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Impact of different vegetable fats and oils on instrumentally measured color and texture of processed chicken sausages*

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A b s t r a c t: The effect of vegetable fats and oils on instrumentally measured color and texture of processed chicken sausages was investigated using six variants of sausages: control, containing pork back fat (Po); olive oil (O); rapeseed oil (R); sunflower oil (S); palm fat (Pa) and a mixture (Mi) of 60 % rapeseed oil (R) and 40 % palm fat (Pa). Palm (Pa) fat resulted in the darkest ($p \leq 0{,}05$) surface color of processed poultry sausages. High intensity red color was most desirable on the sausage surface and was obtained with palm (Pa) fat and a mixture (Mi) of 60% palm fat and 40% rapeseed oil (R). Incorporation of all other plant oils and fats increased yellowness on the surface of processed poultry frankfurters. Palm (Pa) and pork (Po) fat, that are rich in saturated fatty acids, ($p \leq 0.05$) darkened color on poultry sausages at the fresh cross sectional plane. Pork (Po) fat also ($p \leq 0.05$) improved the red color hue at the fresh cross section plane of sausages. Plant oils, when not used in a mixture with palm fat ($p \leq 0.05$) increased the Warner Bratzler Shear Force (WBSF) making the product harder and firmer in texture.

Key words: *processed chicken, frankfurter-sausages, plant fats, plant oils, color, texture.*

Introduction

Fats are important and a key factor in development of aroma, texture, juiciness and color in meat products. Hence, fat presence makes the product more acceptable from a flavor perspective and attractive for customers. Using some of the substitutes for pork fats causes a weakening of color intensity in meat products. *Reitmaier and Prusa* (1991) reported using flour from corn germ increased yellow color of the product. Animal fat replacement with vegetable oils is the reason for decreasing the typical color and intensity of color in meat products. According to *Keeton* (1994), fats are also important for rheological and structural characteristics of meat products and for creation of a stable emulsion.

Texture of meat products is dependent on a creation of a matrix that strengthens structure and stability. Formation of the matrix is dependent on several factors including: types, quantity and functional properties of proteins and fats, salt concentration, pH value, content of connective tissue, water binding capacity and other factors. *Huffman* (1996) reported proteins are absorbed in the disperse system of fats and water, thus incorporating fat globules into the matrix.

The melting point and extent of fat exudation are important factors for retaining fats in the meat structure. *Žlender* (2000) reports creation of texture of meat products is influenced by type and quantity of fat added due to effects of fat on the interaction between fats and other meat components.

The structure of cooked meat is important for interactions between the three basic components: proteins, fats and water. If this relationship is not optimal there will be limited heat stability and breakdown in the structure of the homogenate (*Radetić,* 2000). *Yilmaz*, (2004) found decreasing fat content below 15% reduced texture characteristics of meat products.

The aim of the present investigation was to determine how different fats and oils affect instrumentally-measured color and texture of processed chicken sausages.

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Material and method

Frankfurter style sausages made from chicken (boneless thigh and breast, 50% each) were used for this study. As an alternative to pork back fat (control; Po) plant oils or fats were used: olive (O), rapeseed (R), sunflower oil (S), palm fat (Pa), or a mixture (Mi) of 60% rapeseed oil (R) and 40% palm fat (Pa). The study was conducted at the Biotechnical faculty in Ljubljana, Republic of Slovenia, Department of Meat Technology. Treatments are shown in Table 1.

Artificial edible collagen casings, 23 mm in diameter, (Naturin GmbH, Weiheim, Germany) were used to contain the batter. Three replications were conducted.

Chromometer MINOLTA CR-200 b with an attached data processor DATA DP 100 was utilized for analyzing sausage color. Color of samples was measured according to the basic X, Y, Z system with a coordinates of Y, x, y (according to the system of L^*, a^* and b^*) which was used in this research. L^* value describes the lightness of the sample (greater L^*, the lighter and less L^*, the darker); value a^* describes color hue (greater a^*, more red, less green and less a^*, more green, less red). The measurement of b^* indicates yellow blue ratio (greater b^*, more yellow, less blue and lesser b^*, more blue, less yellow). Four (average reported) different locations, both at the surface and cross section plane of sausages were used for color measurements.

Table 1. Raw material composition in different groups of processed chicken, frankfurter-style sausages (%)
Tabela 1. Sirovinski sastav različitih grupa pileće kobasice u tipu viršle (%)

Components/Komponente	Groups of sausages/Grupe kobasica					
	Po[1]	**O[2]**	**R[3]**	**S[4]**	**Pa[5]**	**Mi[6]**
Chicken breasts without skin/ Pileće grudi bez kože	23	23	23	23	23	23
Chicken thighs without skin/ Pileći batak bez kože	23	23	23	23	23	23
Pork back fat/ Svinjska leđna mast	20					
Olive oil/ Maslinovo ulje		20				
Rapeseed oil/ Ulje semena uljane repice			20			12
Sunflower oil/ Suncokretovo ulje				20		
Palm fat/ Palmina mast					20	8
Nitrite curing salt (0.6% nitrite)/ Nitrirtna so (0,6% nitrita)	1.7	1.7	1.7	1.7	1.7	1.7
Ice/ Led	32	32	32	32	32	32
Sodium tripolyphosphate(SOFOS 4X)/ Natrijum tripolifosfat (SOFOS 4X)	0.2	0.2	0.2	0.2	0.2	0.2
Mixture of spices/ Mešavina začina	0.2	0.2	0.2	0.2	0.2	0.2
Sodium isoascorbate/ Natrijum izoaskorbat	0.075	0.075	0.075	0.075	0.075	0.0705
Soy protein isolate (SUPRO EX 32-IP)/ Sojin izolat (SUPRO EX 32-IP)	2	2	2	2	2	2

Po[1] = Pork back fat/Po[1] = svinjska leđna mast;
O[2] = Olive oil/**O[2]** = maslinovo ulje;
R[3] = Rapeseed oil/**R[3]** = ulje semena uljane repice;
S[4] = Sunflower oil/**S[4]** = suncokretovo ulje;
Pa[5] = Palm fat/**Pa[5]** = palmina mast;
Mi[6] = Mixture of 60% rapeseed oil (R) and 40% palm fat (Pa)/**Mi[6]** = mešavina od 60 posto ulja semena uljane repice (R) i 40 posto palmine masti (Pa)

For the shear force sausage measurment, the Warner Bratzler shear was utilized. Shear force (Warner Bratzler, WBSF) was measured for rheological (texture) variables. For this purpose, samples of sausages were prepared utilizing a precise cylider shaped cutter number 8. Utilizing this cutter the sausage sample had a cylinder form, with a diameter of 8 mm and a length of 4 cm. Sample temperature during shear force measurement was maintained at aproximately 20°C. The speed of the cutter during measurement was 2 mm/second. Shear force was calculated with the following equation: A = F x S, where F = force measured in Newton (N) and S = distance passed (8 mm).

The program package SAS/STAT (SAS Software. Version 8.01, 1999) was used for statistical processing of data and significant, means were separated using the Duncan test.

Results and discussion

The L-values (Lightness) on surface of sausages

Results from instrumental color measurement of processed poultry sausages at the surface (Table 2) indicated numerically the L^* value of 72.4 was the lightest color which was obtained by treatments Mi and O. However, both treatments, Mi and O, did not differ from treatments R and S. The control treatment (Po) with the L^* value of 70.1 is darker ($p \leq 0.05$) than treatments Mi and O, but does not differ from treatments R and S. Palm fat decreased ($p \leq 0.05$) the L^* value (67.9) at the surface, when compared to all the other treatments. It was, therefore, concluded palm fat produced the darkest color ($p \leq 0.05$) on the surface of processed poultry sausages.

The a^*-values (redness) at the surface of sausages

The least ($p \leq 0.05$) a^* value (4.5) at the surface of sausages with the least expressed red color resulted when olive oil (O) was used (Table 2). This indicates olive oil, negatively influenced surface color of sausages. The numerically greatest a^* value (7.8), and the greatest red color resulted from use of Pa, which was not statistically different from treatment Mi (a^* value of 7.3). Treatments with Po resulted in an a^* value of 6.6 and S with an a^* value of 6.7 with these values not differing ($p \leq 0.05$) from the Mi treatment. Based on expressed red color at the surface of poultry sausages, the most desirable fat to use was palm (Pa) fat and a mixture (Mi) of 60% palm fat and 40% rapeseed oil (R). Palm fat (Pa) treatment was superior ($p \leq 0.05$) to the control (Po).

The b^*-values (yellowness) at the surface of sausages

The b^* values in all the treatments when plant oils or fats were utilized are greater ($p \leq 0.05$) than the control treatment (Po) with a b^* value of 33.6 (Table 2). This suggests all plant oils and fats increase ($p \leq 0.05$) surface yellowness of processed poultry frankfurter-style sausages which is negative from a color perspective.

The L^*values (Lightness) at the fresh cross section plane of sausages

All groups of sausages where plant oils or fats were employed were lighter ($p \leq 0.05$) in color at the fresh cross section plane than the control group (Po) with a L^* value of 80.5 (Table 2). *Hammer* (1992) also found the L^* value to be greater, which means a lighter color hue in processed frankfurter-style sausages, when sausages were made utilizing sunflower oil and compared to sausages made by utilizing pork fat. Numerically the lightest color at the fresh cross section plane was with treatment R (87.6). However, there is no significant difference, in color lightness when evaluated at the fresh cross section plane among treatments O, R, and S. Use of palm fat (Pa) resulted in the darkest color when compared to all other treatments with a L^* value of 81.4 (Table 2). This would suggest palm and pork fats, which are rich in saturated fatty acids, darkened ($p \leq 0.05$) the color of poultry sausages at the fresh cross section plane.

The a* values (redness) at the fresh cross section plane of sausages

The control treatment (Po) had the greatest ($p \leq 0.05$) expressed red color at the fresh cross section with an a^* value of 4.0 (Table 2). This means pork fat improves ($p \leq 0.05$) red color hue at the fresh cross section plane of sausages. *Hammer* (1992), also found greater a^*values, and a redder color hue when pork fat was used to make sausages compared to sunflower oil treatments. These differences in color, according to *Hammer* (1992) are due to more evenly distributed plant oil droplets in the emulsion in comparison to larger animal fat droplets.

Treatment O, when olive oil was utilized, had the least ($p \leq 0.05$) a^* value of 0.6 which indicated the greatest expressed green color. The greatest ($p \leq 0.05$) expressed red color (a^* value of 3.1), when compared to all the other plant oil treatments was when the Pa treatment was used which is similar to the control (Po) treatment (a^* value of 4.0). However,

Table 2. Differences in color and texture – Warner Bratzler shear force (WBSF) between groups of processed chicken, frankfurter-style sausages (Duncan-test, $p \leq 0.05$)
Tabela 2. Razlike u boji i teksturi – Warner Bratzlerova sila smicanja (WBSF) između grupa pilećih kobasica u tipu viršle (Duncanov test $p \leq 0,05$)

Value/ Vrednost	GROUPS OF SAUSAGES (Color at surface)/ GRUPE KOBASICA (boja na površini)						
	Po[1]	**O[2]**	**R[3]**	**S[4]**	**Pa[5]**	**Mi[6]**	**Significance/ Značajnost**
L*	70.1 ± 1.8[b]	72.4 ± 2.4[a]	71.2 ± 1.9[ab]	70.9 ± 1.9[ab]	67.9 ± 1.5[c]	72.4 ± 2.4[a]	***
a*	6.6 ± 0.4[bc]	4.5 ± 1.1[d]	6.2 ± 0.9[c]	6.7 ± 1.6[bc]	7.8 ± 1.1[a]	7.3 ± 1.4[ab]	***
b*	33.6 ± 3.3[c]	37.7 ± 3.1[b]	39.0 ± 2.0[ab]	39.9 ± 3.5[ab]	39.9 ± 1.5[ab]	40.8 ± 3.1[a]	***
Color at fresh cross section plane/Boja na svežem poprečnom preseku							
L*	80.5 ± 1.2[d]	87.0 ± 0.8[a]	87.6 ± 0.5[a]	87.5 ± 0.5[a]	81.4 ± 1.0[c]	86.0 ± 1.2[b]	***
a*	4.0 ± 0.5[a]	0.6 ± 0.4[e]	1.7 ± 0.3[d]	1.6 ± 0.4[d]	3.1 ± 0.3[b]	2.1 ± 0.3[c]	***
b*	14.6 ± 0.4[b]	14.1 ± 0.8[c]	12.2 ± 0.6[e]	12.3 ± 0.7[e]	16.5 ± 0.5[a]	13.3 ± 0.6[d]	***
Texture/Tekstura							
WBSF (N)	4.6 ± 1.1ab	4.9 ± 0.6a	4.9 ± 0.4a	5.1 ± 0.2a	4.7 ± 0.4a	4.2 ± 0.3b	**

***$p \leq 0.001$ – Significant effects/Značajni efekti; Groups with the same letters in a row are not statitistically different/ Grupe sa istim slovima u redu se statistički značajno ne razlikuju;
**$p \leq 0.01$ – Effect on WBSF/Efekat na WBSF; Groups with the same letters in a row are not different/Grupe sa istim slovima u redu se ne razlikuju.

Po[1] = Pork back fat/Po[1] = svinjska leđna mast;
O[2] = Olive oil/**O[2]** = maslinovo ulje;
R[3] = Rapeseed oil/**R[3]** = ulje semena uljane repice;
S[4] = Sunflower oil/**S[4]** = suncokretovo ulje;
Pa[5] = Palm fat/**Pa[5]** = palmina mast;
Mi[6] = Mixture of 60% rapeseed oil (R) and 40% palm fat (Pa)/**Mi[6]** = mešavina 60 posto ulja semena uljane repice (R) i 40 posto palmine masti (Pa)

L*value describes the lightness of the sample (greater L*, the lighter and lesser L*, the darker)/ L*vrednost opisuje svetlinu uzorka (veća L*vrednost ukazuje na svetliju boju, dok manja L*vrednost ukazuje na tamniju boju;
a*value describes the red hue – redness of the color (greater a*, more red, less green and lesser a*, more green, less red)/ a*vrednost opisuje nijansu crvene boje (veća vrednost a*ukazuje na veći udeo crvene boje i manji udeo zelene, dok manja a*vrednost ukazuje na veći udeo zelene, a manji udeo crvene boje);
b* value describes the yellow color hue – yellowness (greater b*, more yellow, lesser blue and lesser b*, more blue, less yellow)/ b* vrednost opisuje nijansu žute boje (veća b* vrednost ukazuje na veći udeo žute boje, a manji plave, dok manja b* vrednost ukazuje na veći udeo plave boje i manji udeo žute boje)

[a]Three replications were conducted/[a]Analiza rađena u tri replikata.

the Pa treated resulted in less red color at the fresh cross section plane than the Potreatment.

The b*values (redness) at the fresh cross section plane of sausages

The greatest b value (16.5), indicative of yellow color hue, occurred with the palm fat (Pa) treatment ($p \leq 0.05$). The b* value is numerically least (12.2) with the rapeseed oil (R) treatment (Table 2). However, the b* value (12.2) with this treatment (R), is not statistically different when compared to the sunflower (S) oil treatment (12.3). This suggests palm fat could replace pork fat from a b* color perspective.

Rheological (texture) measurements

Results from Warner Bratzler Share Force (WBSF) measurements are shown in Table 2. WBSN, expressed in Newton (N), was least (4.2) with the Mi treatment but not different from the control (Po) and was less compared to all the others plant oils and fats treatments ($p \leq 0.05$). Therefore, plant oils, when not used in a mixture with palm fat impacted ($p \leq 0.05$) WBSF with a greater value making the product harder.and firmer in texture.

Stevanović (1993) also concluded frankfurter--type sausages in which sunflower oil was incorporated had a firmer texture. *Bishop et al.* (1993)

reported that pre-emulsifying fat or oil decreased product firmness.

Comparisons with other plant oils and fat treatments (O, Pa, R, and S) with the control (Po) treatment, the most similar WBSF value (4.7) to the control group (Po = 4.6) was the palm (Pa) fat treatment. There is no significant difference between these two groups. However, the other plant oil and fat treatments (O, R, S) were also not different from the control (Po) treatment.

Conclusions

Palm (Pa) fat had the greatest impact and produced the darkest color on the surface of processed poultry sausages ($P \leq 0.05$). With the well expressed red color at the sausage surface indicating the most desirable fat alternatives were the palm (Pa) fat and a mixture (Mi) of 60% palm fat and 40% rapeseed oil (R). All plant oils and fats increased surface yellowness of processed poultry frankfurter-style sausages. Palm (Pa) and pork fat (Po), which are rich in saturated fatty acids, effected ($p \leq 0.05$) darkening of color of poultry sausages when compared at the fresh cross section plane. Use of pork (Po) fat improved ($p \leq 0.05$) red color hue in fresh cross section planes of sausages. Plant oils, when used not in a mixture with palm fat, had an effect ($p \leq 0.05$) on WBSF with the product being harder and firmer in texture. It is recommended a mixture (Mi) of 60% palm fat and 40% rapeseed (R) oil be used, from the perspective of texture and color.

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Uticaj različitih biljnih masti i ulja na instrumentalno merenu boju i teksturu pilećih kobasica

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R e z i m e: U radu je ispitivan uticaj biljnih masti i ulja na instrumentalno merenu boju i teksturu pilećih kobasica. Korišćeno je šest varijanti kobasica: kontrolna grupa sa svinjskom leđnom slaninom (Po), maslinovo ulje (O), ulje semena uljane repice (R), suncokretovo ulje (S), palmina mast (Pa) i mešavina (Mi) od 60 posto ulje semena uljane repice (R) i 40 posto palmine masti (Pa).

Upotreba palmine masti (Pa) je rezultirala najtamnijom ($p \leq 0,05$) bojom na površini živinskih kobasica. Intenzivna crvena boja se smatra najpoželjnijom i postignuta je upotrebom palmine masti (Pa) i smeše (Mi) od 60 posto i 40 posto ulja semena uljane repice (R). Dodavanjem svih ostalih biljnih ulja i masti povećao se udeo žute boje na površini živinskih kobasica. Palmina (Pa) i svinjska (Po) mast su bogate zasićenim masnim kiselinama ($p \leq 0,05$) i njihovom upotrebom dobijena je tamnija boja na svežem poprečnom preseku kobasica. Svinjska mast (Po) je takođe povećala udeo crvene nijanse na svežem poprečnom preseku. Biljna ulja, ukoliko se ne koriste u smeši sa palminom mašću ($p \leq 0,05$) povećavaju Warner Bratzlerovu silu smicanja (WBSF) što proizvod čini tvrđim i sa čvršćom teksturom.

***Ključne reči**: pileća kobasica, viršla, biljne masti, biljna ulja, boja, tekstura.*

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