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APPLICATION OF COMPOSITE PROTECTIVE COATINGS ON THE SURFACE OF SAUSAGES WITH DIFFERENT WATER CONTENT

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Background. Emulsion coatings on the surface of sausages counteract weight loss during storage. Therefore they could be applied instead of synthetic foils, which are used for vacuum packaging. The aim of this study was the assessment of the properties of two emulsion coatings (with different carrageenan content) applied on the surface of two Polish sausages with various water content (kabanosy and frankfurterki).
Material and methods. Sausages were coated with emulsions containing gelatine, kappa-carrageenan, beeswax, lard, glycerol and water. Coated and uncoated sausages were stored for 7, 14 or 21 days at the temperature of 4-6°C. After each storage period weight losses and hardness of peeled sausages, as well as colour values (L*, a*, b*) and water activity of removed coatings were determined.
Results. Coated sausages incurred smaller weight loss and after similar storage periods they were characterized by lower hardness in comparison with uncoated sausages. Reducing the carrageenan content decreased the consumption of emulsion for coating. However, it did not have any impact on the barrier properties of coating. Water activity of coatings decreased during storage. Their colour values also changed.
Conclusions. Irrespective of water content in the sausages, emulsion coatings effectively inhibited their weight loss during storage. The coating with lower content of carrageenan could be recommended. Instability of coatings colour during storage implies the need of adding a colorant to the composition of emulsion.

Key words: sausages, emulsion coatings, storage, weight loss

INTRODUCTION

Synthetic (polymer) materials produced mainly from petroleum oil are commonly used for food packaging because of their low price and good technological properties.

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However, their basic drawback is lack of biodegradability [Leszczyński 2001]. The new trend emerging among food manufacturers and consumers is interest in environment-friendly bio-based packaging materials [Tederko 1995, Gajewska-Szczerbal 2005, Chlebowska-Śmigiel and Gniewosz 2009].

Attempts to use natural materials for coating and improving shelf-life of foodstuffs were made already many years ago (for example coating fresh lemons and oranges with wax or meat products with fat) [Tederko 1995]. At present special composite coatings are developed.

Edible films and coatings are most frequently described in the literature. The aim of applying edible coatings is to limit undesired changes during food storage: microbial growth, oxidation of fat and pigments, weight loss, absorption of off-flavours. Another aspect is reducing cooking loss and absorption of oil during frying. Coatings could also serve as carriers of incorporated additives (pigments, spices, antioxidants and antimicrobial compounds) [Tederko 1995, Garcia et al. 2002, Sagoo et al. 2002].

Edible coatings could be considered, as a packaging, as well as food component. Therefore they should fulfil several requirements: among others, the appropriate sensory, mechanical and barrier properties [Cutter 2006]. Properties of edible coatings are influenced by their components. The basic raw materials used for coating are: proteins (among others: albumins, soy proteins, corn zein, milk proteins, collagen), polysaccharides (cellulose derivatives, starch, pectin, alginate, dextrin, plant gums) and lipids (fatty acids and their esters, mono-, di- and triglycerides, waxes: beeswax and carnauba) [Guilbert et al. 1996, Kokoszka and Lenart 2007].

Most coatings manufactured from hydrophilic substances have good mechanical and barrier properties against transfer of gases, aroma compounds and fat. However, they do not counteract water loss. Hydrophobic materials have poor mechanical properties but they protect well products against water loss or absorption [Yang and Paulson 2000]. Using both groups of the mentioned components enables to develop appropriate properties of coatings. For example incorporating fats into hydrophilic materials improves the barrier properties of coatings [Kokoszka and Lenart 2007, Cutter 2006]. In practice lipid components and biopolymers are combined by emulsifying or the lamination technology [Yang and Paulson 2000].

Plasticizers (non-volatile, low molecular weight components) are added to improve the mechanical properties of coatings. Most frequently used plasticizers are: glycerol, sorbitol, glycol, sugars (saccharose, honey) and lipids (monoglycerides). The type of plasticizer and its amount affect properties of the coating [Kokoszka and Lenart 2007].

Potential applications of coatings in meat processing include: diminishing of weight (water) loss and microbial growth during storage, reduction of oil absorption during frying and separation of components in ready-to-eat dishes [Tederko 1995, Gennadios et al. 1997, Mellema 2003].

Natural sausage casings are special type of retail packaging. They create shape, appearance and sometimes affect taste of meat products [Domaszczyńska 1997]. The gas permeability of natural casings makes possible smoking and drying. However, this feature causes also weight loss (water vapour) during storage of sausages. Manufacturers counteract this phenomenon by vacuum packaging of sausages in synthetic foils. An alternative solution is coating the sausage surface with barrier materials after drying [Bauer et al. 2000].

Attempts were made to develop emulsion coatings made from gelatin, carrageenan, lard and beeswax. They diminished weight loss during storage of dry sausage known in Poland by the name myśliwska. These coatings were not edible (because of sensory properties), but all their components could be used as ingredients of food products. The coatings could be easily peeled like commercial artificial coatings [Tyburcy et al. 2006, 2007].

The aim of this work was to compare the properties of two emulsion coatings developed during our previous experiments [Tyburcy et al. 2006, 2007, Tyburcy and Kozyra 2010] and applied in the case of two sausages. Polish sausages with different water content were chosen (kabanosy and frankfurterki).

MATERIAL AND METHODS

Vacuum packaged kabanosy and frankfurterki were purchased from a local supermarket. The formulation of kabanosy declared on the label comprised: pork meat, sodium chloride, spices, antioxidant and sodium nitrite. The formulation of frankfurterki was the following: pork meat, pork skins, pork plasma, water, sodium chloride, spices, soya protein, polyphosphate, maltodextrin, sodium glutamate, and sodium nitrite. After opening the retail packages both sausages were cut into 5 cm long sticks.

Composite coatings were manufactured from: pork gelatin (dr Oetker), carrageenan (a mix of kappa-carrageenan and potassium chloride, Tari Gel, Gulini Chemie GmbH), beeswax (Stanpol s.c., Warsaw), glycerol (Chempur, Piekary Śl.) and lard. Sticks of sausages were coated with emulsions manufactured according to two formulas (Table 1). In the formulation II amount of carrageenan was diminished by half compared to the formulation I.

Table 1. Formulations of emulsion coatings

Emulsion component	Component proportion, %	
	formula I	formula II
Gelatin	5.4	5.4
Carrageenan	1.1	0.5
Water	49.2	49.5
Glycerol	4.9	5.0
Lard	19.7	19.8
Beeswax	19.7	19.8

The appropriate amount of gelatin was mixed with carrageenan. This mixture was dissolved in the prescribed amount of water in beakers (250 ml) covered with foil and immersed in a water bath (80°C). Thereafter melted beeswax, lard and glycerol were added. After all ingredients had become liquid contents of beakers were homogenized using a Philips HR 1351 kitchen blender for 60 s. Sticks of kabanosy or frankfurterki (5 cm long) were coated by dipping in hot emulsions. After solidification of emulsion coatings on the surface sticks were dried in a smoking-cooking cabin (Jugema P.P.H.U.)

at 50°C for 60 min. Control sticks were not coated. All sticks (coated and control) were hung (using thread) in a refrigerated room (4-6°) and stored for 7, 14 or 21 days.

In order to determine the percentage weight gain after coating and weight loss during storage sticks of sausages were weighed: before dipping in emulsions, after coating solidification and after 7, 14 or 21 days of storage and removal of coatings.

After each period of storage colour values (L*, a*, b*) and water activity of removed coatings were determined. A Minolta CR-200 (D_{65} lighting, 2° standard observer, 10 mm aperture) and an Aqua Lab Series 3 (measurement at 25°C) apparatus were used, respectively. Colour measurements in five different sites of a coating peeled from each 5 cm long sausage stick were taken. The coatings were spread on a brown artificial casing during these measurements. The mean values of colour parameters were calculated for each stick. For water activity measurement all pieces of a coating peeled from each stick were put to a measuring container (a coating from each stick was in a separate container).

Shear force (hardness) of peeled sausage sticks was measured with a Zwicki 1120 machine (a Warner-Bratzler device, a measuring head 0-1000 N, head speed 50 mm × min^{-1}). Each sausage stick was sheared in two different sites (the mean value for each stick was calculated).

Samples taken from each batch of sausages used in the experiment were analyzed for moisture (modification of the method described in the Polish Standard PN-ISO 1442: 2000), fat (the Soxhlet method based on sample weight loss determination using a Buechi Extraction System) and NaCl (the potentiometric method using a 702 SM Titrino apparatus of Metrohm) contents.

Kabanosy and frankfurterki from two different production batches were used (identified based on the different expire date on the label). Emulsions were prepared twice for each batch of sausages. After each period of storage two 5 cm long coated sticks and two control (uncoated) sticks were subjected to investigation. Therefore for statistical analysis n = 4 was taken. One-way analysis of variance and the Duncan multiple range test were used (Statgraphics Plus 4.1., Manugistics, Inc. Rockville, Md., USA).

RESULTS AND DISCUSSION

Commercial kabanosy contained 38.6-39.5% moisture, 35.4-35.7% fat and 2.6-2.7% NaCl. The amounts of these components in the case of frankfurterki were 59.5-59.8%, 20.8-24.9% and 2.0-2.4%, respectively. The moisture content in frankfurterki was distinctly greater than in kabanosy.

The average increase of kabanosy weight after dipping in emulsion I was 42.9% of the initial weight. The diminished amount of carrageenan (formulation II) caused that the emulsion was less viscous. In this case weight gain was significantly ($p \leq 0.05$) lower (26.7%). Similar tendency was observed for frankfurterki. The average weight gain after dipping in the emulsion I and II was 38.3% and 20.8%, respectively.

In the case of frankfurterki weight gain of sticks after dipping in emulsion was a little lower than in the case of kabanosy. It probably resulted from a slightly bigger diameter of frankfurterki and, therefore, a lower area to mass ratio. Much lower emulsion absorption ratios (12.5 do 21.2%) in comparison to this study were noted by Tyburcy et al. [2007]. This discrepancy was an effect of differences in product range, because in both cases used emulsions were of similar composition. The sausage tested in the referenced study had a bigger diameter than kabanosy and frankfurterki.

Weight loss of sausage sticks during storage was determined after the removal of coatings (Table 2). Weight loss of frankfurterki (stored in coatings and without coatings) was distinctly higher than in the case of kabanosy. It resulted from higher initial water content of frankfurterki than of kabanosy. In the case of both sausages the highest weight loss of control sticks occurred in the initial 7 days of storage. Between 7 and 14, and 14 and 21 day weight loss of the control sausages did not rise significantly. After every period of storage weight losses of the coated sausages were significantly lower than of control sticks. In the case of both sausages (kabanosy and frankfurterki) weight loss of coated sticks after 21 days did not differ significantly from the loss which occurred in control sticks just after 7 days of storage. In spite of high differentiation of the amount of emulsion adsorbed on the surface of sausages, no impact of the composition of coating on weight loss was noted.

Table 2. Weight loss of kabanosy and frankfurterki after 7, 14 and 21 days of storage, %

Coating I			Coating II			Control sausage		
7 days	14 days	21 days	7 days	14 days	21 days	7 days	14 days	21 days
Kabanosy								
13.2 a	19.7 b	21.8 cd	11.8 a	17.3 b	20.6 bcd	24.3 de	26.5 e	27.8 e
Frankfurterki								
19.7 a	30.3 bc	39.2 de	20.7 a	28.8 b	37.5 de	42.8 def	45.9 ef	48.0 f

a, b, c – mean values (n = 4) in a row with at least one the same letter are not significantly different ($P \geq 0.05$).

No interrelation between the thickness of emulsion coating and its barrier properties was observed in the previous study too [Tyburcy and Kozyra 2010]. Protective activity of the emulsion coating is a complex phenomenon. It is influenced by the lipid phase dispersion degree present in the emulsion coating. With smaller beeswax particles size the improvement of barrier properties of emulsion films produced from whey proteins was noted [Shellhammer and Krochta 1997]. In our study smaller viscosity of emulsion II could influence higher dispersion degree of lipid particles during homogenisation. The barrier properties of emulsion coatings can also result from the fact that water evaporates at first from the coating, and then from the product. Such a phenomenon was observed in the case of using single ingredient coatings made of hydrophilic materials, for example carrageenan [Krochta and De Mulder-Johnston 1997]. In the case of our experiment both described mechanisms of slowing down the weight loss occurred probably simultaneously. It led to the equalization of the barrier properties of emulsion coatings despite their different composition.

Bauer et al. [2001] investigated barrier properties of several commercial coatings, which were applied in the form of alcohol solutions on the dry sausage surface. After a 24 day period of storage they noted weight loss of the control (uncoated) sausage at the level of 26.1%. Weight losses of product coated with cellulose propionate amounted to 26.3%, modified polymeric resin to 24.4%, and modified natural resin to 6.7%. Coatings tested by the referenced research were characterised by highly diversified barrier properties. The authors, however, did not provide any details concerning the composition of tested coatings.

The observed differences in weight loss of both kinds of sausages were confirmed by hardness (shear force) tests (Table 3). Throughout the whole storage time coated sausages showed lower hardness than control sausages. In the case of frankfurterki difference in hardness of control sticks and coated sticks was proved to be statistically significant. Irrespective of storage time differences in hardness of frankfurterki coated with different emulsions were not statistically significant. The increase of hardness of dry sausages stored without packaging (at a shop or at home) is one of the most important factors contributing to the deterioration of their quality.

Water activity of coatings removed from frankfurterki sticks was distinctly higher than of coatings removed from kabanosy sticks (Table 4). It was the result of different water content in both kinds of sausages. In the case of both sausages water activity in coatings was significantly decreasing during storage.

Table 3. Hardness (shear force values) of kabanosy and frankfurterki after 7, 14 and 21 days of storage, N

Coating I			Coating II			Control sausage		
7 days	14 days	21 days	7 days	14 days	21 days	7 days	14 days	21 days
Kabanosy								
81.3*	87.6	97.1	76.3	76.7	84.8	110.6	112.0	126.9
Frankfurterki								
64.7 a	85.1 bc	97.3 c	66.0 a	77.7 ab	89.3 bc	123.5 d	162.8 e	168.0 e

a, b, c – mean values (n = 4) in a row with at least one the same letter are not significantly different (P ≥ 0.05).

*Carring out of statistical analysis (analysis of variance) of hardness in the case of kabanosy was not possible due to statistical inequality of variances in groups of results.

Table 4. Water activity of coatings removed from kabanosy or frankfurterki after 7, 14 and 21 days of storage

Coating I			Coating II		
7 days	14 days	21 days	7 days	14 days	21 days
Kabanosy					
0.842 de	0.801 bc	0.763 a	0.850 e	0.813 cd	0.775 ab
Frankfurterki					
0.930 c	0.880 b	0.828 a	0.920 c	0.888 b	0.828 a

a, b, c – mean values (n = 4 with exception of water activity of coating I removed from franfurterki sticks after 21 days, where n = 3) in a row with at least one the same letter are not significantly different (P ≥ 0.05).

Table 5. Colour values (L*, a*, b*) of coatings removed from kabanosy or frankfurterki surfaces after 7, 14 and 21 days of storage

Colour values	Coating I			Coating II		
	7 days	14 days	21 days	7 days	14 days	21 days
			Kabanosy			
L*	71.1 c	70.7 bc	69.5 ab	71.3 c	69.6 ab	69.1 a
a*	0.2 a	0.6 ab	2.5 bc	1.3 ab	2.4 bc	4.0 c
b*	31.8 b	31.5 b	31.5 b	26.8 a	26.9 a	27.9 a
			Frankfurterki			
L*	80.9 b	76.9 ab	73.4 a	76.1 ab	76.1 ab	73.0 a
a*	–3.8**	–2.8	–1.6	–1.7	–1.7	–0.8
b*	33.9 cd	36.3 d	35.3 cd	28.6 a	30.3 ab	32.6 bc

a, b, c – mean values (n = 4) in a row with at least one the same letter are not significantly different ($P \geq 0.05$).
**Carring out of statistical analysis (analysis of variance) of coating redness (a*) in the case of frankfurterki was not possible due to inequality of variances in groups.

In the case of kabanosy, as well frankfurterki, a reduction of coating lightness (L*) was observed during storage (Table 5). The composition of coating did not have a significant effect on this colour parameter. Coatings removed from frankfurterki were characterised by distinctly higher lightness of colour than coatings peeled from kabanosy. It resulted from higher water activity of coatings applied on the surface of frankfurterki. The a* colour value (redness) of coatings grew along with storage time. In the case of frankfurterki the a* values were negative. The significant effect of the composition of coating on this parameter was not noted. In both cases of frankfurterki and kabanosy after the same storage time yellowness (b*) of coating I was higher than of coating II. The colour parameter b* significantly increased during storage only in the case of coating II being removed from the surface of frankfurterki. In the case of coating I removed from this sausage and both coatings removed from kabanosy sticks no significant change of b* parameter over time was noted. Tyburcy and Kozyra [2010] observed the significant growth of a* and b* values and the decrease of lightness (L*) of coatings peeled from kabanosy stored for 7 or 15 days. The authors explained this phenomenon with the dehydration of coatings and the increase of beeswax content (yellow substance). A slightly different nature of change of b* parameter observed in this study could result from different conditions in which colour measurements were taken. In the referenced study during measurements white background was applied under coating, whereas in this study, it was brown (closer to the colour of the sausage surface). To some extent coatings were transparent. Due to this the brown background masked the change of b* parameter during storage. The instability of coating colour parameters during storage indicates the need to add to the composition of emulsion a colorant, which could, to some extent, mask the change of colour.

CONCLUSIONS

1. Both sausages (kabanosy and frankfurterki) stored in coatings incurred smaller weight losses, and after similar storage times they were characterised by lower hardness (shear force values) in comparison to sausages without coatings. The weight loss of coated sausages after 21 days of refrigerated storage was on the level, which control sticks reached already after 7 days.

2. Reducing the dose of carrageenan limited the amount of emulsion adsorbed on the surface of sausages. However, it did not have any impact on the effectiveness of coating to reduce weight loss during storage. This suggests using the coating with lower carrageenan content.

3. Colour parameters of emulsion coatings were changing during storage. It implies the need of adding a colorant to the composition of emulsion.

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ZASTOSOWANIE POWŁOK WIELOSKŁADNIKOWYCH CHRONIĄCYCH PRZED USUSZKĄ NA POWIERZCHNI KIEŁBAS O ZRÓŻNICOWANEJ ZAWARTOŚCI WODY

Wprowadzenie. Powłoki emulsyjne na powierzchni kiełbas hamują proces ususzki przechowalniczej. Mogą więc być użyte zamiast syntetycznych folii stosowanych w pakowaniu próżniowym. Celem pracy była ocena właściwości dwóch powłok emulsyjnych (różniących się zawartością preparatu karagenowego) zastosowanych na powierzchni dwóch kiełbas różniących się zawartością wody: kabanosów i frankfurterek.
Materiał i metody. Kiełbasy były powlekane powłokami emulsyjnymi zawierającymi żelatynę, preparat kappa-karagenu, wosk pszczeli, smalec, glicerynę i wodę. Kiełbasy pokryte powłokami i kontrolne przechowywano przez 7, 14 i 21 dni w temperaturze 4-6ºC. Po każdym czasie przechowywania określano ubytki masy i twardość kiełbas (po zdjęciu powłok) oraz parametry barwy (L*, a*, b*) i aktywność wody zdjętych powłok.
Wyniki. Kiełbasy przechowywane w powłokach miały mniejsze ubytki masy oraz charakteryzowały się mniejszą twardością w porównaniu z kontrolnymi po analogicznych czasach przechowywania. Zmniejszenie zawartości preparatu karagenowego w emulsji pozwoliło zmniejszyć jej zużycie przy powlekaniu bez pogorszenia właściwości barierowych powłoki. W czasie przechowywania zmniejszała się aktywność wody w powłokach. Parametry barwy także ulegały zmianom.
Wnioski. Niezależnie od zawartości wody w kiełbasach, powłoki efektywnie ograniczały ich ususzkę przechowalniczą. Można zalecić zastosowanie powłoki z mniejszą zawartością preparatu karagenowego. Niestabilność barwy powłok podczas przechowywania sugeruje potrzebę zastosowania barwnika w składzie emulsji.

Słowa kluczowe: kiełbasy, powłoki emulsyjne, przechowywanie, ususzka

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