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Original scientific paper

The Impact of Replacing Backfat With Microcrystalline Cellulose Gel on Physico-Chemical and Sensory Quality of Frankfurter[1]

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Abstract: The aim of this study was to evaluate the effect of different concentrations of dietary fiber *Vitacel MCG 0018 Gel* (consisting of microcrystalline cellulose - MCC and two different qualities of carboxymethyl cellulose - CMC) as back fat substitute on the physico-chemical and sensory quality of frankfurter.

Five production series were evaluated to examine the back fat replacement: the control group (C) - a sample with just the addition of back fat (100% fat - 0% Vitacel MCG 0018 Gel); 75% fat and 25% gel (E1); 50% fat and 50% gel (E2); 25% fat and 75% gel (E3); 0% fat and 100% gel (E4).

In our research, the moisture content increased (59.69% - 71.07%) and the fat content decreased (23.48% - 9.99%) with increasing of back fat replacement by Vitacel MCG 0018 gel. The protein content was higher than 10% (10.18% - 10.35%) and relative content of connective tissue proteins was lower than 20% (6.33 – 17.43) in all examined samples which is in accordance with the criteria of the Serbian Regulation.

Sensory evaluation of color, smell and taste and texture and juiciness are less assessed in frankfurters where the fat is replaced by the Vitacel MCG 0018 gel in the proportion of more than half.

In general, it can be concluded that the replacement of up to 50% back fat with cellulose fiber gives sausages almost unchanged properties, while the addition of larger fiber amount leads to decrease of sausage quality.

Keywords: microcrystalline cellulose, fat substitutes, frankfurter, sensory acceptability

Introduction

Meat and meat products are essential in the diet of the modern world. Food of animal origin including meat is required to maintain the health of a human body (Nestle, 1999).

Since the mid-1970s, interest in the role of dietary fibers in health and nutrition has prompted a wide range of research and received considerable public attention (Abdul-Hamid and Luan, 2000; Chau and Huang, 2003). Published reports indicate numerous health benefits associated with an increased intake of dietary fiber, including reduced risk of coronary heart disease, diabetes, obesity, and some forms of cancer (Mann and Cummings, 2009).

It is important for food materials to be delicious as well as nutritious and natural. Rapidly increasing of human population of world, environmental pollution caused by consistently developing technology, insufficient education and problems caused by wrong nutrition are making supplying of natural food is more difficult. Healthy nutrition refers to efficient and balanced nutrition, that is, efficient intake of nutrient elements (lipids, carbohydrates, proteins, vitamins, minerals) for body cells to work smoothly (Yangilar, 2013).

There is an increasing trend of fiber addition in meat products for technological reasons and benefits to human health (Vendrell-Pascuas *et al.*, 2000). Functional meat products either possess nutritional

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ingredients that improve health or contain lesser quantity of harmful compounds like cholesterol, fat etc (Yue, 2001).

Reducing the total fat content of processed meats is not only desirable but feasible. Combinations of different fat substitutes can reduce significantly the caloric content and the level of saturated fats. This could result in a new category of products which have an acceptable taste and a high degree of nutritional merit and offer the consumer an alternative to traditional processed products (Jalal *et al.,* 2014). Meat processing industry is faced with the request of consumers who seek new products with reduced energy value, whose consumption would reduce the total intake of fat into the organism of people. Production of meat products with reduced fat is not an easy job. In addition to providing energy, fats in cooked sausages influence the formation of the appropriate texture and juiciness of the product, and have a positive effect on the emulsion stability and sensory properties of sausages (Dolata *et al.,* 2002; Turhan *et al.,* 2008).

Dietary fiber is a key ingredient widely used nowadays while developing nutritionally designed foods due to its significance in health promotion (Puupponen-Pimïa et al., 2002) and technological impact. Meat products that contain dietary fibers are excellent meat substitutes due to their inherent functional and nutritional effects (Hur et al., 2009; Kumar et al., 2010).

Fiber is suitable in meat products and has previously been used in meat emulsion products (Cofrades et al., 1995, Grigelmo-Miguel and Martin-Belloso, 1999) because it retains water, decreases cooking losses and has a neutral flavour. Inclusion of dietary fiber in the meat matrix contributes to maintain its juiciness, which implies that the volatile compounds responsible for the flavour of product are more slowly released (Chevance et al., 2000). Several dietary fibers have been used as potential fat substitutes (Mansour and Khalil, 1999).

In general, cereal products are recognized sources of dietary fiber and many bioactive components such as lignans, phenolic acids, phytosterols, minerals, tocopherols and tocotrienols. Microcrystalline cellulose (MCC) is an example of a hydrocolloid with no solubility in water that adsorbs mechanically at the interface. MCC is also able to stabilize the oil-in-water emulsions. Its strong affinity for both the oil and the water results in precipitation and some orientation of the solid particles at the oil-in-water interface (Philips *et al*., 1984). It was proposed that the colloidal network of the free MCC thickens the water phase between the oil globules preventing their close approach and subsequent coalescence. Therefore, the MCC provides long term stability (Philips *et al*., 1990). These colloidal dispersions are unique when compared to other soluble food hydrocolloids. MCC, considered GRAS, is no caloric. MCC mimics fat in aqueous systems; contributes body, consistency, texture modification and mouth feel; stabilizes emulsions and foams; controls syneresis; ice crystal control and adds viscosity, gloss, and opacity to foods. Applications include salad dressings, frozen desserts, sauces, and dairy products (Akoh, 1998; Imeson, 2010). Lander (2004) also reported the use of cereal fibers like Vitacel®, a wheat fiber, as functional ingredients in meat products such as cooked sausages, mince, raw fermented sausages and cooked ham.

Microcrystalline cellulose (MCC) is purified cellulose, produced by converting fibrous cellulose to are dispersible gel or aggregate of crystalline cellulose using acid hydrolysis. MCC is prepared by treating natural cellulose with hydrochloric acid to partially dissolve and remove the less organized amorphous regions of this polysaccharide. The end product consists primarily of crystallite aggregates. MCC is available in powder form after drying the acid hydrolysates. Dispersible MCC is produced by mixing a hydrophilic carrier (e.g., guar or xanthan gum) with microcrystals obtained through wet mechanical disintegration of the crystallite aggregates (Cui, 2005).

Hydrocolloid materials i.e. proteins and polysaccharides can be used extensively for the formation of edible films and coatings. Polysaccharide - cellulose derivatives have various principal function: CMC like thickener, HPC thickener and emulsifier, HPMC thickener and MC thickener, emulsifier and gelling agent (Hollingworth, 2010). Biswas *et al*. (2011) reported that the Microcrystalline cellulose extracted from wood pulp, bamboo, wheat, cottonseed hulls improves water holding capacity, and modified cellulose (MC, CMC, MHPC) by chemical reaction of cellulose have functions in meat products like thickener, stabilizer and humectants. Inclusion of fibers, such as carboxymethyl cellulose (CMC) and microcrystalline cellulose (MCC), at the expense of fat or protein in meat batters could be used to produce healthier sausages while lowering production costs (Schuh *et al.,* 2013).

The objective of this study was to investigate the effect of replacing pork back fat with different concentrations of colloidal system *Vitacel MCG 0018 Gel* on the physico-chemical and sensory quality.

Material and Methods

Frankfurters preparation and processing

Cooked finely minced sausages, frankfurter, were used as the test group material in this research, all produced in meat processing "Štrand", Novi Sad.

In order to create the control sample (C) of cooked sausages, common raw materials were used, with the production specification as follows: drumstick meat 30%, mechanically separated (poultry) meat (MSM) 30%, back fat derived from dorsal part of the carcass 20%, water/ice 20%, spices and additives. While preparing the experimental sausages, fat was partially replaced by hydrogenated microcrystalline cellulose to the amount of 25% (E1), 50% (E2), 75% (E3) and 100% (E4).

The microcrystalline cellulose was pre-hydrated by adding water/ice in a ratio of 1:9. Microcrystalline cellulose for obtaining the gel comes from the manufacturer J Rettenmaier & Sohne GMBH + CO, Rosenberg, Germany, branded as *Vitacel MSG 0018 Gel*. *Vitacel MCG 0018 Gel*, consisting of microcrystalline cellulose (MCC E 460) and two different qualities of carboxymethyl cellulose (CMC E 466).

Table 1. Raw material of frankfurter of control (C) and experimental groups (E1- E4)

	C	E1	E2	E3	E4
Drumstick	30	30	30	30	30
MSM	30	30	30	30	30
Backfat	20	15	10	5	0
Gel (Vitacel MCG 0018) 1:9	0	5	10	15	20
Water, ice	20	20	20	20	20
Nitrite salt	1.8	1.8	1.8	1.8	1.8
Polyphosphate mixture "Combi mix"	1.0	1.0	1.0	1.0	1.0
Vitacel MGN 150MGN 150	1.0	1.0	1.0	1.0	1.0
Spices	0.5	0.5	0.5	0.5	0.5

Polyphosphate mixture "Combi mix" („Miltrade", Novi Sad, Serbia) was added, with composition of: disodium diphosphate (E 450 (i)), trisodium diphosphate (E 450 (ii)), dextrose, penta sodium tri phosphate (E 451(i)), ascorbic acid (E 300), monopotassium-glutamate (E 622), sodium erythorbate - sodium isoascorbate (E 316) and citric acid (E 330) in an amount of 1%. As emulsifier Vitacel MGN 150 MGN 150, dietary fiber compound (oat and potato fiber and psyllium) was used.

The mass was stuffed in impermeable casings Ø 24 mm diameter and heat treated at a temperature of 74-76 ^{0}C, until reaching a temperature of 72 ^{0}C in the center of the product. After cooled to 30 ^{0}C with cold water showers, the sausages were cooled down, vacuum-packed, and samples were stored at a temperature of 4°C until the completion of the analysis.

Basic chemical composition

Analyses of sausages were performed at the Institute of Food Technology in Novi Sad. The basic chemical composition was assessed by determining moisture content (SRPS ISO 1442:1998), total protein (SRPS ISO 937:1992), hydroxyproline content - the relative content of connective tissue proteins (SRPS ISO 3496:2002), free fat content (SRPS ISO 1444:1998) and total ash (SRPS ISO 936:1999).

Caloric value

The energy value of sausages was determined using the formula: $CV = 4xP + 4xC + 9xF,$ where are, CV = caloric value (kcal/100g), P = total proteins (%), C = carbohydrates (%), F = free fat (%) Grujic *et al*., 2001). Carbohydrates are calculated from the difference between the total chemical composition (moisture + fat + protein + ash) to 100%

Sensory evaluation

The sensory properties of sausages (outward appearance, layout and composition sections, colors and the sustainability of color, smell and taste, texture and juiciness) were evaluated using quantitative descriptive test (SRPS ISO 6658:2001), the numerical descriptive scale ranging from 1 to 5 (worse property was assessed a lower grade, a better performance higher mark). A group of five trained persons formed a panel of assessors for the evaluation of sensory properties of tested sausages. Assessors had previously tested heard by a test for determining the sensitivity of taste (SRPS ISO 3972:2002) and initiation and training of assessors in the detection and recognition of odours (SRPS ISO 5496:2002).

Statistical analysis

Test results were statistically analyzed. For all examined properties the mean value of the mark ($\overline{x}$) with a standard deviation (Sd) were calculated. The coefficients of variation (Cv) as a relative measure of dispersion, which show variation between different groups of sausages was also calculated. Data were analyzed statistically with one way ANOVA and post-hoc test (DUNCAN'S test). Levels of significance $P<0.05$ were used. Correlation coefficients were also calculated. Statistical analysis was conducted using STATISTICA software version 10 (STATSOFT, Inc., 2011).

Results and Discussion

Results of the basic chemical composition of frankfurters with fat replaced by microcrystalline cellulose are presented in Table 2.

It was obtained that the moisture content increased (59.69% - 71.07%) and the fat content decreased (23.48% - 9.99%) with increasing back fat replacement by *Vitacel MCG 0018 Gel*. This results is in accordance with the results of Almeida *et al.* (2014), who were produced emulsified cooked sausages (beef: 52.5%; pork: 15%; and pork back fat: 20%) with 25, 50, 75 or 100% of their pork back fat content replaced by amorphous cellulose gel (ACG). The moisture content of low-fat high dietary fiber (DF) frankfurters increased linearly (r^2=0:994) with added water in all the formulations and was inversely proportional to the fat content (Grigelmo-Miguel et al., 1999).

Chemical analyses showed that the free fat content in the frankfurters were decreased with increasing of fat replacement with *Vitacel MCG 0018 Gel*.

Table 2. Basic chemical composition of frankfurters of control (C) and experimental groups (E1-E4), %

	Moisture	Total fat	Total protein	RCCTP	Total ash	Carbo-hydrates	Energy value, kcal/100 g
C	59.69±0.90*	23.48±1.60	10.18±0,10	17.43±1.67	2,68±0.09	3.97±1.80	267.92
E 1	62.18±0.74	19.96±0.70	10.26±0,23	10.56±0.87	2.76±0.27	4.86±0.78	240.04
E 2	64.12±0.97	17.77±0.65	10.30±0,25	8.31±0.51	2.88±0.12	4.93±0.75	220.85
E 3	66.27±1.01	15.38±0.76	10.18±0,07	6.59±0.58	2.38±0.04	5.79±1.03	202.30
E 4	71.07±0.37	9.99±0.57	10.35±0.09	6.33±0.28	2.62±0.28	5.97±0.64	155.19

*The values are presented as average values±standard deviation.

Szczepaniak et al (2007) came to the same conclusion that amount of water was increased in produced sausages along with the increase of amount of fat replacement applied. It resulted from the introduction of additional amounts of water required to rehydrate fiber in experimental sausage

The protein content remained predominantly constant in the control (10.18%) and different production series (10.26% – 10.35%). Similar results were reported by several authors: Grigelmo-Miguel *et al*. (1999) in low-fat high dietary fiber (DF) frankfurters (20±5% fat) produced with two different peach DF suspensions (17 and 29%) and Lin *et al*. (1988) in frankfurters made with carboxymethyl cellulose.

The relative content of connective tissue proteins was the highest in frankfurter control group C, (17.43%) and lower in the frankfurters experimental group E (10.56%, 8.31%, 6.59%, 6.33%). The relative content of connective tissue proteins in fat tissue was higher than in chicken meat and as expected, relative content of connective tissue proteins of the frankfurters with reduced share of back fat decrease.

The protein (>10%) and relative content of connective tissue proteins (<20%) satisfies the criteria of the Serbian regulation.

Microcrystalline cellulose gel content follows the energy value. Energy values are greatly related to fat contents. According to the reduction of fat content, energy value were also reduced. Energy value in the samples amounted 267.92 kcal/100 g, 240.04 kcal/100 g, 220.07 kcal/100 g, 202.30 kcal/100 g, and 155.19 kcal/100 g. The energy value of the sample in which the total replacement of fat (E4) was reduced to 42.08% compared to the control sample.

In similar study (Choi *et al.,* 2012), the differences in fat contents and energy values of reduced-fat chicken sausages were statistically significant (p<0.05). The fat contents varied between 2.20 and 23.61%. As expected, the fat contents were lower in all treatments than in the control.

The sensory properties of frankfurters with fat replacesd by *Vitacel MCG 0018 Gel* are presented in Table 3.

Table 3. Sensory properties of frankfurters from control (C) and experimental groups (E1 – E4)

	External appear-ance	Cut surface	Colour and color stability	Smell and taste	Texture and Juiciness	Overall accept-ability
C	5,00±0,00[a]	4,67±0,26[a]	4,75±0,27[a]	4,83±0,26[a]	4,58±0,20[a]	4,77±0,25[a]
E 1	5,00±0,00[a]	4,67±0,26[a]	4,67±0,26[a]	4,75±0,27[a]	4,67±0,26[a]	4,75±0,25[a]
E 2	5,00±0,00[a]	4,67±0,26[a]	4,75±0,27[a]	4,67±0,26[a]	4,58±0,20[a]	4,73±0,25[a]
E 3	5,00±0,00[a]	4,58±0,20[a]	4,67±0,26[a]	4,67±0,26[a]	4,50±0,00[a]	4,68±0,25[a]
E 4	5,00±0,00[a]	4,58±0,20[a]	4,50±0,45[b]	4,50±0,45[b]	4,08±0,20[b]	4,53±0,41[b]

*The values are presented as average values±standard deviation.
[ab] indicates signifi cant difference within column at P<0.05

Samples of sausages in control (C) and experimental groups (E1 - E4) were rated with the best mark (5.00) for the external appearance and for the cut surface (4.67 - 4.58) with no determined statistically significant (p>0.05) differences.

In evaluating the color, taste and smell and texture and juiciness frankfurters where fat was replaced by the *Vitacel MCG 0018 Gel* in the proportion of more than half (E3 and E4) were less assessed. Statistical analysis of the color, taste and smell and texture and juiciness parameters revealed that no significant differences between the samples of frankfurters from control (C) and experimental (E1, E2 and E3) groups were obtained, but statistically significant difference was obtained between all mentioned groups and experimental (E4) group in which all fat was replaced by *Vitacel MCG 0018 Gel* .

Overall acceptability analysis of produced frankfurters showed that frankfurters from control group (C), as well as frankfurters from experimental groups E1, E2 and E3 were rated as excellent (4.77; 4.75; 4.73 and 4.68, respectively), while overall acceptability of sausages with 100% replaced fat from experimental group (E4) was rated as very good (4.53) which were significantly different (p<0.05) from other groups of sausages.

Similar, satisfactory results were obtained by Grujic et al. (2014) in sausages which have been integrated with 5%, 10% and 15% of the different plant fibers. The obtained functional cooked sausages fully meet the sensory needs of consumers. Also, Choi et al (2014) concluded that the replacement of back fat with 20-25% BSG pre-emulsion can be successfully used to improve reduced-fat chicken sausages.

Conclusions

The moisture content increased (59.69% - 71.07%) and the fat content decreased (23.48% – 9.99%) with increasing back fat replacement by *Vitacel MCG 0018 Gel*.

The protein content remained predominantly constant in the control (10.18%) and different experimental groups (10.26% – 10.35%).

The relative content of connective tissue proteins was the highest in control group C, (17.43%) and lower in the experimental groups E1, E2, E3 and E4 (10.56%, 8.31%, 6.59%, 6.33%, respectively).

The protein (>10%) and relative content of connective tissue proteins (<20%) satisfies the criteria of Serbian regulation.

Sensory evaluation of the color, smell and taste and the texture and juiciness are less assessed in frankfurters where fat was replaced by the *Vitacel MCG 0018 Gel* in the proportion of more than a half. Frankfurters from all groups meet the sensory needs of consumers.

Fat could be substituted with cellulose fiber gel in frankfurters in order to produce functional products that can improve health benefits to consumers.

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