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Rabbit meat in production of frankfurters

M. Lušnic Polak[1], T. Polak[1], K. Lekše[1], L. Demšar[1]*

Abstract

Meat is the most important source of protein, essential amino acids, minerals and B-complex vitamins in our diet. From the nutritional point of view, rabbit meat has a favourable composition due to its relatively low-fat content and belongs to dietary foods. At the same time, consumers of rabbit meat also recognize the typical delicate flavour and distinct tenderness of rabbit meat. For purpose to increase the consumption of rabbit meat products, we prepared and evaluated rabbit frankfurters with the addition of pork back fat and/or sunflower oil (rich in monounsaturated fatty acids, favourable ratio of n-3/ n-6 fatty acids) and without the addition of phosphate. The results showed that the frankfurters with pork back fat are more acceptable from a sensory point of view. The absence of phosphate results in a lighter, less rubbery texture, and at the same time the oxidation process is faster. It can be concluded that rabbit meat is suitable for processing into meat products, especially when combined with vegetable oils, which gives good results, as such a product approaches the optimal fatty acid composition and thus has a positive effect on the health of the consumer.

Keywords: rabbit meat, frankfurters, chemical composition, sunflower oil, pork back fat, sensory properties

Introduction

The basic characteristics of rabbit meat are high protein content (about 22 g/100 g in loins), a relatively low fat content (1.8-8.8 g/100 g) with a favorable ratio saturated and unsaturated fatty acids, a high vitamin B content, a low sodium content (37-49.5 mg/100 g), a high phosphorus content (222-234 mg/100 g) (Dalle Zotte and Szendro, 2011; Olmedilla-Alonso et al., 2013), and the muscle proteins exhibit angiotensin-converting enzyme inhibitory characteristics and antioxidant properties (Chen et al., 2021). Rabbit meat can also be enriched by adding bioactive components, namely by enriching the rabbit diet or by adding supplements to the meat during processing. As defined by the EC consensus document FUFOSE (1999), rabbit meat can be considered a functional food if it has been shown to have a beneficial effect on one or more physiological functions in the body or to reduce various health risks at levels normally consumed in the human diet (Diplock et al., 1999;

[1] **Assistant professor Mateja Lušnic Polak, PhD, associate professor Tomaž Polak PhD, Katja Lekše, M.Sc., full professor Lea Demšar, PhD;** University of Ljubljana, Biotechnical Faculty, Jamnikarjeva 101, 1000 Ljubljana
****Corresponding author: mateja.lusnic@bf.uni-lj.si***

Kwak and Jukes, 2001). Therefore, some effective strategies are known to further improve the functional value of rabbit meat, as the essential fatty acid content can be very effectively increased by nutritional approaches (Martinez et al., 2005; Bianchi et al., 2009; Matics et al., 2017), increased with vitamin E (Castellini et al., 1998; Dalle Zotte et al., 2000), selenium (Matics et al., 2017) and spirulina algae, a natural source of vitamin B12 (Dalle Zotte et al., 2014), and improved their oxidative stability (Cardinali et al., 2015; Dal Bosco et al., 2014). On the other hand, the quality of rabbit meat is already very good without the addition of these substances and there is not much need for additional improvements (Cullere and Dalle Zotte, 2018).

Health is often the reason for changing consumers' eating habits and, consequently, the frequency of meat consumption (Escriba-Perez et al., 2017). The nutritional quality of rabbit meat definitely meets the requirements of the modern consumer. The advantages for the sale and consumption of rabbit meat are its low fat content, characteristic aroma and excellent water-holding capacity, as well as the reputation of traditional specialties (Leroy and Praet, 2017). In addition, consumers of rabbit meat also recognize the typical flavor and tenderness of rabbit meat. However, those who are not accustomed to rabbit meat believe that it has a gamey taste and therefore reject it (Dalle Zotte, 2002). The appearance of the meat also plays an important role for consumers, as rabbit meat is sold in the form of whole or half carcasses, often with the head. Due to the unattractive appearance and lack of awareness of this type of meat, rabbit meat does not sell very well. In summary, the constraints are technical and economic (Petracci and Cavani, 2013): high production costs, sale of whole rabbit carcasses with heads, difficult carcass cutting, brittle bones, low juiciness of meat after heat treatment and, on the other hand, consumer perception of rabbits as pets, consumer concern about the environment and animal welfare in caged farming (Leroy and Praet, 2017; Petracci et al., 2018; Ščap, 2021). Strategies to increase sales and consumption of rabbit meat and products in the future include: a stress-free way of raising rabbits, changing the nutritional profile of meat, using the good technological properties of meat in processing, using different forms of marinating and attractive packaging, culinary revival of different traditional dishes by tricks such as adding different fillings or rolling steaks in bacon slices, and using modern marketing approaches (Petracci and Cavani, 2013; Matics et al., 2017; Petracci et al., 2018).

The largest producer of rabbit meat in the world is China; in Europe, the largest producers of rabbit meat are Italy, Spain, and France (Dalle Zotte and Szendro, 2011). Rabbit meat is mainly consumed in European countries or in Mediterranean countries such as Malta, Cyprus, Italy, Spain, Portugal, France, Slovenia, as well as in the Czech Republic, Belgium, and Luxembourg (FAOSTAT, 2018). Rabbit meat is also popular in some North African countries (Egypt, Algeria) and Indonesia (Leroy and Degreef, 2015).

Frankfurters are a very popular meat product and represent an economic gain worldwide. Due to the trend of "healthy eating', the type and amount of fat contained in the products is an important parameter in their production. Pork back fat is the most used, as it forms a stable emulsion, reduces losses during heat treatment, can bind water better, and provides more juiciness and suitable texture. Due to its high cholesterol content, bacon is substituted with vegetable oils (Panagiotopoulou et al., 2016). Rabbit meat can be used to produce frankfurters. Therefore, the main objective was to produce and evaluate rabbit frankfurters with a favourable fatty acid composition and a lower use of additives. In addition, the sensory acceptability of rabbit frankfurters was evaluated. It was assumed that rabbit frankfurters with added vegetable fat have a nutritionally very favourable fatty acid composition, frankfurters without added phosphate mix are sensory acceptable and comply with current legislation.

Material and methods

Material

For the production of rabbit frankfurters, the following ingredients were used: hand-separated meat of whole rabbits and pork back fat (purchased in a local store, frozen at -30 °C and kept at -18 °C until analyses and production of frankfurters), sunflower oil (Cekin brand, Tovarna olja Gea d.d.), ice, nitrite salt (mix of NaCl and additives: salt, preservative (E 250) 0.5 % to 0.6 %, Prava Aroma, d.o.o.), ground red pepper (Maestro brand, Žito d.o.o.), curry (Maestro brand, Žito d.o.o.), spice mix for chicken frankfurters, phosphate mix (Aroma UK), potato starch and isoascorbate (Prava Aroma, d.o.o.), and artificial collagen casings.

Production procedure of rabbit frankfurters

Frankfurters were produced from rabbit meat and sensory evaluation was performed the next day after production. The recipe used for the preparation of the four experimental groups is presented in Table 1. For this purpose, four experimental groups of frankfurters were prepared: group A using rabbit meat and pork back fat as control, group B using rabbit meat and sunflower oil, group C using rabbit meat, pork back fat (50 %) and sunflower oil (50 %) and group D using rabbit meat, pork back fat (50 %), sunflower oil (50 %), isoascorbate and potato starch as a substitute for the phosphate mix.

Table 1 Ingredients (g) for the preparation of four experimental groups of rabbit frankfurters

Item (g)	Group			
	A	B	C	D
Rabbit meat	600	600	600	600
Pork back fat	200		100	100
Ice	200	200	200	200
Sunflower oil		200	100	100
Nitrite salt	14	14	14	14
Ground red pepper	2	2	2	2
Curry	1	1	1	1
Spice mix	2	2	2	2
Phosphate mix	4	4	4	
Isoascorbate				2
Potato starch				20

A: rabbit meat + pork back fat, B: rabbit meat + sunflower oil, C: rabbit meat + pork back fat/sunflower oil, D: rabbit meat + pork back fat/ sunflower oil without phosphate mix.

The procedure for making the frankfurters is briefly described below. Conditioned rabbit meat and pork back fat (-5 °C) were ground separately in a meat grinder. Minced meat, spice mix, phosphate mix (or potato starch + isoascorbate in experiment D), ground red pepper, and curry were homogenized with half of the ice in the Stephan UMC 5 electronic (double-layer vacuum cutter Stephan Nahrungsmittel und Verfahrenstechnik, Germany) at a speed of 2400 × rpm until the temperature of the meat batter was 8 °C. Then nitrite salt, fat and the remaining ice were added and homogenization continued under vacuum until the temperature reached 12 °C. The emulsion was filled into artificial collagen casings, hot smoked, and thermally treated in a Fessmann chamber at moist heat until the core temperature of 72 °C. The frankfurters were vacuum packed and stored in a refrigerator at 4 °C until analysis. The frankfurters were produced in four batches.

Methods

Determination of chemical composition: The moisture, protein, colagen, and fat content of the samples were determined using the Food Scan-TM Analyser with self-calibration (FOSS, Denmark). Ash content was determined by mineralizing the samples at 550 °C (according to AOAC 920.153; AOAC 1997). After obtaining the results of the basic chemical composition, the carbohydrate content and energy value for the frankfurters were calculated (Golob et al., 2006). The conversion factors used to calculate the energy value of foods are 17 kJ/g for carbohydrates and proteins and 37 kJ/g for fats. Sodium was determined by automatic titration - Sodium Analyzer AP214 (Mettler Toledo) and calculated to NaCl. The data from the chemical analyses were expressed on the basis of wet weight.

The fatty acid composition of the samples was determined by in situ transesterification (according to ISO 12966; ISO 2015). Fatty acid methyl esters (FAMEs) were determined by capillary gas chromatography on a GC Agilent Technologies 6890 with a flame ionization detector and HP-88 capillary column (100 m × 0.25 mm × 0.20 µm, Agilent Technologies). Separation and detection conditions are published in Polak et al. (2021). Samples were analysed in duplicate. FAMEs were expressed as percentage of total content FA.

Determination of colour: A CR-400 colorimeter (Konica Minolta Optics, Inc., Osaka, Japan; Illuminant C, 0° viewing angle) was used to determine Commission Internationale de l'Eclairage (CIE; International Commission on Illumination) *L** (lightness), *a** (±, red to green) and *b** (±, yellow to blue) values on the surface of a 3-4 cm slice. A white ceramic tile with the specifications Y = 84.6, x = 0.3176, y = 0.3245 was used to standardise the colorimeter. The first measurement was made on a fresh horizontal cut of slice, then the colour was determined again on the same section after 30 minutes at room temperature. The colour values CIE *L**, *a**, *b** were measured at four different points on the surface.

Sensory evaluation: the evaluation of the sensory profile of frankfurters was carried out by a panel of four experts in the field of meat products was appointed. The evaluation was carried out under defined, precisely prescribed, controlled and reproducible operating conditions (ISO 8589:2007). The panellists evaluated the sensory quality of frankfurters according to an abbreviated analytical test with the sum of the values for all evaluated attributes 20 and a deduction system. External appearance, cross-sectional composition, cross-sectional colour, texture, odour and aroma were evaluated. A score of 0 represents a very poorly expressed or inappropriate sensory attribute, while the highest scores (3, 4, or 5) represent optimally to perfectly expressed individual sensory attributes. For each defect found in an attribute, a certain number of points is deducted from the maximum score. If a product defect is scored 0, the product is eliminated (Demšar and Polak, 2009). All points are then added together. Samples that score less than 15 points are considered inferior but still acceptable; products that score less than 13 points are unacceptable. For the sensory evaluation of external appearance and slice cross-section, the samples were cold (not thermally regenerated). One of the paired frankfurters was given to the panellists, which was sliced lengthwise with a knife, and two strips of approximately 1 cm thick and 12-16 cm lenght were evaluated. For the sensory evaluation of the other attributes, such as texture, smell and aroma, the samples were heated in hot water at about 90 °C for 10 minutes and then cut into 1-cm-thick slices for the panellists to evaluate. The panel evaluated the sensory attributes in the order in which they were perceived. To neutralise the taste, the panellists used the middle dough of a white bread soaked in lukewarm water with lemon-flavour (1 %).

Data analysis: Data were analysed using the SPSS statistical programme (*version 23.0, SPSS Inc., Chicago, USA*). The results were analysed with a one-way analysis of variance (ANOVA), and Duncan's test with a significance level of 0.05 was used to compare the data of sensory attributes of frankfurters from four experimental groups.

Results and discussion

Basic chemical composition

Table 2 shows the chemical composition of four different formulations of rabbit frankfurters. The frankfurters of the different formulations did not differ significantly in protein, fat and water content, and energy value, which was in accordance with the formulation. It was found that the frankfurters without phosphate mix (D) had the highest energy value (but not statistically significant), which was due to the addition of potato starch (20 g/1041 g frankfurter batter). The main differences between the different frankfurter formulations were in collagen, ash and NaCl content; frankfurters A and B had significantly higher ash and NaCl content than frankfurters C and D, and the highest collagen content was found in frankfurters A. All frankfurters (A, B, C, D) contained more protein and less fat than in the study by Golob et al. (2006) (protein 12.7 g/100 g, fat 23.6 (21.0-26.7) g/100 g, and comparable ash 2.42 (2.08-2.70) g/100 g). As a result, the energy value is also somewhat lower, since proteins contribute less to total energy than fats. In this study, rabbit frankfurters contained more protein than classic (12.9 (11.5-13.6) g/100 g) and chicken frankfurters (13.1 (11.9-14.5) g/100 g), less fat than classic (26.2 (20.8-30.5) g/100 g) and chicken (25.7 (21.4-27.4) g/100 g), and less ash than classic (2.57 (2.46-2.71) g/100 g) and chicken (3.06 (2.28-3.50) g/100 g) frankfurters (Golob et al., 2006). The idea of offering an innovative meat product (frankfurters) to increase rabbit consumption has been developed in the past, with little or no rabbit/pork back fat, or as in our study, with the usual fat content but with vegetable oil or no additives. Researchers made a low-fat version of sausages (with 4.82 % and 0 % rabbit fat) using konjac gum (Honrado et al., 2022). Their results showed a significant reduction in fat content and energy value (535.13 kJ/100 g versus 469.86 kJ/100 g) compared to our results. Other researchers produced rabbit meat-based frankfurters with 7 % and 12 % pork fat (Petraci and Cavani, 2013; Cury et al., 2011).

Rabbit frankfurters meet the legal requirements (Regulations on the Quality of Meat Products and Meat Preparations, 2017), the fat content of frankfurters made from other types of meat must be up to 30%, and in the present study it is about 20 %.

Table 2 Comparison of the chemical composition of four different formulations of rabbit frankfurters

Parameter	Group					
	A	B	C	D	SE	*P-value*
Protein (g/100 g)	16.30	15.10	15.70	15.30	0.78	0.322
Fat (g/100 g)	19.97	21.62	20.72	21.50	1.05	0.263
Water (g/100 g)	61.58	59.12	60.79	59.15	3.01	0.693
Colagen (g/100 g)	1.76[a]	0.90[c]	1.35[b]	0.72[d]	0.06	≤0.001
Ash (g/100 g)	2.44[a]	2.44[a]	2.32[b]	2.22[c]	0.02	≤0.001
$EV_{100\,g}$ (kJ)	1015.65	1056.13	1033.71	1090.11	52.46	0.396
NaCl (g/100 g)	1.71[a]	1.76[a]	1.54[b]	1.71[a]	0.07	0.022

A: rabbit meat + pork back fat, B: rabbit meat + sunflower oil, C: rabbit meat + pork back fat/sunflower oil, D: rabbit meat + pork back fat/sunflower oil without phosphate mix. $EV_{100\,g}$ – energy value. SE – standard error. Data with different superscript letters (a-d) within a row are significantly different ($P < 0.05$, differences between groups).

Fatty acid composition

A total of 42 fatty acids (> 0.01 wt.% FA) were detected in rabbit frankfurters; 27 of them are listed in Table 3. The major FA in frankfurters with pork back fat (A) were oleic acid (C18:1c-9; 44.70 wt.% FA) and palmitic acid (C16:0; 24.08 wt.% FA), followed by stearic acid (C18:0; 11.16 wt.% FA) and linoleic fatty acid (C18:2n-6, 11.05 wt.% FA), and all others were below 5 wt.% FA. The major FA in frankfurters B were linoleic fatty acid (C18:2n-6, 52.69 wt.% FA) and oleic acid (C18:1c-9; 30.05 wt.% FA), followed by palmitic acid (C16:0; 9.34 wt.% FA), stearic acid (C18:0; 3.83 wt.% FA) and others below 1 wt.% FA. The major FA in frankfurters C and D were oleic acid (C18:1c-9; 35.11/35.59 wt.% FA) and linoleic fatty acid (C18:2n-6, 33.94/33.50 wt.% FA) and, followed by palmitic acid (C16:0; 15.44/15.32 wt.% FA), stearic acid (C18:0; 9.00/9.21 wt.% FA) and others below 1 wt.% FA.

Frankfurters with pork back fat contained significantly more saturated fatty acids (37.36 wt.% vs. 14.66 wt.%) and less polyunsaturated fatty acids (53.47 wt.% vs. 12.93 wt.%) than those with sunflower oil. Consequently, the ratio of polyunsaturated to saturated fatty acids (PUFA/SFA) was also ten times higher in frankfurters made with sunflower oil than in those made with pork back fat (3.65 vs. 0.35). Frankfurters with added sunflower oil (B) had the highest content of linoleic acid (C18:2n-6), as expected, since this is the main fatty acid in sunflower oil, as shown in Table 3. For the same reason, the content of oleic acid (C18:1n-9) is highest in the other frankfurters (A, C, D), since it is the predominant fatty acid in pork back fat. The ratio between n-6 and n-3 fatty acids is significantly higher than the recommended limit (n-6/n-3 = 5:1). When fat was added to rabbit hot dogs, the n-6/n-3 ratio increased significantly from 7.02 ± 3.62 (Dalle Zotte and Szendro, 2011) to 17.22 (pork back fat) and 124.51 (sunflower oil). The use of pork back fat also increased the trans fatty acid content (0.34 vs. 0.08) in frankfurters in comparison with frankfurters with sunflower oil. Despite the favourable fatty acid composition of frankfurters with added sunflower oil, there are not many products with added vegetable fat on the Slovenian market. Only pork sausages with added olive oil and beef with sunflower oil were found during the review of the products.

Table 3 Fatty acid composition (wt.% of total fatty acids) and calculated indicators of nutritional quality of four different formulations of rabbit frankfurters.

FA (wt.% of total FA)	Group A	B	C	D	SE	*P-value*
C8:0	0.01^{a}	<0.01^{c}	0.01^{b}	0.01^{b}	<0.01	≤0.001
C10:0	0.05^{a}	0.01^{d}	0.04^{b}	0.03^{c}	<0.01	≤0.001
C12:0	0.08^{a}	0.02^{c}	0.05^{b}	0.04^{b}	<0.01	≤0.001
C14:0	1.22^{a}	0.38^{c}	0.76^{b}	0.72^{b}	0.04	≤0.001
C14:1c	<0.01^{d}	0.03^{c}	0.04^{a}	0.03^{b}	<0.01	≤0.001
C15:0	0.10^{a}	0.07^{c}	0.09^{a}	0.08^{b}	<0.01	≤0.001
C16:0	24.08^{a}	9.34^{c}	15.44^{b}	15.32^{b}	0.71	≤0.001
C16:1t	0.34^{a}	0.07^{c}	0.19^{b}	0.18^{b}	0.01	≤0.001
C16:1c	1.31^{a}	0.41^{c}	0.79^{b}	0.76^{b}	0.04	≤0.001
C17:0ISO	<0.01^{d}	0.02^{c}	0.04^{a}	0.04^{b}	<0.01	≤0.001
C17:0	0.34^{a}	0.11^{c}	0.22^{b}	0.21^{b}	0.01	≤0.001
C17:1t	<0.01^{b}	0.01^{a}	0.01^{a}	<0.01^{b}	<0.01	0.005
C18:0	11.16^{a}	3.83^{c}	9.00^{b}	9.21^{b}	0.36	≤0.001
C18:1t11	<0.01^{b}	<0.01^{b}	0.13^{a}	0.13^{a}	<0.01	≤0.001
C18:1c9	44.70^{a}	30.05^{c}	35.11^{b}	35.59^{b}	1.43	≤0.001
C18:1c11	1.99^{a}	0.86^{c}	1.31^{b}	1.32^{b}	0.06	≤0.001
C18:2n-6	11.05^{c}	52.69^{a}	33.94^{b}	33.50^{b}	0.90	≤0.001
C18:3n-6	<0.01^{d}	0.01^{c}	0.01^{a}	0.01^{b}	<0.01	≤0.001
C20:0	0.33^{a}	0.24^{c}	0.27^{b}	0.27^{b}	0.01	≤0.001
C18:3n-3	0.71^{a}	0.42^{d}	0.62^{b}	0.56^{c}	0.02	≤0.001
C20:1c11	1.37^{a}	0.20^{c}	0.68^{b}	0.71^{b}	0.04	≤0.001
C20:2n-6	0.63^{a}	0.04^{c}	0.29^{b}	0.30^{b}	0.02	≤0.001
C20:3n-6	<0.01^{c}	0.02^{b}	0.05^{a}	0.05^{a}	0.02	≤0.001
C22:0	<0.01^{c}	0.66^{a}	0.36^{b}	0.36^{b}	<0.01	≤0.001
C20:4n-6	0.54^{a}	0.24^{c}	0.38^{b}	0.37^{b}	0.01	≤0.001
C23:1	<0.01^{c}	0.24^{a}	0.13^{b}	0.13^{b}	0.02	≤0.001
C22:6n-3	<0.01^{d}	0.01^{c}	0.02^{b}	0.03^{a}	<0.01	≤0.001
SFA	37.36^{a}	14.66^{c}	26.23^{b}	26.26^{b}	1.14	≤0.001
MUFA	49.71^{a}	31.87^{c}	38.37^{b}	38.85^{b}	1.58	≤0.001
PUFA	12.93^{c}	53.47^{a}	35.39^{b}	34.88^{b}	0.94	≤0.001
PUFA/SFA	0.35^{c}	3.65^{a}	1.35^{b}	1.33^{b}	0.04	≤0.001
n-3	0.71^{a}	0.43^{d}	0.64^{b}	0.59^{c}	0.02	≤0.001
n-6	12.22^{c}	53.00^{a}	34.68^{b}	34.23^{b}	0.92	≤0.001
n-6/n-3	17.22^{d}	124.51^{a}	54.14^{c}	58.20^{b}	1.64	≤0.001
trans FA	0.34^{a}	0.08^{c}	0.32^{ba}	0.31^{b}	0.01	≤0.001

A: rabbit meat + pork back fat, B: rabbit meat + sunflower oil, C: rabbit meat + pork back fat/sunflower oil, D: rabbit meat + pork back fat/sunflower oil without phosphate mix. FA – fatty acid; SFA – saturated fatty acid; MUFA – monounsaturated fatty acid; PUFA – polyunsaturated fatty acid. SE – standard error. Data with different superscript letters (a-d) within a row are significantly different (P <0.05, differences between groups).

Table 4 shows that the addition of sunflower oil in frankfurters significantly changed the value of *L** (from 74.44 for A to 79.25 for B), which means that frankfurters B are darker in cross-section. It was also found that the *L** values did not change significantly after the samples were stored at room temperature for 30 minutes. The *a** values of the frankfurters decreased significantly after 30 minutes at room temperature, indicating that the colour was less durable. The cross-sectional colour values changed from pink to greenish. However, the *b** values of frankfurters increased after 30 minutes, also indicating that the colour was not durable. The colour change was most pronounced in sample D without phosphate mix and with the addition of potato starch, as *b** value increased the most. A change in *b** value means that the hue changed to yellow-brown due to oxidation.

Table 4 Instrumentally measured colour values of four different formulations of rabbit frankfurters, on fresh cut and after 30 minutes at room temperature (20 °C)

Value	Group					
	A	B	C	D	SE	*P-value*
*L**	74.44^{c}	79.25^{a}	78.50^{b}	78.27^{b}	0.45	≤0.001
*a**	10.62^{a}	7.68^{c}	8.39^{b}	8.44^{b}	0.25	≤0.001
*b**	22.31^{b}	21.74^{b}	21.93^{b}	23.20^{a}	0.45	0.003
*L*30*	74.58^{c}	79.80^{a}	78.85^{b}	78.27^{b}	0.52	≤0.001
*a*30*	10.59^{a}	7.28^{c}	8.14^{b}	8.22^{b}	0.21	≤0.001
*b*30*	23.05^{a}	21.82^{b}	22.00^{b}	23.38^{a}	0.32	≤0.001

*A: rabbit meat +pork back fat, B: rabbit meat + sunflower oil, C: rabbit meat + pork back fat/sunflower oil, D: rabbit meat + pork back fat/sunflower oil without phosphate mix. SE – standard error. Data with different superscript letters (a-d) within a row are significantly different (P <0.05, differences between groups). L*30, a*30, b*30 – colour values after 30 minutes.*

Sensory properties

Table 4 shows the results of the sensory of four different formulations of rabbit frankfurters. It was found that the appearance of all groups of frankfurters was typical of this type of meat product: the frankfurters had the correct shape and had no visible discoloration or wrinkles on the surface, the 16-cm-long half ends were excellently formed and without mass residues, and there were no fat or jelly secretions under or over the casing. Porosity was evident in the cross-section of the frankfurters, which could be avoided by filling with a vacuum filler. An inhomogeneous emulsion was noted in some areas of the cross-section, which could be attributed to incomplete homogenization of the sausage mass. The colour of the cross-section was slightly too light (2.4-2.6) in all groups

Table 5 Sensory attributes of four different formulations of rabbit frankfurters

Attribute (value)	Group					
	A	B	C	D	SE	*P-value*
External appearance (0-2)	2.0	2.0	2.0	2.0	0.0	-
Composition of cross-section (0-3)	2.1	2.4	2.4	2.4	0.3	0.426
Colour (0-3)	2.5	2.4	2.5	2.6	0.3	0.781
Texture (0-4)	2.9^{ba}	2.8^{b}	3.0^{b}	3.3^{a}	0.2	0.063
Odour (0-3)	3.0^{a}	3.0^{a}	3.0^{a}	2.8^{b}	0.1	0.073
Aroma (0-5)	4.5	4.6	4.8	4.6	0.2	0.517
Total score (0-20)	17.0	17.1	17.6	17.6	0.1	0.276

A: rabbit meat + pork back fat, B: rabbit meat + sunflower oil, C: rabbit meat + pork back fat/sunflower oil, D: rabbit meat + pork back fat/sunflower oil without phosphate mix. EV100 g – energy value. SE – standard error. #Data with different superscript letters (a-b) within a row are significantly different (P ≤0.10 differences between groups).

of frankfurters, although the differences between groups were not significant. Panellists described the texture of all groups of frankfurters too firm (2.8-3.3), with only the slightly firm group D standing out (P ≤0.10). The smell of the frankfurters was adequate, perhaps somewhat insufficiently distinctive (the least distinctive smell in group D (P ≤0.10)), but the panellists could not detect any foreign smells. In terms of aroma, frankfurters A were rated the worst, mainly because of the sour aftertaste.

Conclusion

The advantages of selling and eating rabbit meat are its low-fat content, its characteristic aroma and good water-binding capacity, and its reputation as a traditional specialty. The limitations are economic and technical: high production costs, sale of whole rabbit carcasses with heads, heavier cuts, brittle bones, low juiciness of meat after heat treatment and, on the other hand, consumer perception of rabbits as pets, ecological problems and animal welfare in cage farming. In order to increase the sales and consumption of rabbit meat and products, various strategies can be considered, such as stress-free rearing of rabbits, changing the nutritional profile of the meat, using the good technological properties of the meat in processing, various forms of marinating and attractive packaging, and in the kitchen, reviving various traditional dishes and modern marketing approaches. One of the approaches to increase the consumption of rabbit meat products is in this study proposed production of rabbit frankfurters with modified fatty acid profile or with phosphate replacement. The results show that rabbit frankfurters with sunflower oil are more acceptable than the classic frankfurters from a nutritional point of view, but taste better from a sensory point of view when pork back fat and oil are added in a 1:1 ratio. When phosphate was replaced with isoascorbate and potato starch, rabbit frankfurters become a tenderer or less rubbery texture and were quite acceptable. In our market, most frankfurters contain animal fat, although vegetable fat is more desirable from a nutritional point of view.

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Meso kunića u proizvodnji hrenovki

Sažetak

Meso je najvažniji izvor proteina, esencijalnih aminokiselina, minerala i vitamina B-kompleksa u našoj prehrani. S nutricionističkog gledišta meso kunića ima povoljan sastav zbog relativno niskog sadržaja masti i spada u dijetalnu hranu. Istovremeno, potrošači mesa kunića prepoznaju i tipični istančani okus i izrazitu mekoću mesa. U svrhu povećanja potrošnje proizvoda od mesa kunića pripremili smo i ocjenjivali hrenovke od kunića s dodatkom leđnog masnog tkiva svinja i/ili suncokretovog ulja (bogato mononezasićenim masnim kiselinama, povoljan omjer n-3/n-6 masnih kiselina) i bez dodatka fosfata. Rezultati su pokazali da su hrenovke sa svinjskim masnim tkivom senzorski prihvatljivije. Odsutnost fosfata rezultira lakšom, manje gumastom teksturom, a ujedno je proces oksidacije brži. Može se zaključiti da je meso kunića pogodno za preradu u mesne prerađevine, posebice u kombinaciji s biljnim uljima, što daje dobre rezultate, jer se takav proizvod približava optimalnom sastavu masnih kiselina, a time ima pozitivan učinak na zdravlje potrošača.

Ključne riječi: meso kunića, hrenovke, kemijski sastav, suncokretovo ulje, leđna svinjska mast, senzorna svojstva

Kaninchenfleisch für die Herstellung von Würstchen

Zusammenfassung

Fleisch ist die wichtigste Quelle für Eiweiß, essentielle Aminosäuren, Mineralstoffe und Vitamine des B-Komplexes in unserer Ernährung. Aus ernährungsphysiologischer Sicht hat Kaninchenfleisch aufgrund seines relativ geringen Fettgehalts eine günstige Zusammensetzung und gehört zu den diätetischen Lebensmitteln. Gleichzeitig erkennen die Verbraucher von Kaninchenfleisch auch den typischen feinen Geschmack und die ausgeprägte Zartheit von Kaninchenfleisch. Um den Verzehr von Kaninchenfleischerzeugnissen zu steigern, haben wir Kaninchenwürstchen mit dem Zusatz von Schweinerückenspeck und/oder Sonnenblumenöl (reich an einfach ungesättigten Fettsäuren, günstiges Verhältnis von n-3 zu n-6 Fettsäuren) und ohne den Zusatz von Phosphat zubereitet und bewertet. Die Ergebnisse zeigen, dass die Würstchen mit Schweinerückenspeck sensorisch akzeptabler sind. Der Verzicht auf Phosphat führt zu einer leichteren, weniger gummiartigen Textur, wobei der Oxidationsprozess schneller verläuft. Daraus lässt sich schließen, dass sich Kaninchenfleisch für die Verarbeitung zu Fleischerzeugnissen eignet, insbesondere wenn es mit pflanzlichen Ölen kombiniert wird, was zu guten Ergebnissen führt, da sich ein solches Produkt der optimalen Fettsäurezusammensetzung annähert und sich somit positiv auf die Gesundheit des Verbrauchers auswirkt.

Schlüsselwörter: Kaninchenfleisch, Würstchen, chemische Zusammensetzung, Sonnenblumenöl, Schweinerückenspeck, sensorische Eigenschaften

Carne de conejo en la producción de salchichas tipo Frankfurt

Resumen

La carne es la fuente más importante de proteína, aminoácidos esenciales, minerales y vitaminas del complejo B en nuestra dieta. Desde el punto de vista nutricional, la carne de conejo tiene una composición favorable debido a su contenido relativamente bajo en grasa y pertenece a los alimentos dietéticos. Al mismo tiempo, los consumidores de carne de conejo también reconocen el típico sabor delicado y la distintiva ternura de esta carne. Con el propósito de aumentar el consumo de productos cárnicos de conejo, preparamos y evaluamos salchichas tipo Frankfurt de conejo con la adición de grasa dorsal de cerdo y/o aceite de girasol (rico en ácidos grasos monoinsaturados, una proporción favorable de ácidos grasos n-3/n-6) y sin la adición de fosfato. Los resultados mostraron que las salchichas con grasa dorsal de cerdo son más aceptables desde el punto de vista sensorial. La ausencia de fosfato resulta en una textura más ligera y menos gomosa, y al mismo tiempo el proceso de oxidación es más rápido. Se puede concluir que la carne de conejo es adecuada para procesar en productos cárnicos, especialmente cuando se combina con aceites vegetales, lo que ofrece buenos resultados, ya que dicho producto se acerca a la composición óptima de ácidos grasos y tiene un efecto positivo en la salud del consumidor.

Palabras claves: carne de conejo, salchichas tipo Frankfurt, composición química, aceite de girasol, grasa dorsal de cerdo, propiedades sensoriales

Carne di coniglio nella produzione di wurstel

Riassunto

La carne è la fonte più importante di proteine, aminoacidi essenziali, minerali e vitamine del complesso B nella nostra dieta. Dal punto di vista nutrizionale, la carne di coniglio ha una composizione favorevole grazie al suo contenuto di grassi relativamente basso e, pertanto, appartiene al novero degli alimenti dietetici. Allo stesso tempo, i consumatori di carne di coniglio riconoscono anche il tipico gusto delicato e la spiccata morbidezza della carne. Per aumentare il consumo di prodotti a base di carne di coniglio, abbiamo preparato e valutato wurstel di coniglio con l'aggiunta di lardo di maiale e/o olio di semi di girasole (ricco di acidi grassi monoinsaturi, rapporto favorevole di acidi grassi n-3/n-6) e senza l'aggiunta di fosfati. I risultati hanno mostrato che i wurstel con lardo di maiale sono più accettabili dal punto di vista sensoriale. L'assenza di fosfati si traduce in una consistenza più leggera, meno gommosa e, allo stesso tempo, il processo di ossidazione è più veloce. Si può concludere che la carne di coniglio è adatta alla produzione di prodotti a base di carne, soprattutto in combinazione con oli vegetali, il che dà buoni risultati perché tale prodotto si avvicina alla composizione ottimale degli acidi grassi e, quindi, ha un effetto positivo sulla salute dei consumatori.

Parole chiave: carne di coniglio, wurstel, composizione chimica, olio di semi di girasole, lardo di maiale, proprietà sensoriali