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The Impact of Glucono Delta Lactone (GDL) and Starter Cultures over the Chemical Composition in Fermented Sausages

Elena Joshevska[1], Aco Kuzelov[2], Tatjana Kalevska[3], Gordana Dimitrovska[1], Borche Makarijoski[1]

[1]Department of Food Technologies, University "St. Kliment Ohridski"- Bitola, Faculty of Biotechnical Sciences, North Macedonia
[2]Department of Food Technologies and Processing of Animal Products, Goce Delcev University of Stip, Faculty of Agriculture, North Macedonia
[3]Department of Food Technologies and Biotechnology, University "St. Kliment Ohridski"- Bitola, Faculty of Technology and Technical Sciences, Veles,Nort Macedonia

Corresponding Author: Elena Joshevska

ABSTRACT

The paper presents the dynamics of changes in the chemical composition of fermented sausages produced in the local meat industry, from the beginning until the end of ripening process (3; 7; 14; 20-day). Sausages are produced using Glucon Delta Lactone (GDL) additive and starter cultures. The addition of GDL and starter cultures has great influence on the pH value, as well as of the overall enzymatic process and of the achieved degree of ripening and drying. The results indicate more intensive proteolysis during the first seven days of the ripening. The intensity of proteolysis was stimulated by the activity of endogenous proteins and peptides of microorganisms from starter cultures. The complete chemical composition in all production batches corresponds to the requirements of the Rulebook on quality of minced meat, meat preparations and meat products.

Key words: ripening, quality, meat, sausages, technology

INTRODUCTION

Meat and the fatty tissue are basic raw materials which have a large influence on the consistence, fermentation process of maturation of the sausages and their nutritive value.

The assortment of fermented sausages is quite developed, depending on the composition of the filling, the degree of chop of the components in the filling, the diameter of the casing, the seasonal production, and the duration of ripening.

In Germany, which appears as one of the largest sausage producers, around 350 types of fermented sausages are produced, although the tradition of producing them is only 160 years old. In Spain, about 50 varieties are cataloged, MAPA (1997).

For the significance of this high-quality group of sausages, the data shows that around 750,000 tons are produced annually in the European Union, (Vukasinović et al., 2012).

Through the appropriate selection of raw materials, (meat and fat tissue-basic technological operation), the production of fermented sausages is based on controlled biochemical processes of enzymatic and microbiological nature.

Their quality depends on the dynamics of changes in components primarily of carbohydrates, proteins and fats. According to their intensity, such changes more or less influence of the formation of the sensory, rheological and microbiological properties of the finished

product, (Inzze, 1992; Flores & Bermell, 1996; Erkylä, 2001).

The basic filling constitutes the meat and fat tissue. In the opinion of a number of authors, the influence of exogenous factors on meat quality is greater than the impact of endogenous factors, whereas the authors (Redde 1987; Čepin & Čepon, 2001) state that the dominant influence on the quality of meat has the diet and the practice of raising animals. In order to produce fermented sausages well-cured meat of healthy animals, with normally marked postmortem changes should be used (Čavlek & Mavraćić, 1993).

Under these conditions additives and supplements, primarily salt, easily penetrate the interstitial structures and have an intense influence on the formation of the color and structure of the brine. Sausages produced of meat with such quality easily discharge water, they dry quickly, and the water exchange is established in the central and peripheral layers is done easily, and greater sustainability of the product is achieved.

The white granular back bacon from old obese pigs is the most acceptable. The larger the percentage of the added bacon, the lighter color of the final product is achieved.

Stiebing et. al.,(1993**)** established that the fermented sausages (dry-cured pork, kulen), with the use of optimal technology, can also be produced from "soft" fat tissue (polyunsaturated fatty acids to 21%). On the other hand, the larger percentage of polyunsaturated fatty acids can cause bad taste of the final product. According to this, the possibility for storage of these products is limited. The sausages that are produced from fatty tissue with lower level of polyunsaturated acids can keep their sensor characteristics for six months of storage.

The ripening of fermented sausages is a complex chemical- biochemical process of decomposition of proteins, fats and carbohydrates in which besides the enzymes from the muscles and fats, the enzymes of the added starter cultures partake, Žlender, (2001).

During the ripening process, color formation, joining the components to the filling with the consistency, the change of the pH and the pH, dryness and aromatization (change of the taste and odor) are achieved.

MATHERIALS AND METHODS

Materials

Durable pork sausages were produced in industrial conditions according to standard recipe in the factory for meat "MIK"-Sveti Nikole in the Republic of N. Macedonia.

Two different series were produced:

Group A (40% first category pork meat (thigh), 40% second category pork meat (shoulder blade), 20% firm fatty tissue (back bacon) and Glucon delta-lacton (13g/50kg).

Group B (40% first category pork meat (thigh), 40% second category pork meat (shoulder blade), 20% firm fatty tissue (back bacon) and freeze-dried starter culture Bactoferm F-SC-111, Chr.Hansen (30g/50kg). The starter culture was mixed culture with *Lactobacillus sakei* and *Staphylococcus carnosus*.

The following additives were used: nitrite curing salt (2.2%), sodium erythorbate (0.05%), dextrose (0.5%), grinded pepper (0.025%), garlic in powder (0.015%) and a mixture of spices "Koleks" for durable pork sausage.

Every group of sausages was produced in three repeated series in a quantity of 50 kg. Seven samples of each group during the three repeated series (at the day of filling, at the 3rd, 7th, 14th and 20th day of the ripening) were taken for examination.

Technological process of production

Temperature of the pork meat before the chopping was -3.2ºC, - 11ºC of the firm fatty tissue (Group A and B). The frozen meat and the fatty tissue were chopped in pieces of 10 cm, and then chopped again with granulation of 10 mm. To the chopped mixture with temperature of -3 ºC, spices

and GDL (Group A) and starter culture (group B) were added.

Then, the filling was additionally chopped and mixed with granulation of 3 mm for a period of 2-3 minutes. After the chopping, the temperature of the prepared filling was -2.5ºC. Prepared filling was then filled with vacuum machine in collagen intestines with a diameter of 36 mm. The filled sausages were hanged on metal rails and washed with cold water and then, were transported to thermo-chambers where they were drained for 24 hours at a temperature of 16 ºC. Then, there was a phase of smoking for 12 hours at a temperature of 15-20 ºC, and relative humidity of 95%.

After the smoking, the sausages were left to ripening to the 20th day, with two more phases of smoking at the 7th day of their ripening, for 5 to 10 hours (5 hours of smoking with 5 hours of pause), at a temperature of 18 ºC and humidity of 82% and at the 14th day of their ripening for 5 hours at a temperature of 14 ºC and relative humidity of 75%.

Methods

Determination of chemical composition

Chemical composition of meat and fatty tissue as raw materials for the production of durable sausages were carried out according to standard methods described by (IDF-ISO-AOAC). After the manufacturing process, the chemical composition was carried out for the finished sausages. The protein content was examined by using Kjeldahl method. The moisture content was determined by means of drying at 105± 2°C up to constant mass. The fats were determined according the (ISO 1443:1973) and the mineral matters were determined by means of burning and combustion (4-5 hours) at 525 - 550°C (ISO 936:1998). Value of pH was determined by pH meter'' *testo*'' 205.

Statistical analysis

Each parameter was determined after three repetitions, and the results are presented as mean value ± Sd. The obtained results are mathematically and statistically processed in Microsoft Excel.

RESEARCH RESULTS

Chemical composition of meat as a raw material

The results from the chemical composition of pork meat and fatty tissue used as raw materials in production of sausages are given in Table 1

Table1: Chemical composition of pork meat I category and fatty tissue (bacon)

Batches	A					B				
	Pork meat from the I category (thigh)									
Day	$\bar{x}$	min	max	Sd	Cv	$\bar{x}$	min	max	Sd	Cv
Water	74.38±0.03	74.30	74.49	0.07	0.09	75.96±0.08	75.60	76.14	0.21	0.27
Fats	1.98±0.03	1.85	2.00	0.07	3.42	2.02±0.09	1.50	2.30	0.25	12.58
Proteins	22.05±0.14	21.84	22.85	0.36	1.62	20.82±0.13	20.43	21.42	0.34	1.66
Ash	1.19±0.01	1.16	1.20	0.02	1.78	1.18±0.01	1.15	1.20	0.02	1.80
	Fatty tissue (bacon)									
Water	36.03±0.02	35.95	36.08	0.05	0.13	32.89±0.12	30.97	33.87	0.33	0.97
Fats	55.08±0.05	54.95	55.26	0.12	0.22	57.34±0.14	54.07	59.30	0.36	0.67
Proteins	7.27±0.02	7.20	7.35	0.05	0.72	8.35±0.02	8.27	8.43	0.06	0.73
Ash	1.44±0.02	1.40	1.50	0.04	3.04	1.46±0.02	1.39	1.50	0.05	3.21

$F_{0,05}$= 3.55 /p<0,05
$F_{0,01}$= 6.01/ p<0,01

The results obtained from the analysis of the chemical composition of pork from the first category used for the production of durable sausages (production series A and B) are shown in Table 1. The average values for the water content are as follows: 74.38 ± 0.03% for the production series A, 75.96 ± 0.08% for the production series B. Regarding the fat content, the following average values for the production series A, B can be ascertained: 1.98 ± 0.03%; 2.02 ± 0.09%. For the protein content of pork, the following average values were found: 22.05 ± 0.14%; 20.82 ± 0.13%. The content of the minerals for the production series A and B have an average

value of: 1.19 ± 0.01%; 1.18 ± 0.01%. The results of the analysis of the chemical composition of pork I category for the production series show a statistically significant difference at the level of ($p < 0.01$); with the exception of minerals where differences between groups are not statistically significant. Differences in the chemical composition of pork intended for the production of sausages between the production batches are the result of the influence of two groups of factors: factors that are affecting before rigor mortis (genetic basis, way of keeping and feeding, race, sex, age, transport and preparation for slaughter) and factors that post mortal affect the body mass (the technological procedure of carcass handling). Our results are similar to the results of the analysis of the chemical composition of pork in a large number of literary data (Okrouhlat et al., 2006, Butco et al., 2007; Migdal et al., 2007).

The results of the analysis of the chemical composition of the fatty tissue (bacon), used as a raw material of the technological process of production, in the production series A and B, show a statistically significant difference ($p < 0.01$); with the exception of minerals where statistically significant differences were not found between the analyzed groups. Fat tissue has an influence on the water retention ability (aw), (Klettenner & Rödel, 1980), as well as on the maturity of ripening, (Rödel, 1985).

Dynamics of the changes in the active acidity (pH)

On the quality of fermented sausages, pH value has the great influence of the filling during the whole production process.

The dynamics of the changes in the active acidity (pH) of durable sausages during the various stages of ripening, expressed through the average values, are shown in Table 2.

Table 2: The dynamics of the changes in the active acidity (pH) of sausages during ripening

Production Batches	A					B				
Day of Sausage filling	$\bar{x}$	min	max	Sd	Cv	$\bar{x}$	min	max	Sd	Cv
0	5.66±0.03	5.56	5.87	0.12	2.06	5.71±0.02	5.58	5.85	0.09	1.51
3	5.13±0.02	5.00	5.21	0.06	1.15	5.12±0.03	4.96	5.28	0.10	1.98
7	4.66±0.03	4.49	4.89	0.12	2.64	4.63±0.02	4.69	4.87	0.08	1.65
14	4.70±0.02	4.57	4.83	0.07	1.56	4.79±0.02	4.59	4.93	0.09	1.97
20	4.83±0.02	4.68	4.95	0.09	1.77	4.96±0.02	4.82	5.03	0.07	1.31

$F_{0,05}$= 3.55 /p<0,05
$F_{0,01}$= 6.01/ p<0,01

From the presented data of pH values changes in the production batches (A and B), we can conclude that there is a tendency of decline, where minimal values have been achieved on the 7th day of ripening (4.66 as well as 4.63). After the 7th day, a slight increase of the pH value has been noticed and kept until the end of the ripening process, as a consequence of the protolithic changes in the fermented sausage. The same dynamics and similar pH values have also been established in the investigation of the (Kozachinski et al., 2008) in traditional fermented sausages. Salgado et al., (2005) state that the initial decline in the pH value in various dry and fermented products varies in a wide range of 0.16 to one or more units, and then, during ripening, there is an increase in the pH, most often in an interval of 0.2 -0.5 units, as evidenced by our research. The addition of GDL and starter cultures has great influence on the pH value, as well as of the overall enzymatic process, the achieved degree of ripening and drying and for the formation of the sensory properties of sausages.

Chemical composition on sausages during ripening

The results from the impact of GDL and starter culture on the chemical composition on sausages during ripening are given in Table 3.

From the results it can be concluded that statistically significant differences at the level of ($p<0.01$) for the water content are determined on the 7th, 14th and 20th day of ripening. Durable sausages are characterized by less water content and a larger amount of dry matter. The low water content of sausages is not a consequence only of the ripening and drying process, but also of the higher content of fat in the filling.

According to the proteins content on the 20th day, the protein content is: 28.90 ± 0.38% in the production batches A; 28.15 ± 0.28% in the production batches B. From the presented data, dynamics of protein growth during the entire ripening period in both production batches. The most increasing of the protein content has been noticed in the first seven days of production, which is in proportion with the decrease of the pH value. These results also indicate more intensive proteolysis during the first seven days of the sausage filling.

Table 3: Chemical changes in the production batches during ripening

Production Batches	**A**					**B**				
	Water									
Day of sausage filling	$\bar{x}$	**min**	**max**	**Sd**	**Cv**	$\bar{x}$	**min**	**max**	**Sd**	**Cv**
0	45.70±0.22	44.87	46.75	0.68	1.48	47.16±0.19	46.25	48.06	0.61	1.30
3	38.85±0.28	36.88	39.35	0.89	2.28	39.05±0.21	38.05	40.02	0.65	1.67
7	37.10±0.19	36.00	38.30	0.63	1.69	38.00±0.22	37.00	39.07	0.68	1.77
14	31.70±0.35	29.75	32.95	1.10	3.46	33.80±0.20	32.88	34.65	0.62	1.84
20	28.45±0.32	27.22	30.07	1.02	3.59	30.90±0.21	29.90	32.06	0.65	2.09
Fats										
0	31.90±0.27	30.55	33.10	0.85	2.66	31.20±0.25	30.05	32.25	0.78	2.51
3	34.25±0.28	32.33	35.25	0.87	2.55	34.70±0.36	32.90	36.93	1.15	3.30
7	35.35±0.19	34.45	36.10	0.60	1.70	34.90±0.37	33.80	37.90	1.16	3.34
14	37.30±0.17	36.40	38.15	0.55	1.48	36.20±0.30	34.10	37.50	0.95	2.63
20	38.18±0.12	37.77	39.07	0.38	1.00	36.70±0.34	34.55	38.10	1.08	2.95
Proteins										
0	19.60±0.15	18.70	20.15	0.48	2.43	18.90±0.17	18.20	20.15	0.55	2.89
3	23.90±0.30	22.00	25.02	0.96	4.00	23.30±0.43	20.10	24.60	1.35	5.78
7	24.20±0.28	22.85	26.25	0.90	3.70	24.00±0.29	22.00	25.00	0.93	3.78
14	27.25±0.23	26.25	28.60	0.74	2.70	26.45±0.25	25.20	28.10	0.79	2.98
20	28.90±0.38	25.95	29.95	1.21	4.17	28.15±0.28	27.65	29.10	0.87	3.07
Ash										
0	2.70±0.09	2.10	3.10	0.30	11.28	2.74±0.07	2.20	3.07	0.22	7.93
3	2.88±0.16	2.17	3.85	0.50	17.65	2.91±0.08	2.35	3.20	0.25	8.43
7	3.64±0.14	2.85	4.10	0.43	11.78	3.14±0.17	2.40	4.08	0.54	17.17
14	3.75±0.15	2.65	4.35	0.49	12.96	3.55±0.12	2.95	4.10	0.37	10.35
20	4.31±0.12	3.80	5.30	0.37	8.73	4.16±0.09	3.70	4.55	0.27	6.54

$F_{0,05}$= 3.55 /p<0,05
$F_{0,01}$= 6.01/ p<0,01

The intensity of proteolysis was stimulated by the activity of endogenous proteins and peptides of microorganisms from starter cultures, which is particularly important for increasing the content of polypeptides, peptides, and free amino acids that effect on the taste, smell and aroma of the sausages. Zanardi et al., (2004), depending on the raw material composition of the filling, the used additives and ripening conditions, in traditional fermented sausages, the protein content was determined from 17.60 ± 0.6% to 24.0 ± 0.2%. Fats represent a significant component of the chemical composition of durable sausages.

On the day of filling, the average fat content of durable sausages from the production batches A was 31.90 ± 0.27% and 31.20 ± 0.25% for durable sausages from the production batches B.

On the 7th day of filling of durable sausages, the fat content is: 35.35 ± 0.19% or 34.90 ± 0.37%. On the 14th day of filling, the fat content is 37.30 ± 0.17% in the production batches A; 36.20 ± 0.30% in the production batches B. On day 20, the

average fat content is: 38.18 ± 0.12% or 36.70 ± 0.34% for both batches.

The differences in fat changes in the sausages are statistically significant ($p < 0.01$), in all ripening period. Based on the presented results there is a dynamics of increase in the fat content: 19.69% in the production batches A; 17.63% in the production batches B. The reason for this increasing in the total fat content from the moment of filling to the end of ripening is due to the type of raw material used in the composition of the filling. It is considered that the release of water is more difficult for the fat tissue, due to its histological construction. The added additives do not have a major impact on the fat content.

Petrovic et al., (2011), in traditional fermented sausages, found fat content from 34.09 ± 1.15% to 37.71 ± 0.52%, produced in areas protected by geographical indication of the product (Petrovacka kobasica). Fats have a major influence on the energy and nutritional value of durable sausages.

The content of ash from the investigation show changes throughout the enzymatic process, (Table 3). At the end of ripening, the average content of ash is: 4.31 ± 0.12%; 4.16 ± 0.09% where statistically significant differences were noted ($p < 0.05$).

From the data presented, it is noticeable the dynamics of the increase in the ash in the production batches during the whole production period. The increasing is the results of evaporation of water during ripening.

Minerals in durable sausages derived primarily from the basic raw material of the filling, the meat and the added amount of brine during production. Their influence on the ripening is direct because of their selective action on microorganisms that perform fermentation and reduce the amount of water. Minerals also influence of the sensory properties of durable sausages

CONCLUSION

From the results it can be seen that in both production batches can be determined that the sausages have the correct course of fermentation and adequate maturity.

The added additives (GDL and starter culture) in both production batches show similar results with certain variations. Through the completed comparative analysis, it can be concluded that both can be successfully added in the sausage filling if the correct production technology and ripening conditions are observed.

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