly used instead.

Yeast is most commonly used rising agent in cereal products. In heavy, rich dough, where large amounts of added sugar, fat or eggs greatly slow down or prevent yeast activity, chemical rising agents are used (De Leyn, 2006).

Preservatives are substances that prolong the shelf-life of food by protecting them against deterioration caused by microorganisms and/or protect them against the development of pathogenic microorganisms. Their use depends on the composition of the product, the way it is packaged, the storage conditions and the expected shelf- life of the product. The development of mould is the most common defect of bakery products (Ribotta et al., 2004). Bread comes from the stove practically sterile. However, since mould spores are present everywhere in the air, there may be a subsequent contamination of the crust, or in cut bread, the core may also be contaminated. When cutting slices of bread, the air needed for the mould development comes between the slices (Požrl and Mondic, 2017).

Enzymes are also used in the production of bakery products.

Regulation (EC) No. 1333/2008 of the European Parliament is the main regulation on enzymes used in foodstuff, including enzymes that are used as additional technological means. It is planned that by the end of the year 2017 the Commission should establish a public register of all food enzymes for which valid applications have been submitted. In order to increase transparency, the Commission has published a list of valid applications for enzymes for which EFSA will assess the risk

or prepare a scientific assessment of the safe use. The list can be found on the Commission website (EC 1333/2008).
Under the Food Additives Regulation (Regulation 1333/2008), two enzymes have been approved: invertase (E 1103) and lysozyme (E 1105) (EC 1333/2008).
Due to the increasing number of children with celiac disease, kindergartens also need gluten-free bread and cakes.
Contracting authorities are aware that the use of additives, emulsifiers and hydrocolloids in these products is necessary. The production of gluten-free bakery products is a major technological problem for bakeries. Most gluten-free breads have significantly worse properties compared to conventional wheat breads (smaller volume, non-characteristic colour, different core structure, core more easily crushed) and a changed composition with lower protein content and higher fat content. The production of gluten-free bakery products is based on the replacement of wheat with gluten-free raw materials such as rice, corn, buckwheat, amaranth, quinoa. They use different starch types such as corn, potatoes, rice, beans. The typical highly-elastic properties of gluten are replaced by the addition of various types of hydrocolloids such as guar gum, xanthan, carrageenans, alginates, which form a stable structure. In order to consolidate the structure of the dough, protein supplements such as milk, egg proteins, and the enzymes such as transglutaminases, proteases are used. Additives of emulsifiers such as DATEM, lecithin contribute to the ability to retain gases in the dough and improve the texture of the core. It is possible to add various dairy products such as whey, milk powder and similar substances. Numerous combinations allow the production of a wide range of gluten-free bakery products, which can also be of very different quality (Požrl and Mondic, 2017).

CONCLUSIONS

Educational institutions have the opportunity to influence the baking industry with the knowledge and legislation in order to bring their products closer to the desired quality requirements of kindergartens, to reduce various substances added to bread, such as additives, preservatives, salt, sugar and emulsifiers. It is accomplished through the public procurement. Most educational institutions have this logistic option to order bread and bakery pastries on a daily basis. This means that their products are freshly baked, so the use of preservatives is not needed. The bakery industry is already aware that contracting authorities want a variety of products, as the children evaluate the bread and pastries and quickly detect the inadequate characteristic, inappropriate structure, freshness, the insignificant aroma, the smell, the taste and also crumbling of the bread. Bakeries are forced to adapt their offer, offering more and more special types of bread, of smaller shapes and weight at reasonable prices.
In their demands, the contracting authorities have a direct impact on the baking industry, which, due to that influence, develops new processes in the baking industry, such as the production of bread and bakery pastry by reducing the use of

various additives. Nevertheless, the quality grading of food is still too narrow. Food is much more important, as it has ecological, social, psychological and finally economic significance.

It is necessary to think about the quality of food widely in terms of food safety, as well as in terms of nutritional and physiological needs of the individual. Last but not least, the appearance is also important, since food is far more than just the ingestion of microbiologically and chemically safe substances.

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POSITIVE EFFECTS OF OATS ON HUMAN HEALTH

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SUMMARY
Consumption of fruits, vegetables and cereals is a basic precondition for diverse and nutritionally balanced diet. Whole grains are beneficial for human health and reduce the risk of developing chronic diseases and also contribute to maintaining normal body weight. Oat is a cereal that contains necessary macro- and micro-nutrients, a high proportion of *β*-glucan, as well as specific polyphenols with strong antioxidant activity. Although world production of oats is steadily falling, there is an increasing demand for oats and oat products. Health benefits of oats to human health have been proven by many researchers, so the EFSA (European Food Safety Authority) has approved four health claims related to oats that can be applied on food products. In addition, oats have been approved by the European Commission as a component of gluten-free foods under certain conditions. The Nordic countries have recognized the benefits of oatmeal diet, and are investing in increasing the share of oats in the diet by developing and promoting healthy Nordic nutrition. Functional foods based on oats are a great challenge and great potential in the food sector, but further efforts are needed in research, marketing and collaboration with health institutions regarding better acceptance of oat products by the consumers.
The paper presents the current situation of world and domestic oat production, scientific research and legislative framework related to positive effect of oat to human health.

Keywords: oats, *β*-glucans, health claims, functional foods

INTRODUCTION

Diverse and nutritionally balanced nutrition implies regular consumption of fruits, vegetables and cereals. Whole grains are an important factor in the prevention of chronic diseases such as diabetes, various cancers and cardiovascular diseases (Slavin, 2003). In addition, dietary fibre intake, in particular cereals, contributes to the prevention of weight gain and waist circumference (Du et al., 2010). Oat (*Avena sativa* L.) is a grain rich in all valuable nutrients characterized by a large amount of total protein, crude fat, dietary fibre, vitamins, antioxidants and mineral substances (Sangwan et al., 2014). What is particularly important is the presence of

avenanthramides, unique polyphenols, which have shown strong antioxidant activity in in vitro and in vivo conditions (Meydani, 2009). However, oat is best known for its high content of β-glucan, a soluble fibre, which is becoming increasingly interesting due to its multiple functional and bioactive properties (El Khoury et al., 2011).
The aim of the paper is to present the current state of world and domestic production of oats, current health evidence and a legislative framework indicating the positive effect of oats on human health.

MATERIALS AND METHODS

By grouping statistical data, an overview of the most important producers of oats in the world and the state of the production of oats in the Republic of Croatia was made. The most important health benefits of eating oats and oat products have been analyzed by reviewing scientific literature and approved European Food Safety Authority (EFSA) health claims.

RESULTS AND DISCUSSION

World production of oats

The largest producers of oats in the world are Russia, Canada, Poland, Australia, Finland and the United States (**Figure 1**). The Republic of Croatia is ranked 37th in the world with a production of 56,555 tons (**Figure 1**) and a yield of about 3 tons per hectare (Central Bureau of Statistics, 2017).

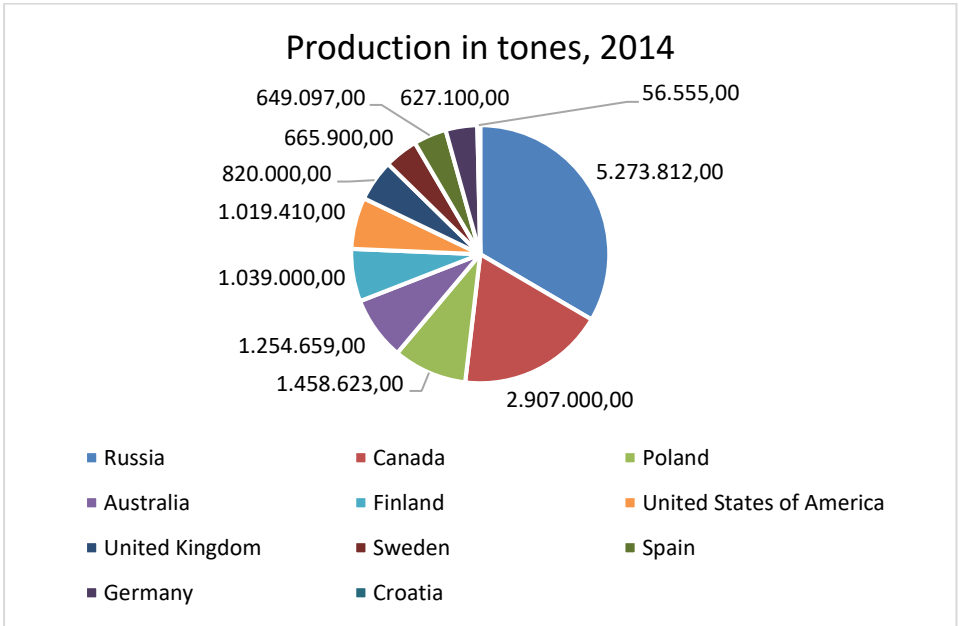

Figure 1 Largest producers of oats in the world (web 1)

Major consumers and importers of oats, globally, are the United States, Germany and Mexico. Other countries have emerged as the fastest growing exporters in the last five years, such as the Czech Republic and Sweden. The increased demand for oat products, resulting from proven health benefits, increased demand for oats. In 2014-2015, European Union countries have become the main consumers of oats globally (Oats Market, 2017). However, there is a concern about the reduced production of oat crops as a steady decline in the production has been observed since 1970 and it amounts to 60% (Jones and Sheats, 2016).

Oat is primarily adapted to a colder and moderate climate; it does not tolerate high and low temperatures, and is sensitive to drought (Jukić et al., 2011). It has been shown that the *β*-glucan content is further dependent on oat cultivars (Herrera et al., 2016). However, the health value of oats and the content of nutrients depend on both oat processing (Decker, 2014) and the production conditions (Jukić et al., 2011). Due to favorable climatic conditions in Nordic countries, as well as the recognized benefits of oats, those countries are making an effort to increase the share of oats in its populations' diet by developing and promoting healthy Nordic nutrition (Kolehmainen, 2017). The Republic of Croatia has good geographical opportunities for oat production. Although there is a slight increase in the trend of oat production (**Table 1**), it is still insufficient, and the food industry is increasingly expressing interest in the production of functional food products.

Table 1 Production of the most important cereals in Croatia, 2013 – 2016 (web 2; web 3)

Cereals	**Production, t**			
	2013	2014	2015	2016
Wheat	998 940	648 917	758 638	960 081
Maize	1 874 372	2 046 966	1 709 152	2 154 470
Barley	201 339	175 592	193 451	263 165
Rye	2 955	2 800	3 356	4 646
Oats	**60 178**	**56 555**	**71 743**	**80 414**
Triticale	47 855	61 316	54 595	81 393
Other cereals	2 238	2 656	5 860	10 264
TOTAL	3187877	2994802	2796795	3554433

Health benefits of oats and the oat products

Improper nutrition and the lack of physical activity, obesity and smoking are inevitable followers of modern lifestyles. All these are risk factors and favour the development of cardiovascular diseases, which are the major cause of death in almost all countries of the world. According to the World Health Organization, they are the cause of death of 17.3 million people worldwide, or cause 30% of total mortality (Kralj, 2012).

Due to the increasing consumer demand and their interest in their own health, there is a growing demand for the development of new products in the area of functional foods and functional food ingredients. In this context, oats have been recognized as an interesting food for which a number of positive health impacts has been identified.

Oat is the source of many compounds that exhibit antioxidant activity, among which are vitamin E (tocols), phytic acid, phenolic compounds and avenanthramides. Flavonoids and sterols are also present (Peterson, 2001). Recent observation and intervention studies conducted on humans indicate that oats may have an effect on various non-communicable diseases such as cardiovascular diseases, diabetes, obesity and others (Varma et al., 2016; Katz, 2001). Oat is a significant source of dietary fibres, especially *β*-glucans, with distinct functional properties, one of which exhibits high viscosity at relatively low concentrations (Butt et al., 2008).

Beta-glucan (**Figure 2**) is a linear D-glucose polymer bound to *β*-(1-4) and *β*-(1-3) glucosidic bonds (Wang and Ellis, 2014). It is found in all grains, but its concentration is the highest in oats (4.6 - 4.9%) and barley (1.8 - 6%), while it is much less present in wheat (0.2 - 1%) (Schönlechner and Berghofer, 2006).

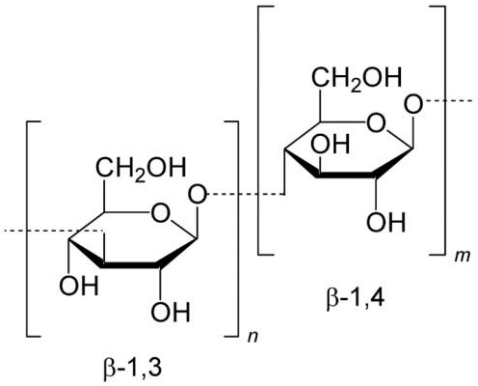

Figure 2 *β*-glucan structure (web 4)

Beta-glucans from oats regulate blood pressure and improve lipid profile in the blood, regulate postprandial glycemic effect and insulin responses, and reduce and maintain body weight (Jenzer *et al*., 2016). A number of studies indicate that beta-glucan from oats is the major active component that lowers the value of cholesterol in the blood (Katz, 2001). The daily addition of ≥ 3 grams of the oats *β*-glucan in the diet decreases the LDL cholesterol and a total cholesterol by 0.25 mmol/L and 0.30 mmol/L, without altering the value of the HDL cholesterol or triglyceride (Whitehead at al., 2014).

Beta-glucans from oats can stimulate the immune functions by activating monocytes/macrophages and increasing the amount of immunoglobulin, natural killer (NK) cells, lymphocytes, and so on, which improve resistance to cancer,

infectious diseases, as well as their prevention and enhance biological therapy (Daou and Zhang, 2012). Furthermore, a mixture of beta-glucans, inositol and digestive enzymes reduces bloating and abdominal pain, thereby improving the overall clinical condition of patients with inflammatory bowel disease (Spagnuolo et al., 2017). *In vivo* study showed that the role of oats' *β*-glucan in 5-Fluorouracil (5-Fu) induced intestinal barrier dysfunction, which provides a new explanation for the use of *β*-glucan from oat in an adjuvant chemotherapy (Wang et al., 2017).

Although there is still a concern about the use of oats in the gluten-free diet of people with celiac disease, there is a growing evidence that oats (without gluten / gliadin contamination) and oat cultivars, which do not contain celiac activating proline and glutamine sequences, can be used without the risk of intestinal damage (Poley, 2017). Moreover, some research has shown that inclusion of oats in gluten-free nutrition is safe and, in the long term, can improve the quality of life (Aaltonen et al., 2017). Taking the scientific research into account, oats have been approved by the European Commission as a component of gluten-free products (Commission implementing regulation (EU) No 828/2014) under certain conditions. Implementing Commission Regulation (EU) No. 828/2014 on Consumer Information on Absence or Reduced Gluten Food Presumes states that most gluten-intolerant persons may include oats in their diet without any harmful consequences for their health. The additional requirements for food containing oats according to this Regulation are as follows: "Oats contained in a food presented as gluten-free or with a very low gluten content must have been specially produced, prepared and/or processed in a way to avoid contamination by wheat, rye, barley, or their crossbred varieties and the gluten content of such oats cannot exceed 20 mg/kg" (Commission implementing regulation (EU) No 828/2014).

Approved health claims

Due to the scientifically proven positive effects of oats and oat products on human health, the European Food Safety Authority (EFSA) has approved four health claims related to oats that can be referred to food products (**Table 2**).

Table 2 Approved health claims (web 5)

Claim type	***Nutrient substance, food or food category***	***Claim***	***Conditions of use of the claim / restrictions of use / reasons for non-authorisation***	***Health relationship***
Art.13(1)	Beta-glucans	Beta-glucans contribute to the maintenance of normal blood cholesterol levels	The claim may be used only for food which contains at least 1 g of beta-glucans from oats, oat bran, barley, barley bran, or from mixtures of these sources per quantified portion. In order to bear the claim information shall be given to the consumer that the beneficial effect is obtained with a daily intake of 3 g of beta-glucans from oats, oat bran, barley, barley bran, or from mixtures of these beta glucans.	maintenance of normal blood cholesterol concentrations
Art.13(1)	Beta-glucans from oats and barley	Consumption of beta-glucans from oats or barley as part of a meal contributes to the reduction of the blood glucose rise after that meal	The claim may be used only for food which contains at least 4 g of beta-glucans from oats or barley for each 30 g of available carbohydrates in a quantified portion as part of the meal. In order to bear the claim information shall be given to the consumer that the beneficial effect is obtained by consuming the beta-glucans from oats or barley as part of the meal.	reduction of post-prandial glycaemic responses
Art.13(1)	Oat grain fibre	Oat grain fibre contributes to an increase in faecal bulk	The claim may be used only for food which is high in that fibre as referred to in the claim HIGH FIBRE as listed in the Annex to Regulation (EC) No 1924/2006.	increase in faecal bulk
Art.14(1)(a)	Oat beta-glucan	Oat beta-glucan has been shown to lower/reduce blood cholesterol. High cholesterol is a risk factor in the development of coronary heart disease	Information shall be given to the consumer that the beneficial effect is obtained with a daily intake of 3 g of oat beta-glucan. The claim can be used for foods which provide at least 1g of oat beta glucan per quantified portion.	

CONCLUSIONS

The inclusion of oats and oat products in the diet has shown positive effects on human health, especially in reducing cardiovascular diseases and diabetes. It is quite certain that future food testing will increasingly focus on the bioactive phytochemicals with strong antioxidant and anti-inflammatory activity. Functional food based on oats is a challenging prospect in the food sector, but additional efforts are needed in the research, marketing and collaboration with healthcare institutions to make oat products more acceptable to consumers.

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KNOWLEDGE AND HABITS RELATED TO DIETARY FIBRE INTAKE IN ADULTS FROM THE CITY OF ZAGREB

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SUMMARY
Numerous studies have confirmed that an increased consumption of dietary fibre lowers the risk of cardiovascular diseases, diabetes type 2, constipation, obesity and certain malignant diseases. The aim of this study was to evaluate the eating habits related to dietary fibre intake in subjects from the city of Zagreb. Furthermore, the aim was to determine the level of knowledge, sources of information and food label reading habits related to dietary fibre. The study included 734 adults (18 – 61 years old) who completed a questionnaire of self-report response on dietary fibre developed by the CI&DETS Research Centre. The intake of food rich in dietary fibre among the inhabitants of Zagreb was relatively low and inadequate. Most of the participants (83.1%) recognized the importance of dietary fibre in terms of prevention and/or treatment of various diseases. However, general knowledge about dietary fibre was insufficient. The internet was the most common source of information on dietary fibre. On average, the subjects consult the food label, only sometimes (M = 3.36; scale 1 – 6), but they rarely read the amount of dietary fibre (M = 2.06). There is a need to educate the general population about the benefits of dietary fibre with the purpose of adopting desirable eating habits, which will increase their intake.

Keywords: dietary fibre, eating habits, sources of fibre, knowledge about fibre, food labelling

INTRODUCTION

Over the last few decades, scientists have been giving increased importance to dietary fibre. Dietary fibre can be defined as a part of plant food that cannot be broken down by enzymes normally found in the digestive system and it is divided into two large groups: soluble and insoluble dietary fibre (Johnson, 2012).

By passing through the digestive system, dietary fibre is retained in the stomach and it postpones the discharge of gastric content, which leads to the feeling of fullness and satiety. It slows down the absorption of carbohydrates and fat in the small intestine and can also bind minerals. Dietary fibre binds water in the large intestine which softens the stool and therefore has a beneficial effect in the cases of constipation. Aside fromdietary fibre preventing and/or treating constipation, many scientists also associate it with other diseases that can be prevented and/or treated, for example, cardiovascular disease, obesity, increased cholesterol, colon cancer and diabetes (Johnson, 2012).

As insufficient dietary fibre intake can have a negative impact on human health, excessive intake can also have a negative impact on health, such as flatulence, cramps, diarrhea and other symptoms. Excessive amount of dietary fibre can also reduce the absorption of important vitamins and minerals (zinc, potassium, magnesium, iron) (Martinho et al., 2013).

The World Health Organization, together with the Food and Agriculture Organization, recommends the intake of more than 25 grams of dietary fibre per day for an average adult (WHO, 2003). The recommended daily intake for a man is 38 g and 25 g for a woman, if they are under the age of 50. Due to the reduced energy intake over the age of 50, the recommended daily intake for a man is 30 g and for a woman 21 g (IOM, 2002).

The aim of this study was to evaluate the eating habits related to dietary fibre intake in subjects from the city of Zagreb. Furthermore, the aim was to determine the level of knowledge, sources of information and food label reading habits related to dietary fibre.

MATERIALS AND METHODS

Respondents

The survey of knowledge and habits related to dietary fibre intake included734 respondents from the city of Zagreb, which were selected randomly through the researchers' acquaintance. The survey included 500 women and 234 men. The age range was 18 to 61. The questionnaires were anonymous, so personal data is protected and cannot be related to the responses. The survey was completed between October of 2014 and March of 2015 in Zagreb and was part of an international project (PROJ/CI&DETS/2014/0001) coordinated by the CI & DETS Research Centre (IPV – Viseu, Portugal).

Questionnaire

In order to achieve the aim of this study, a validated questionnaire of the Portuguese Polytechnic Institute Viseu Research Centre was used to evaluate the knowledge and habits related to dietary fibre. The questionnaire consisted of different parts. The socio-demographic characteristics, like age, gender, level of education, country and living environment, were collected in the first part of the

questionnaire. The second part examined the frequency of consumption of different food groups and consumer habits related to fibre-rich foods. The respondents were asked to point out a typical weekly consumption of certain foods and open-type questions were used to enable receiving values that are consistent with the frequency of consumption. The questions that were asked included the consumption of vegetables and/or salads, fruits and whole grains, eating outside and the consumption of fast food. Furthermore, the attitudes about food labelling were asked and respondents gave their responses using a 5-point scale, ranging from 1 (never) to 5 (always). The questions that were asked were: "When I buy a food product I usually consult the label information", "I usually see the nutritional information relative to the food on the label", "I usually see the fibre content of the food on the nutritional table", "The amount of fibre is a factor to consider when choosing similar foods" and "If I buy a food in a pack that reads "high fibre content" or "fibre rich", I check the label for the amount of fibre present". In the end, the knowledge about the relationship between dietary fibre and food was examined through a group of questions where respondents were asked to point out their agreement by using a 5-point Likert scale from 1 (I disagree) to 5 (I completely agree). Some of the questions asked in this part were: "Dietary fibres originate only from plant food", "Dietary fibres have calories, i.e., they provide energy to the body when ingested", "Legumes (beans, peas,...), cereals and fruits are foods rich in dietary fibre" and "The consumption of dietary fibre is higher in urban than in rural areas" (Guiné et al., 2016).

Statistical analyses

The processing of collected data was done using Microsoft Office Excel (version 2007). Standard descriptive statistics (mean arithmetic value (*M*) ± standard deviation, mod (*M*d) and median (*M*e)) were used to show the results. The T-test was used in order to determine whether there was a statistically significant difference between women and men in different parameters.

RESULTS AND DISCUSSION

Sample characterization

Regarding gender (*n* = 734), 68.1% were female and 31.9% were male. Most respondents (66.1%) were between the ages of 18 and 30, followed by 13.8% aged between 41 and 50; 9.9% between 31 and 40; 8.2% between 51 and 60. 1.8% of the respondents were over the age of 60 and 0.3% did not answer the question about their age. More than half of the respondents completed university education (63.5%), followed by the respondents who completed secondary school (35.8%) and only 0.7% of the respondents completed primary school. The place of residence of all the respondents at the time of the survey was the city of Zagreb.

Eating habits

Open-type questions were used for evaluating the eating habits of the respondents. They answered questions about the typical weekly consumption of vegetables, fruit and whole grains, and how many times per week they eat out and eat fast food. For the first two questions, 65% of the respondents answered that they consume 8 meals containing vegetables per week and 43.2% of the respondents consume 8 pieces of fruit per week (once a day), followed by 29.3% of the respondents who consume 8 to 15 meals containing vegetables, while 33.1% of the respondents consume 8 to 15 pieces of fruit per week (twice a day). The percentage of the respondents who consume vegetables in 22 to 29 meals per week is 5% and the percentage of the respondents who consume 22 to 29 pieces of fruit per week is 16.2% (three times a day). Results are shown in **Figure 1**.

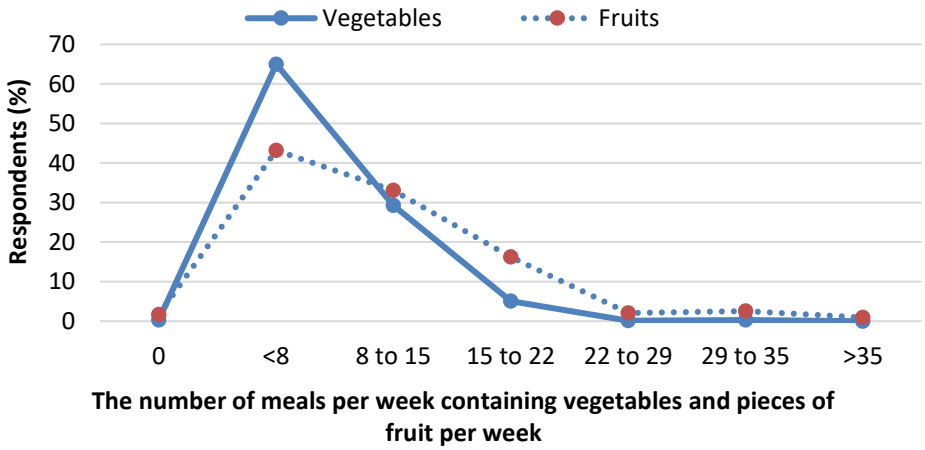

Figure 1 Eating habits: Consumption of vegetables and fruit

The average number of meals per week containing vegetables was 7.7 ± 4.1, which corresponds to at least one a day and the average number of fruit was 10.1 ± 7.6, which corresponds to one and a half pieces of fruit a day. There was no statistically significant difference regarding gender in the number of weekly meals containing vegetables and/or salad (p = 0.578). Also, there was no statistically significant difference regarding gender in the number pieces of fruit (p = 0.310) eaten weekly. That does not follow the recommendations of some authors, who state that there should be a difference in dietary fibre intake regarding gender (IOM, 2002; Tsang, 2007). The Institute of Medicine emphasizes that men need more dietary fibre because they need to have more calories to maintain healthy weight (IOM, 2002). One similar survey among the Portuguese population in 2013 showed that 39% of the respondents had eight or more vegetable meals a week; 17% consumed vegetables every other day and only 2% had more than two meals containing vegetables a day. Regarding fruit, 42% of the respondents had one piece of fruit a day; 40% had two pieces of fruit a day and only 16% had more than two pieces of

fruit a day. The average number of meals containing vegetables was 7.6 (once a day), and the average number of pieces of fruit was 10.8 (one and a half a day) (Martinho et al., 2013). Similarly, in a survey that has compiled data for this study, which was conducted in 10 countries, data analysis has shown that the most common number of meals including vegetables and/or salad per week was 7 (Guiné et al., 2016). The obtained results are similar and the worrisome thing is that they are not following the recommendations. In another study, analyzing the assessment of knowledge about dietary fibre of the Turkish student population, an inadequate consumption of vegetables and fruit per day in the adult Turkish population is mentioned, which is 1.6 meals of vegetables and 1.6 meals of fruit (Deniz and Alsaffar, 2013). Considering the results of this research, it can be said that the consumption of vegetables and fruit in the adult population is below the recommended amounts of 2.5 cups of vegetables and 1.5 - 2 cups of fruit for women aged 19 to 50 and 3 cups of vegetables and 2 cups of fruit for men aged 19 to 50. For example, one cup of vegetables isone cup of cooked spinach, large fresh tomato, or a large red pepper, and one cup of fruit can be a large banana, a large orange, a middle-sized pear or one cup of 100% fruit juice. These recommendations refer to people who are physically active for less than 30 minutes per day (USDA, 2016).

Analyzing the question about whole grains consumption, the results showed that 20% of the respondents do not consume whole grains at all, 48.9% consume it up to 5 times a week; 26.4% consume it 5 - 9 times a week and 3.5% consume whole grains 9 - 13 times a week. Based on these results, it can be concluded that most respondents do not have an adequate whole grains intake in comparison to US recommendations that require at least 3 equivalent ounces of whole grains per day for women or 3 - 4 equivalent ounces for men (depending on age). An equivalent ounce is about 30 g. These recommendations refer to people who are physically active for less than 30 minutes per day (USDA, 2016). Considering the consumption of whole grains in terms of gender, the average intake for women is 3.5 ± 3.0 and for men 2.7 ± 2.9 times a week and this difference was statistically significant (p = 0.001).

As for negative eating habits, fast food consumption is accessible more and more every day due to the number of fast food restaurants, pastry shops, pizzerias and bakeries opening at every corner. In this study, there was a statistically significant difference between women and men regarding fast food consumption (p = 0.000). Women (M = 1.01) consume less fast food than men (M = 1.47), it is similar for eating out (women M = 3.32, men M = 3.82). Likewise, there is a statistically significant difference in eating out regarding gender (p = 0.036). Men eat out more often than women, perhaps because of the predisposition to prepare meals at home, which is still higher among women (Guiné et al, 2016).

Level of knowledge about dietary fibre

In this part, the respondents expressed their knowledge using a 5-point Likert scale (1-strongly disagree, 2-disagree, 3-no opinion, 4-agree, 5-strongly agree). The collected results are expressed as a percentage of the total number of the respondents and shown in **Figure 2**.

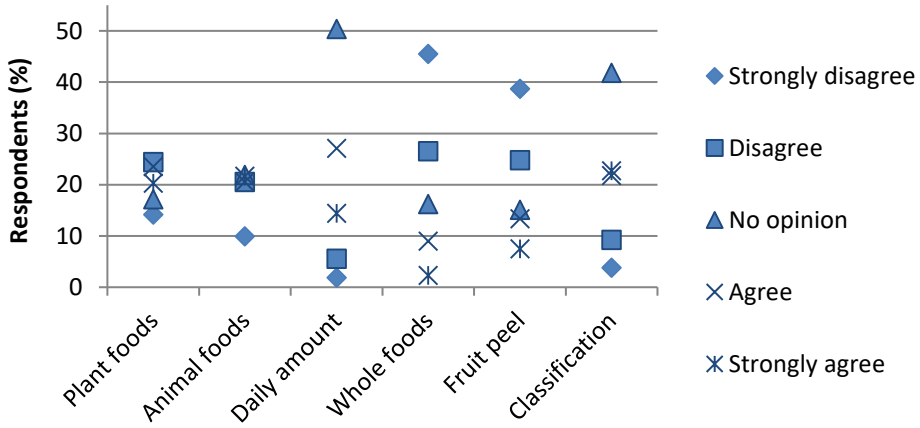

Figure 2 Level of knowledge on dietary fibres

The first statement was „Only plant foods have fibres" and 38.4% of the respondents answered that it was false, 17.2% did not have an opinion and 43.9% answered that the statement was true. The following statement was „Foods of animal origin, such as meat, eggs and dairy products contain no fibres (unless added)" and 30.5% of the respondents answered that it was false, 21.9% did not have an opinion and 42.3% answered that it was true. Furthermore, 7.5% of the respondents thought that the statement „According to WHO, an average adult should eat 25 g of fibre per day" was false and 50% did not have an opinion. On the other hand, 41.5% of the respondents answered that the statement was true. This shows that half of the respondents have no opinion about the daily recommended fibre intake and that fibres are not so important in their diet. The fourth claim stated „Whole foods (pasta, rice, bread, cereals, ...) have lower amounts of fibre than non-integral foods", and 72.1% of the respondents disagree; 16.2% said they neither agree nor disagree. On the other hand, 11.3% agreed. Furthermore, it was investigated how many respondents think „Fruit with the peel have less fibre than peeled fruit". This statement was declared false by 63.5% of the respondents; 15.1% did not have an opinion and 20.9% agreed with it. The last claim was „Dietary fibres are classified into soluble and insoluble" and 13.1% of the respondents disagreed; 41.8% did not have an opinion and this is not surprising because this data is not widely available to the wider population. On the other hand, 44.6% of the respondents agreed.

Based on this data, it can be said that a large number of respondents do not know or have no opinion on basic information about dietary fibre, because a relevant percentage of respondents did not come up with an answer on each claim, and also, a relevant percentage of respondents agreed with the incorrect statement. In a survey conducted in 10 different countries on different continents (Europe, Asia and Africa), women wholived in urban areas with a higher level of education, had the highest level of knowledge on dietary fibre. On the other hand, when speaking about countries, the residents of Romania, Portugal and Turkey were the most informed, while residents of Egypt have shown the lowest awareness of dietary fibre (Guiné et al., 2016).

Sources of information

This questionnaire also examined where the information about dietary fibre was commonly found and which source of information would induce the increase of dietary fibre intake. Health institutions (health centres and hospitals), media (radio, television and internet), educational institutions (schools) and educational materials (books and magazines) were considered. When asked where they usually find information about dietary fibre, descriptive analysis determined that respondents chose internet (M = 4.5 ±1.79; Me = 5; Md = 6 (scale 1 - 6)) as the most common source of information. On the other hand, the rarest sources of information on dietary fibre were radio and health institutions. Regarding the question which source of information is the best for inducing the increase of dietary fibre intake, descriptive analysis also showed it was the internet (M = 4,23±1,71). Similar results were obtained for television (M = 4,04±1,74) and school (M = 3,96±1,64) and the radio is once again the least efficient (M = 2,91±1,76). This is also confirmed in the survey on Portuguese population where 48% of the respondents pointed at the internet (Martinho et al., 2013). This is not unusual for today`s reality where internet is accessible to almost every household and it is an important source of information and communication.

Relation between dietary fibre and different foods

This group of questions was intended for testing the knowledge on dietary fibre content in different food groups. The obtained results are shown in **Figure 3**. Less than half (44%) of the respondents answered that "Dietary fibres originate only from plant food", while 37.5% did not consider this was true. There were 17.7% of respondents who were indecisive. However, 81.6% of the respondents disagree with the claim "Dietary fibres originate only from animal food" and 1.8% of the respondents agreed. The remaining 16.5% of the respondents had no opinion. Third statement was "Dietary fibres originate both from plant and animal food" and 43.7% of the respondents agreed; 33.1% disagreed; 22.6% did not have an opinion. There were inconsistencies in the responses to these three questions, which lead to the conclusion that respondents do not possess the desired knowledge on this subject. In one of the similar surveys, men showed better

knowledge than women on the claim about dietary fibre in plant foods and it was surprising that the respondents with a lower level of education showed better knowledge than those with a higher level of educational (Guiné et al., 2016). The following statement "Dietary fibres have calories, i.e., they provide energy to the body when ingested" analysed the knowledge about the calorie value of dietary fibre among respondents. In this case, 42.5% of the respondents agreed it was true, but it is not clear whether they know that dietary fibre has a calorie value of 2 kcal/g (FAO, 2002), or whether they answered that because the usual components of food have calories. On the other hand, 26.4% of the respondents had no opinion and 30.2% thought that dietary fibres have no calories. The fifth statement was "Legumes (beans, peas,...), cereals and fruit are foods rich in dietary fibre" and this was considered true by 87.6% of the respondents; 8.9% had no opinion and 3.5% disagreed. Similar results were obtained in the Portuguese population, where 77% of the respondents agreed with this statement (Martinho et al., 2013). The last claim was "The consumption of dietary fibre is higher in urban than in rural areas" and only 13.4% of the respondents agreed, while 57.4% thought the opposite and 29.2% did not have an opinion. One of the studies showed that women with a higher level of education in rural areas were more likely to consume five or more meals of fruit and vegetables a day, and likewise, people over 65 in rural areas are also likely to eat at least five servings of fruit and vegetables a day (Lutfiya et al., 2012).

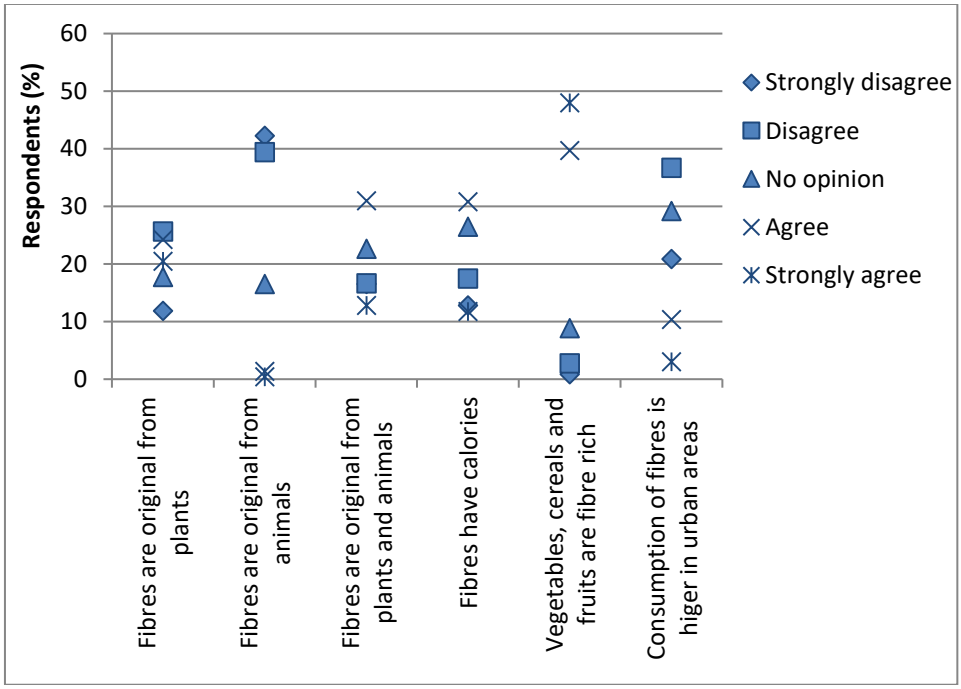

Figure 3 Relation between dietary fibre and various foods

Relation between dietary fibres and health

In this section, the intake of dietary fibre was associated with cardiovascular diseases, increased cholesterol, breast and colon cancer, obesity, constipation, diabetes, lack of vitamins and minerals, and various eyesight problems (Anderson et al., 2009; Marlett et al., 2002). Most respondents (83.1%) believed that consuming a certain amount of dietary fibre can prevent and/or treat certain diseases, while 4.1% were against this statement and 12.5% had no opinion. Furthermore, more than a half considered that dietary fibre can prevent and/or treat cardiovascular diseases (54.2%), increased cholesterol (64.7%), bowel cancer (64.7%), obesity (68%) and constipation (80.9%). These indicate that people are aware of the benefits of dietary fibre against these diseases, especially against constipation, maybe because this benefit is most commonly mentioned in the media. The majority of the aswers was "no opinion" for diabetes (43.5%), eye diseases (48.5%) and breast cancer (53.5%). Statements about the relation between dietary fibres and eye diseases or vitamins and minerals deficiency were those which obtained the highest percentage of disagreement, 33.5% in the first case and 27% in the second case. However, 17.7% of the respondents agreed in the first case and 34.9% in the second case and had a wrong idea about the benefits of dietary fibres. A high intake of dietary fibre is not useful in the absence of micronutrients because it can affect their absorption (Hernández et al., 1995), for example, by inhibiting pancreatic enzymes which break down carbs, lipids and proteins (Alesón et al., 2002). No information was found on the benefits of dietary fibre for eyesight problems. Results are shown in **Figure 4**.

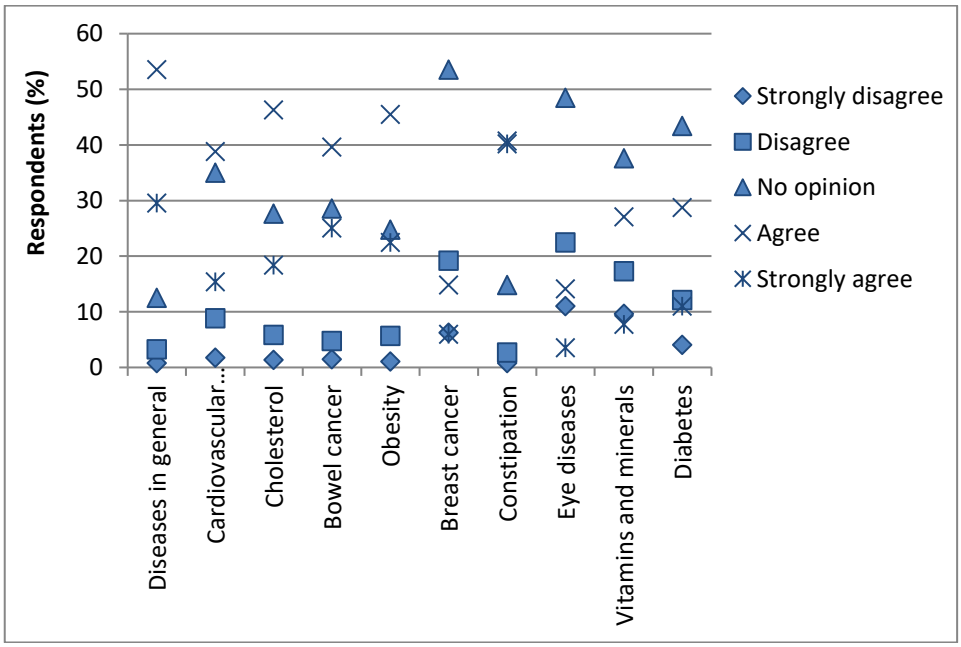

Figure 4 Knowledge about the relation between dietary fibres and diseases

Food labelling

This part of the questionnaire examined the information about consulting food labelling, especially about dietary fibre. Regarding descriptive statistics, the range of mean values in the responses for this group of questions was from 2.06 to 3.36. **Figure 5** shows that the habit of consulting food labeling was not developed as frequent and regular. According to the Likert scale it can be said that respondents sometimes: consult the label information (M = 3.36), see nutritional information relative to the food (M = 3.03) and consider the amount of fibre as a factor when choosing similar foods (M = 3.11). On the other hand, respondents rarely: see the fibre content of the food (M = 2.06) and check the amount of fibre on the label if buying a food that the pack refers to "high fibre content" or "fibre rich" (M = 2.36).

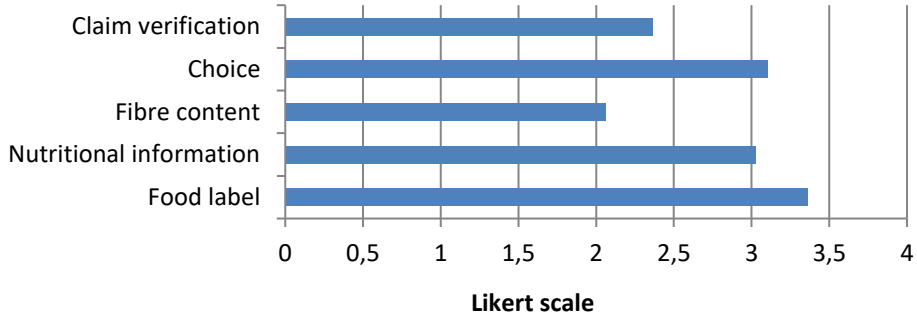

Figure 5 Mean values (according to the Likert scale) of consulting the food label on products

CONCLUSIONS

Regarding the aim of this study, which was to evaluate the eating habits and knowledge related to dietary fibre intake in subjects from the city of Zagreb, the following can be concluded:

Most respondents usually consumed one meal containing vegetables (65%) and one piece of fruit (43.2%) per day. Only 5% of the respondents consumed the recommended amount of vegetables per day, while 33% of the respondents consumed the recommended amount of fruit per day. Whole grains consumption is low, although the respondents recognized (72.1%) that whole grains are richer in dietary fibre. Women, on average, consumed significantly more whole grains (3.5 times per week *vs.* 2.7 times per week, p = 0.001) than men. Regarding the inconsistencies in responses and the number of respondents with an unexplained opinion, the respondents did not possess the necessary knowledge on the origin of dietary fibre, but also on dietary fibre in general.

The internet was the most common source of information on dietary fibre and on the other hand, respondents received the least information through radio and health institutions. The internet was once again pointed as the most appropriate

source for increasing dietary fibre consumption, followed by television and educational institutions.

From the above mentioned diseases, the majority of respondents recognized the association of dietary fibre with constipation (80.9%), followed by obesity, colon cancer, increased cholesterol and cardiovascular disease.

The habit of consulting the food label has not been developed as frequent and regular. Respondents, on average, only sometimes (*M* = 3.36) consult the food label and are rarely informed about the fibre content in food product (*M* = 2.06).

Such conclusions indicate that there is a need to educate the general population about the benefits of dietary fibre, with the purpose of adopting desirable eating habits, which will increase their intake and possibly prevent the occurrence of specific diseases.

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GLUTEN-FREE DIET – KNOWLEDGE AND FREQUENCY OF CONSUMPTION

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SUMMARY
Lately, gluten-free diet gained considerable popularity among the world population. A possible reason for that is the opinion among the general population that a gluten-free diet is a more healthful option. Recent research suggests that there is no evidence to support the consumption of gluten-free products among individuals who do not have celiac disease, wheat allergy, or nonceliac gluten sensitivity. Our aim was to determine the frequency of consumption of the gluten-free diet among the Croatian population. For this purpose, a specially designed questionnaire was used to determine the general knowledge of the population about gluten and gluten-free products, as well as the frequency and the main reasons for the consumption of the gluten-free diet. The questionnaire was conducted on 200 respondents. Only 4% of all interviewed subjects stated that they are not familiar with the terms "gluten" and "gluten-free diet". Furthermore, whenall the answers obtained from the questionnaire are taken into consideration, this number was much higher (around 30%). The results showed that around 13% of the interviewed subjects stated to have non-celiac gluten sensitivity or celiac disease. Among the remaining, apparently healthy subjects, 40% declared that they consume a gluten-free diet every day. Just 5% of the respondents who consume gluten-free products have the opinion that the gluten-free diet is a healthful option. Further investigation with a greater number of respondents and a more detailed questionnaire is needed to obtain more accurate information about the opinion of the general population regarding the gluten-free diet.

Keywords: gluten, gluten-free, diet

INTRODUCTION

Gluten-free diet gained considerable popularity among the world population lately, but its main and valid intent is a medical treatment for people suffering from celiac disease or from non-celiac gluten sensitivity, or either wheat/gluten allergy. Adherence to a gluten-free diet primarily affects the consumption of foodstuffs from the grain food group, i.e. cereals that naturally contain or could be

contaminated with gluten. Gluten is defined as "a protein fraction from wheat, rye, barley, oats, or their crossbred varieties and derivatives thereof, to which some persons are intolerant and that is insoluble in water and 0.5 mol/L NaCl". Foods that are free of wheat, rye, barley and oat or contain 20 ppm of gluten or less are considered as gluten-free foods (FAO, 2008).

Gluten is considered to be a major food component that can trigger gastrointestinal symptoms and gluten-related disorders that are usually classified by their immunologic pathogenesis as autoimmune, allergic and those that are neither autoimmune nor allergic (Sapone et al., 2012). Except for celiac disease, some research has shown that a gluten free diet is also indicated for specific medical conditions like: wheat allergy (those patients usually do not need to exclude rye, barley and oat from their diet), gluten sensitivity (it is hard to define this condition, so more researchis needed), irritable bowel syndrome (it is important to eliminate celiac disease first because of its similar symptoms), and autism (may or may not have benefits, more research is needed in this area) (Pietzak, 2012). Exclusion of gluten from the diet is the critical medical treatment for individuals with diagnosed celiac disease, as well for those with medical-confirmed allergies (Ludvigson et al., 2013; Erkinbaev et al., 2017).

Gluten free diet exploded in popularity over the last decade and is increasingly common in the general population (Kim et al., 2016). Rapid rise in popularity of the gluten free diet is most likely the result of the promotion in the popular media, celebrity endorsements, as well as the support of the restriction among the health and wellness community (Newberry et al., 2017), which contributes to public perception that gluten-free diet promotes improved general health (Reilly, 2016). The growing trend of gluten-free diet consumption caused increased market demands for wheat/gluten free foods from 15% to more than 50% (depending on region/country), which hasresulted in a significant reduction in wheat/cereal consumption in many countries (Brouns, 2015). In response to consumers' demands, gluten-free products have a market share of about 15 billion U.S. dollars, and further growth is expected (Newberry et al., 2017). The global market for gluten-free bread was estimated to be about 1.0 billion U.S. dollars in 2015 (Hosafci, 2016), while some health and wellness data showed an increase of the global sale of gluten-free packaged food by about 75% over the five-year period (from 2008 to 2013) (Baroke, 2014).

These days, gluten-free diet is a very trendy alimentary habit in many countries (Fasano et al., 2015) and there is also an increasing interest for gluten-free grains consumption (Vinning and McMahon, 2006). The number of gluten-free products on the market is expanding nowadays; besides, there are countless articles about the potential benefits of adherence to the gluten-free dietary pattern and at the same time a lot of celebrities (famous people from different life areas, e.g. sports) are promoting the gluten-free lifestyle (Marcason, 2011). Some studies show that

up to 30% of American adults are trying to reduce or completely avoid gluten in their diet (i.e. implementing a gluten-free diet), while the prevalence of celiac disease remained stable (around 0.7%-0.8%) (Topper, 2014; Gaesser and Angadi, 2015; Kim et al., 2017). In westernized countries, the prevalence of documented wheat allergy is about 0.1% (Pietzak, 2012). A possible reason for eliminating gluten from the diet are the opinions among the general population that a gluten-free diet is a healthier option, that such dietary patterns could help with weight loss, or that gluten consumption can be harmful to every human being. Recent research suggests that there is no evidence to support consumption of gluten-free products among individuals who do not have celiac disease, wheat allergy or non-celiac gluten sensitivity (Golley et al., 2014), there is no evidence to suggest that the general population would benefit by excluding gluten from the diet (Gaesser and Angadi, 2012; Gaesser and Angadi, 2015). Moreover, a gluten-free diet may lead to possible nutrient deficiencies, such as fibre and some micronutrients, e.g. iron, folate, niacin and zinc (ADA, 2009; Wild et al., 2010); or nutrient excess (i.e. saturated fats, high sugar intake). By reviewing of published papers, it was noticed that a decrease in vitamins and minerals carriesan increasing obesity risk due to the high content of saturated lipids among people who are conducting lifelong adherence to a gluten-free diet (Vici et al., 2016). For that reason, it is interesting to investigate the consumption of a gluten-free diet and gluten-free products among the population that does not have medical reasons for conducting it, as well as the general knowledge about gluten and gluten-free products and the motivations for avoiding gluten consumption.

The aim of this study was to determine the knowledge about gluten, as well as the frequency of consumption of the gluten-free diet among the Croatian population, particularly among those that do not have any medical reasons for its consumption.

MATERIALS AND METHODS

A specially designed self-administrated short questionnaire was used to determine the general knowledge of the respondents about gluten and gluten-free products/diet, same as the frequency and the main reasons for consumption of the gluten-free diet. The questionnaire was composed of 15 questions made as a combination of questions with offered answers and with free text input, which was distributed online by using the *Google Docs* Platform. The survey was available for filling-in during a short period of time (7 days). The study group contained 200 respondents from Croatia who have completed the questionnaire, both genders, aged 18 to 68 (average age 33.5).

Microsoft Excel 2013 (Microsoft, Seattle, WA, USA) and the *SPSS* statistical package (version 17.0, SPSS Inc., Chicago, IL, USA) were used for the statistical analysis of the obtained data. The Chi-square test, together with the Cramer's V test as the strength test, were used and p values <0.05 were considered as statistically significant.

RESULTS AND DISCUSSION

This preliminary investigation, with the main goal of determining the knowledge about gluten, the gluten-free diet, as well as the frequency of consumption of the gluten-free diet among the Croatian population, included 200 respondents, volunteers who agreed to fill-in the questionnaire.

Out of the 200 respondents, 93% were women and only 7% were male. The possible reasons for this relation are suggested in earlier research and they showed that women are more likely to eliminate gluten from their diet, as well as that women are still mostly in charge of running the household, so consequently they could be more interested in the subject (Golley, 2014).

Of all the included subjects, 66.3% were employed, 10.1% were unemployed and 23.6% of them were students. The degree of education of the respondents in this investigation is shown in **Figure 1**. The data is shown for the total sample, and it is obvious that the greatest number of respondents have finished five years of faculty education (36%), followed by respondents who finished high school education, while the lowest number of respondents have finished elementary school. A larger number of respondents with higher education was partially expected due to a previous study which showed that the level of education has an influence on eating behaviour (Gacek and Chrzanowska, 2009), also, they are surrounded by more information, and they follow lifestyle trends, which include taking care of the quality of the diet more often. It was also expected that those people would be more motivated to participate in a scientific research. Compared to our research investigation conducted in 2015 on the population of 1000 Americans, it showed that the purchasing of gluten-free foods was more common among women with a high school diploma and those with a household income below 30 000 U.S. dollars (Reilly, 2016; Riffkin, 2015).

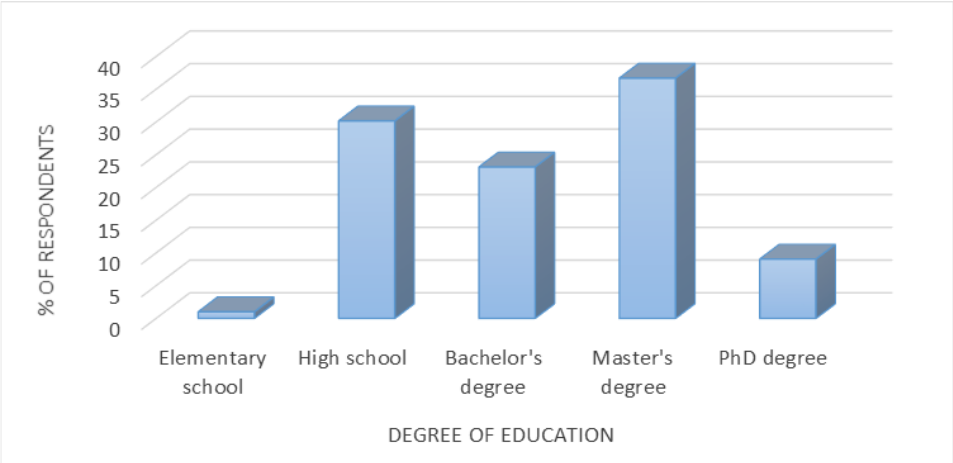

Figure 1 Participants' degree of education (*n* = 200)

Other reasons for being interested in our own diet include a medical condition or an illness, because an adequate diet is not only promoted by major health organisations (such as the World Health Organisation - WHO) for preventing chronic diseases, but it is also an important part of treatment for a lot of medical conditions, especially related to the gastrointestinal tract. That was the reason for checking the health condition of the respondents in this study. **Figure 2** presents whether respondents have a disease or a health condition. It was shown that 13.2% of the respondents stated to have celiac disease and 18.7% stated to have other non-celiac gluten sensitivity disorders. A number of respondents suffering from celiac disease in this study significantly exceeds the estimated 1% of the average European population suffering from this autoimmune disease (Mustalahti et al., 2010). A possible reason for this divergence could be that people suffering from celiac disease probably have a higher motivation for participating in investigations connected with gluten and gluten-free diets. The rest of the respondents that have a chronic health condition (18%) not related with gluten intake confirm the belief that the health status of the individuals is related to their attitudes and behaviours towards healthy eating and diet quality (Aggarwal et al., 2014).

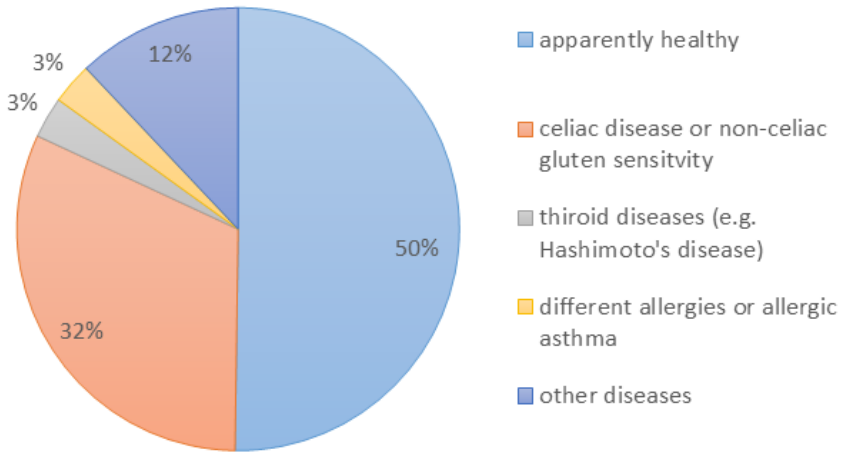

Figure 2 Respondents answers to the question "Do you have a disease or a health condition?" (*n* = 200)

A further goal in this investigation was to determine the frequency of consumption of a gluten-free diet/products among respondents. As it is shown in **Figure 3**, one third of all respondents do not consume gluten-free food at all, and almost half of all respondents consume a gluten-free diet every day. Out of all the respondents (69.3%) that consume a gluten-free diet, regardless of the frequency of consumption, the majority were females (72% of female compared to 39% of male respondents) (**Figure 4**). Previous research also showed that females consume

gluten-free more often and have a higher prevalence of self-reported gluten sensitivity (Aziz et al., 2014). Recent research from Newberry et al. (2017) reported that 23% of the included adult population worldwide avoid gluten-containing foods with an observed geographic variation, from 31% among the participants from Latin America to only 15% among the European population. Furthermore, the age, gender and educational status also had an effect, so that young women without a college degree are most likely to choose gluten-free products (Newberry et al., 2017).

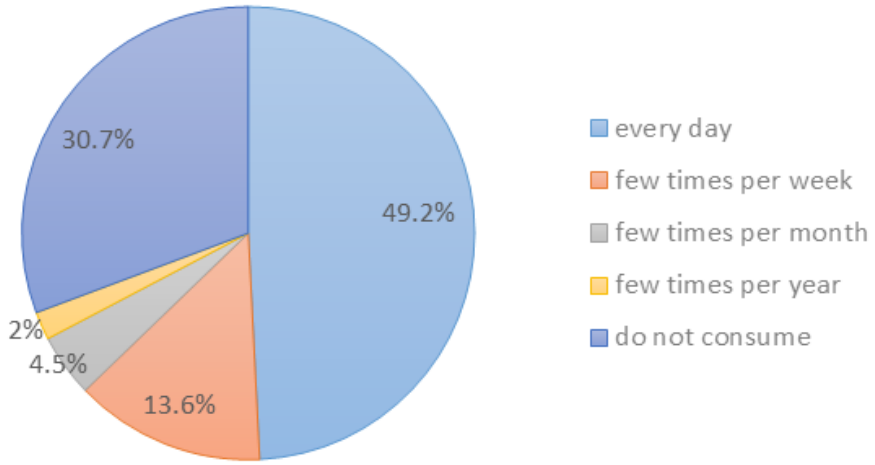

Figure 3 Frequency of consumption of gluten-free diet/products among the respondents (*n* = 200)

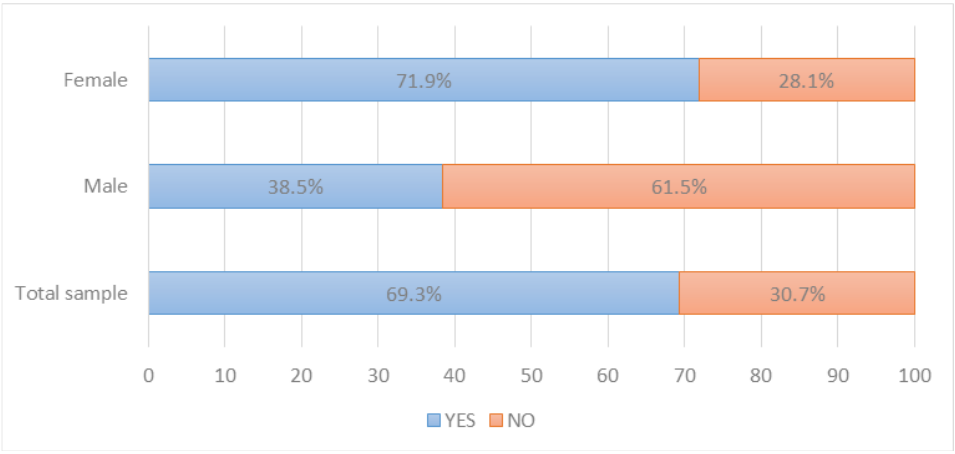

Figure 4 Respondent's answer to the question "do you consume food marked as "gluten-free"" (*n* = 200)

According to previous studies, the gluten-free dietary pattern is a necessity for the 1 - 1.5% of the total population suffering from celiac disease and 0.1% with wheat allergies, while it is beneficial for an additional 5-10% of the population with clinically diagnosed gluten sensitivity (Hadjivassiliou et al., 2010; Lis et al., 2014). When combining the obtained results, it is obvious that more respondents than what is medically supported consume gluten-free foods. This can be caused by the considerable popularity that gluten-free has gained in terms of good health lately (Gaesser and Angadi, 2015). Not only that there is an increasing number of people consuming a gluten-free diet due to their awareness of food and the diet, but also this trend is followed by the industry, so there is a marked significant increase in the availability and variety of gluten-free food products (Aziz et al., 2005).

The data about the reasons for gluten-free diet/products consumption was collected. The respondents in this investigation freely stated their reasons for avoiding gluten containing food. The reasons were different and are presented in **Figure 5**. The most common reason was celiac disease (the respondents or their family member have celiac disease), followed by non-celiac gluten sensitivity (28%) and digestive disorders caused by gluten consumption (25%). The respondents did not provide information about the diagnostic criteria for neither of the listed conditions. Only few of the respondents (5%) stated their belief that the gluten-free diet is the healthier option as the reason. This last group of respondents belong to the new segment of consumers that consume gluten-free products as a lifestyle choice (Foschia et al., 2016). The obtained results differ somewhat from those previously obtained among American adults, where 26% of respondents stated that it is a healthier option as explanation for selecting gluten-free food, 19% stated that the reason is digestive health and 18% stated that they or someone in their family has gluten sensitivity, while 35% of them have no reason for choosing gluten-free (Reilly, 2016).

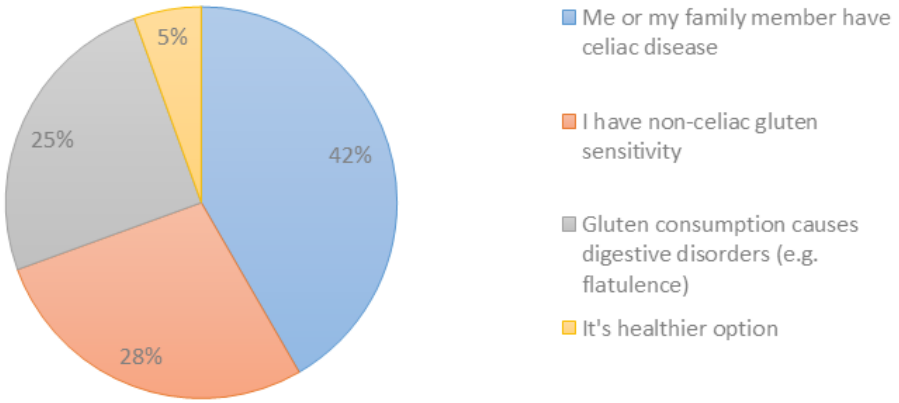

Figure 5 Reasons for choosing the gluten-free diet (*n* = 102)

Aside from the general population, the adherence to a gluten–free diet has also increased in prevalence among the non-coeliac athletic population. The reasons for going gluten-free include: clinically or self-diagnosed gluten sensitivity, the belief that the gluten-free is healthier, and/or the belief that the elimination of gluten will decrease inflammation and gastrointestinal distress. Additionally, the opinion among this population is that the benefits of a gluten–free diet include better performance and increased motivation for training (Lis et al, 2014).

One of the main focuses of this questionnaire was to determine the knowledge about gluten, and the first question for this determination was a simple question based on the personal opinion of the respondents about the knowledge of what the term "gluten" means, with possible yes/no answers. **Figure 6** represents the collected data for the total sample with the additional distribution according to gender. It was noticed that 95.5% of the participants consider that they know what the term "gluten" means, and when comparing according to gender, the results showed that women are more familiar with term, but without significant difference. Same results indicating that women reported higher prevalence of gluten-free diet consumption compared to males were obtained earlier within the Continuous National Health and Nutrition Examination Survey (NHANES) 2009-2010 (DiGiacomo et al., 2013).

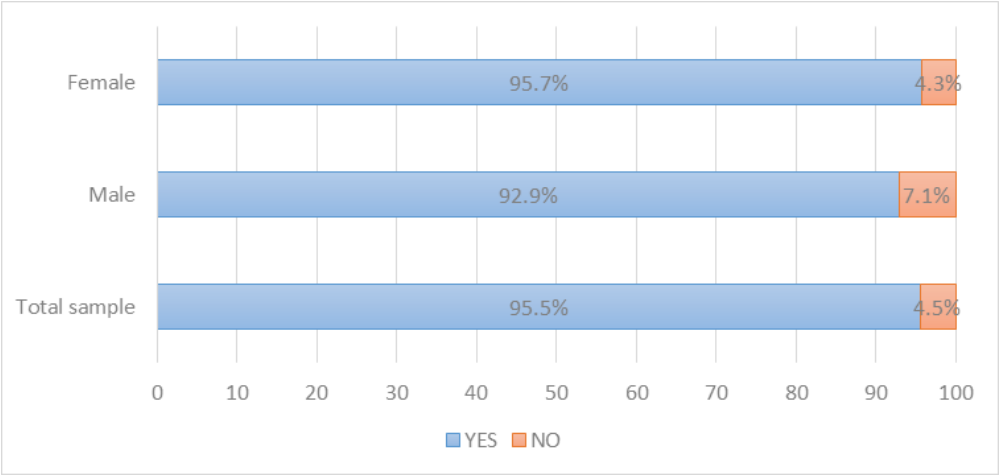

Figure 6 Respondents' statement about familiarity with the term "gluten"

Further questions for the determination of the respondents' knowledge about the gluten and gluten-free diet required providing their own definition of gluten and choosing claims in multiple-choice question which characterised gluten-free food. According to the responses tothosequestions, 4% of the participants who answered that they are not familiar with the meaning of the term gluten increased to 34.2%. This is still better knowledge than what Silvester et al. found in their research, where despite the popularity of the gluten-free diet, people still did not

know what gluten is and no one identified the gluten content of all 17 foods correctly, with only 30% who identified at least 14 foods correctly (Silvester et al, 2016).

The association between basic parameters and knowledge about gluten, as well as with gluten-free food consumption, was tested using the Chi-square test. Cramer's V strength test was used to test the data after a significant Chi-square result has been obtained. As it is shown in **Table 1**, knowledge about gluten was significantly associated with the employment status, with the health condition, and with adherence to a special diet. Regarding gluten-free food consumption, a significant association was established with gender, employment status, level of education, as well as with the health condition and the consumption of a special diet.

Table 1 Association between observed parameters using the λ^2 test

	Gluten-free food consumption				**Familiar with the term "gluten"**			
	λ^2	*p*	φ_c^2	*p*	λ^2	*p*	φ_c^2	*p*
Age	4.958	*0.084*	0.158	*0.084*	3.951	*0.139*	0.141	*0.139*
Gender	6.555	*0.010**	0.181	*0.010*	0.427	*0.514*	-0.084	*0.236*
Employment	11.761	*0.008**	0.243	*0.008*	14.826	*0.002**	0.273	*0.002*
Education	7.733	*0.021**	0.197	*0.021*	5.123	*0.077*	0.160	*0.077*
Income	1.869	*0.600*	0.097	*0.600*	2.703	*0.440*	0.117	*0.440*
Area (urban/rural)	9.505	*0.050*	0.219	*0.050*	1.402	*0.236*	-0.084	*0.236*
Diseases (chronic)	13.514	*<0.001**	0.261	*0.000*	5.696	*0.017**	-0.170	*0.017*
Special diet	54.689	*<0.001**	0.524	*0.000*	11.506	*0.001**	-0.240	*0.001*

**p<0.05*

CONCLUSIONS

In this study, with the aim of determining the knowledge about gluten, as well as the frequency of consumption of the gluten-free diet among the Croatian population, particularly among those that do not have any medical reasons for its consumption, poor knowledge, with around 30% of all interviewed subjects not being familiar with the terms "gluten" and "gluten-free diet", was determined. Almost half of the interviewed subjects (49.2%) stated that they consume gluten-free products/diet every day. More than half of the interviewed subjects who consume gluten-free products/diet stated that gluten causes gastrointestinal disorders for them. Just 5% of the respondents who consume gluten-free products/diet have the opinion that the gluten-free diet is a healthier option.

Further investigation, with a greater number of respondents and taking care of the respondents' gender distribution, and a more detailed questionnaire, is needed in order to obtain more accurate information about the opinion of the general

population regarding the gluten-free diet, with special emphasis on healthy population that adheres to the gluten-free diet.

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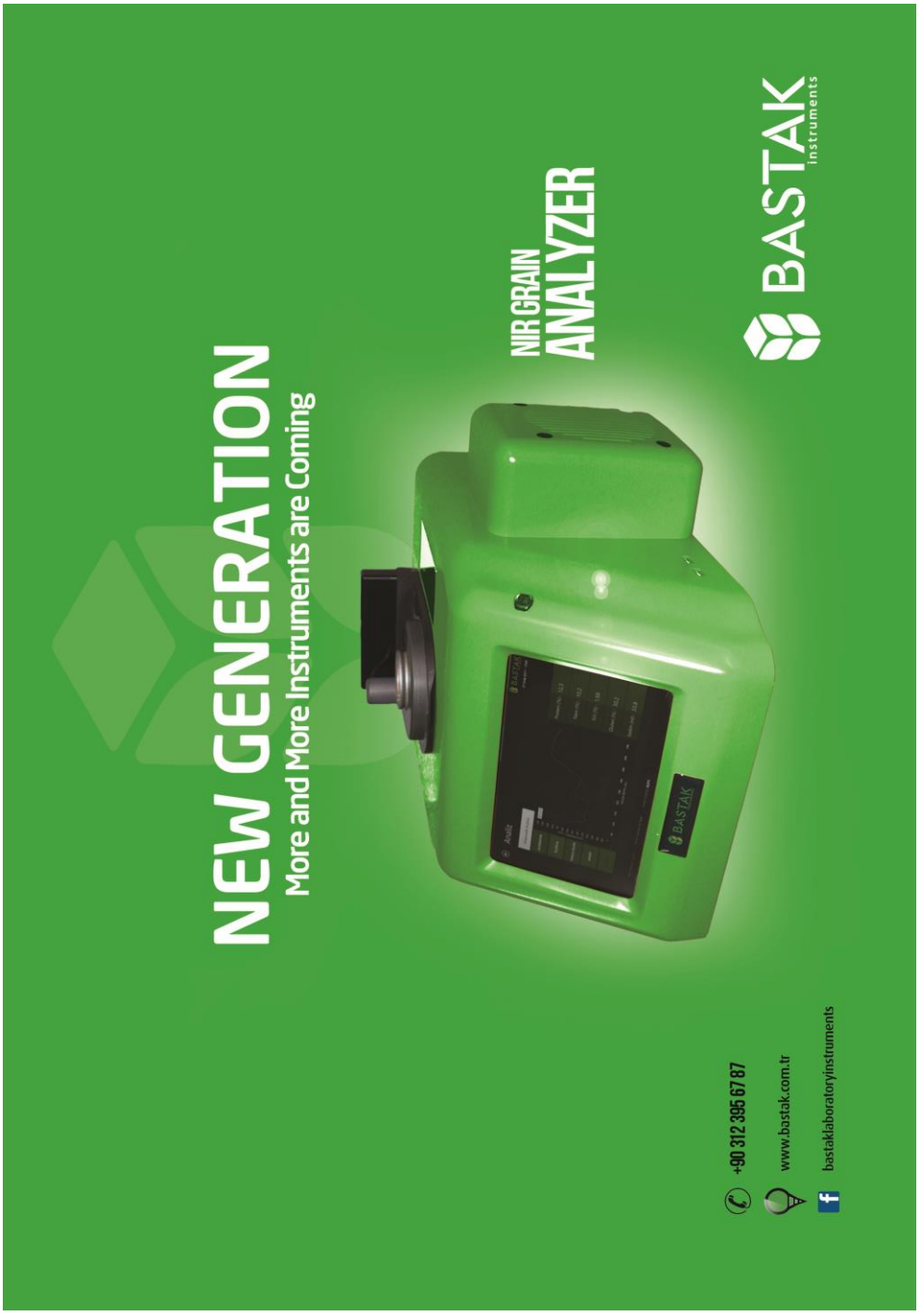

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