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Source / Izvornik: **Ružičkini dani : 13. međunarodni znanstveno-stručni skup Ružičkini dani "Danas znanost - sutra industrija" : zbornik radova, 2011, 412 - 417**

Conference paper / Rad u zborniku

Publication status / Verzija rada: **Published version / Objavljena verzija rada (izdavačev PDF)**

Permanent link / Trajna poveznica: https://urn.nsk.hr/urn:nbn:hr:109:368459

Hrvatsko društvo kemijskih inženjera i tehnologa
Prehrambeno-tehnološki fakultet Sveučilišta Josipa Jurja Strossmayera u Osijeku
European Federation of Food Science and Technology

Međunarodni znanstveno-stručni skup

XIII. Ružičkini dani

"DANAS ZNANOST – SUTRA INDUSTRIJA"

16. i 17. rujna 2010.
Vukovar, Hrvatska

ZBORNIK RADOVA

Osijek, 2011.

ZBORNIK RADOVA XIII. Ružičkini dani
DANAS ZNANOST - SUTRA INDUSTRIJA
PROCEEDINGS *13th Ružička days*
TODAY SCIENCE – TOMORROW INDUSTRY

Izdavači Prehrambeno-tehnološki fakultet Osijek
Hrvatsko društvo kemijskih inženjera i tehnologa (HDKI)
Published by *Faculty of Food Technology Osijek*
Croatian Society of Chemical Engineers

Glavni urednik Drago Šubarić
Chief Editor

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Tehnička urednica Ivana Pavleković
Technical Editor

Tisak i uvez Grafika d.o.o.
Printed by

Naklada 200
Number of Copies

Osijek, 2011.

ISBN (PTF): 978-953-7005-26-9
ISBN (HDKI): 978-953-6894-43-7

CIP zapis dostupan u računalnom katalogu
Gradske i sveučilišne knjižnice Osijek pod brojem 130201016
A CIP catalogue record for this publication is available from the City and University Library Osijek under 130201016

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Supported by:	Ministry of Science, Education and Sports of the Republic of Croatia
	Ministry of Agriculture, Fisheries and Rural Development of the Republic of Croatia
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	City of Vukovar

Topic: ***Food technology and biotechnology***

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UDC: 637.354 (497.5)

V. Slačanac*, J. Hardi, V. Krstanović, Ž. Marketanović

University of Josip Juraj Strossmayer in Osijek Faculty of Food Technology Osijek, Franje Kuhača 20, 31000 Osijek, Croatia

Summary

The aim of this study was to analyze texture of artisanal Croaitian hard cheeses, produced according to long-lasting tradition, originally from some Adriatic islands, such as Pag and Krk. Except texture profile analysis (TPA), composition and some physico-chemical properties of analyzed cheeses (water activity, pH values, colour of cheeses) were determined. Obtained results show that wide range of variability between analyzed hard ewe's cheeses exists. Cheeses were differing in following textural parameters: hardness, cohesiveness, springiness, elasticity and chewiness. Furthermore, parameters of colour, analyzed on the base of colour measurements parameters (L^*, a^*, b^*) varied between analyzed cheeses. It has been indicate that yellow nouance of island cheeses dominate in relation to continent cheeses. Differences pH values were also statistically significant between cheeses, whereas the water activity (a_w) between analyzed cheeses was not significantly different.

Keywords: artisanal ewe' hard cheeses, texture profile, colour, water activity, pH value

Introduction

Every dairy food has a "texture" that defines the product type and level of quality (Foegeding et al., 2003). Cheese is one dairy food where texture is a critical factor in evaluation of quality (Marshall, 1990; Drake et al., 1999). In a number of studies has been confirmed that texture and flavour affect consumer perception of quality and acceptability (Wilkinson et al., 2000). Instrumental TPA (Texture Profile Analysis) has been used to "profile" or "fingerprint" cheese (Drake et al., 1999). In a number of studies has been observed that instrumental TPA good correlating with sensory texture attributes (Rephaelides et al., 1995; Foegeding et al., 2003). In this study, texture profiles and physicochemical characteristics (composition, acidity, colour and water activity) of 6 autochthonous Croatian hard ewe's cheeses, originally from Croatian Mediterranean were analyzed. Additionally, physicochemical and texture properties of analyzed Croatian artisanal cheeses were compared with these of Italian and Spanish hard ewe's cheeses.

*Vedran.Slacanac@ptfos.hr

Materials and Methods

6 types of hard ewe's Croatian cheeses, as well as 1 type of Italian and 1 type of Spanish hard cheese were analyzed. Cheeses were coded as:

- A1, A2, A3, A4, A6 and A6 – for analyzed Croatian cheeses
- B1 – for an Italian type of hard ewe's cheese
- C1 – for a Spanish type of hard ewe's cheese

Cheese composition was analyzed using a FoodScan Analyzer (Foss, Sweden), according to the method described in Lawrence et al. (1987), which has been usually used for composition analyze of semi-hard and hard cheeses. Water, protein, milk fat and NaCl content were analyzed in all cheese samples.
pH values of analyzed ewe's cheeses were measured by MA 235, pH/Ion Analyzer (METTLER TOLEDO; Germany), according to official AOAC 962.19 method.
Water activity in cheeses was conducted by Rotronic Hygrolab 3 (Rotronic AG, Bassersdorf, Switzerland).
Measurement of colour was performed on Hunter-Lab Mini ScanXE (A60-1010-615 Model colorimeter, hunter-Lab, Reston, VA, USA). Hunter's parameters for the colour definition have been explained as:

- a* - green (-a*) or red (+a*)
- b* - blue (-b*) or yellow (+b)
- L* - totally bright (L* = 100) or totally dark (L* = 0).

Texture profile analyzes were conducted on TA.XT2i Plus (SMS Stable Micro Systems Texture Analyzer, Surrey, England)For instrumental TPA cheeses were cut into 15 mm cubes and warmed to room temperature. The test conditions were optimized as the follows (Bourne and Comstock, 1981): TA-25 probe; 50 mm dia cylinder; test speed 0.4 mm/s; pretest and posttest speed 0.4 mm/s; compression 80 %; pause 5 s. Following textural parameters were measure: hardness, cohesiveness, gumminess, resilience (deferred elasticity) and chewiness.
Puncture test was conducted using a TT-43 (PA/20) needle; dia 0.64 cm. Test and pretest speed were 0.5 mm/s, whereas the altitude of puncture throughout the cheese was 20 mm. Two parameters were determined by the puncture test: bioyield (kg/s) and flesh firmness (kg/s).
All the results were statistically analyzed by the use of Descriptive statistics pack in STATISTICA 8.0. Parameter values were compared between different samples using Correlation matrices and Fisher's Least Significance Differences (LSD) test, also in STATISTICA 8.0.

Results and Discussion

The basic composition and salt content in analyzed cheeses was presented in Table 1.

Table 1. Water, protein, milk fat and NaCl content in samples of hard ewe's (%, g/100 g)

Sample	Water*	Milk fat*	Proteins*	NaCl*
A1	37.58±1.2	32.01±0.05	42.08±0.5	1.80±0.2
A2	36.01±2.5	31.98±1.35	45.76±0.7	2.75±0.2
A3	38.26±0.7	31.14±0.11	47.89±1.2	1.65±0.4
A4	31.15±1.3	32.56±0.49	47.70±0.8	1.75±0.2
A5	38.27±1.1	28.66±2.26	40.32±1.4	2.81±0.7
A6	33.21±3.6	30.80±0.75	47.30±1.8	1.56±0.3
B1	33.55±1.8	33.50±2.66	41.41±0.6	2.12±0.5
C1	37.53±0.7	28.21±1.05	42.25±0.5	1.61±0.1

* - mean value ± SD of 5 replications
A1, A2, A3, A4, A5, A6, B1, B2 – coded cheeses

It is obvious that some significant differences between cheeses exist, both in composition and salt content. It could be the result of many factors during production and maturation of cheese, such as ovine milk composition, milk fermentation, traditional technological procedure and ripening duration. All analyzed cheeses are strictly traditional, and procedures of their production have regional character. E. g., cheeses produced on Croatian Mediterranean islands have been characterized with use of sea salt and lower salinity than cheeses produced in Croatian inland (Mioč et al., 2007).
In spite of determined differences in composition, pH values and water activity (a_w) between analyzed cheeses were not statistically significant (Table 2).

Table 2. Water activity (a_w) i pH values of analyzed cheeses*

Sample	a_w	pH
A1	0.906±0.06	5.40±0.05
A2	0.895±0.11	5.45±0.2
A3	0.903±0.10	5.55±0.05
A4	0.858±0.08	5.60±0.13
A5	0.931±0.08	5.60±0.09
A6	0.908±0.06	5.55±0.15
B1	0.915±0.07	5.65±0.15
C1	0.898±0.12	5.50±0.10

* - mean value ± SD of 5 replications
A1, A2, A3, A4, A5, A6, B1, B2 – coded cheeses

It suggests similar duration of ripening processes, as well as similar ways of milk fermentation during cheese production.
Very important parameter which has sensory and psychological influence on customers is colour of cheese. The results of the colour analyses are presented in Table 3.Variations in values of all three Hunter's parameters between cheeses are obvious. However, all analyzed cheeses had clearly expressed yellow nuance and high level of brightness, what has been characteristically for ovine cheeses, especially for hard ovine cheeses which mature during long time (Ryffel et al., 2008). Take to be mentioned that to cheeses analyzed in this study was not added colour, than it is arise from differences in milk composition and ripening processes.

Table 3. Measured values of colour parameters (*, **)

Sample	*L**	*a**	*b**
A1	78.14^{b}	-0.48^{e}	20.75^{d}
A2	77.93^{b}	-1.51^{c}	24.86^{bc}
A3	77.25^{b}	-1.25^{d}	25.52^{ab}
A4	81.86^{a}	4.38^{a}	26.04^{a}
A5	75.65^{c}	-2.37^{b}	18.71^{e}
A6	72.96^{d}	-1.57^{c}	20.21^{de}
B1	74.29^{cd}	-1.63^{c}	24.65^{bc}
C1	78.72^{b}	2.22^{b}	25.50^{ab}

A1, A2, A3, A4, A5, A6, B1, B2 –coded cheeses
L* (0= dark; 100 = total bright), a* (+ red, - green), b* (+ yellow, - blue)
*Mean values followed by the same letter in the same column not significantly different ($P<0.05$)
**Mean ± standard deviation, $n = 5$

Table 4 shows the values of textural parameters measured by TPA. According to the measured values, all cheeses have hardness typical for long-time ripened ewe's hard cheeses (Medina and Nunez, 2004). However, some variability between cheeses texture was still determined. The largest differences between cheeses were noted for hardness and chewiness. Cohesiviness was approximately equable for all analyzed cheeses, whereas the guminess and resilience varied between different cheeses, but not obviously like hardness and chewiness.
Correlation between some TPA parameters, e.g. between hardness and chewiness had been expected. However, calculated correlation parameters (Table 5) show that only statistically significant correlation was between cohesiviness and gummines.

Table 4. The Texture Profile Analysis results (*, **)

Sample	Hardness*	Cohesiviness**	Gumminess**	Resilience**	Chewiness**
A1	13204.073^{bc}	0.587	0.08	0.566	974.979^{b}
A2	12683.214^{c}	0.584	0.08	0.472	360.061^{de}
A3	14302.093^{a}	0.531	0.053	0.610	607.625^{c}
A4	13693.157^{b}	0.556	0.059	0.560	553.192^{cd}
A5	12582.805^{cd}	0.572	0.074	0.596	416.793^{d}
A6	12796.97^{c}	0.598	0.061	0.692	312.350^{e}
B1	13434.779^{b}	0.590	0.042	0.460	299.839^{e}
C1	14517.460^{a}	0.606	0.071	0.874	1207.804^{a}

A1, A2, A3, A4, A5, A6, B1, B2 – coded cheeses
*Mean values followed by the same letter in the same column not significantly different (P<0.05)
** Mean ± standard deviation, *n* = 10

Table 5. Correlation matrix for TPA parameters

	Hardness	Cohesiviness	Gumminess	Resilience	Chewiness
Hardness	1.00	0.12	-0.36	0.51	0.64
Cohesiviness	0.12	1.00	0.83	0.32	0.69
Gumminess	-0.36	*0.83*	1.00	0.17	0.39
Resilience	0,51	0.32	0.17	1.00	0.66
Chewiness	0.64	0,69	0.39	0.66	1.00

Statistically significant on $p \leq 0.05$

Picture test could be good indicator of crust thickness, crust hardness, but also of cheese hardness from crust to the center of cheese. Crust properties have been determined by flesh firmness, while the cheese hardness has been detected on the base of bioyield values. Table 6 show values measured by puncture test. The highest bioyield values were measured for Spanish and Italian hard ewe's cheese, but also for one Croatian cheese (coded as A1).

Table 6. The puncture test results for analyzed hard ewe' cheeses (*,**)

Sample	Bioyield (kg/s)	Flesh firmness (kg/s)
A1	420.068^{a}	161.494^{c}
A2	237.011^{c}	97.369^{e}
A3	320.389^{b}	211.706^{a}
A4	323.467^{b}	180.646^{b}
A5	156.786^{d}	96.578^{e}
A6	199.948^{cd}	141.311^{d}
B1	420.068^{a}	186.453^{ab}
C1	425.408^{a}	156.453^{c}

A1, A2, A3, A4, A5, A6, B1, B2 – coded cheeses
*Mean values followed by the same letter in the same column not significantly different (P<0.05)
**Mean ± standard deviation, *n* = 10

Wide range of variations between bioyield values of analyzed cheeses was noted (Lavanchy et al, 1994). It can be said that cheeses with high bioyield values has high hardness deep in the field of cheese. Differently, in cheeses with lower bioyield values, hardness decrease from crust to the cheese center. Flesh firmess is not in correlation with the bioyield and indicates the force necessary for breakthrough of cheese crust. According to data presented in Table 6, cheese A3 had the highest crust thickness and hardness. Statistical analyze of experimental data show that bioyield values obtained by puncture test are in correlation with values for hardness ($r = 0.78$) and chewiness ($r = 0.69$) given by TPA.

Conclusions

Results obtained by this study show that for the definition of cheese texture complex analyze is necessary and many factors must be taken into consideration. Cheese quality is directly defined with the parameters such as composition, texture, colour and acidity. Between them cheese texture is the most hardly to describe. Both TPA and puncture analysis could give adequate number of information for describing of cheese texture. Some variations in textural and physicochemical parameters between analyzed cheeses were noted, but all cheeses had characteristics typical for hard ewe's cheeses.

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