REDUCED - FAT SAUSAGE AS AFFECTED BY USING FAT REPLACERS, NATURAL BEEF FLAVOR AND COLLAGEN CASINGS

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Abstract

Reducing the fat in the meat products decreases the overall acceptability of these products but, there is an increasble worrying of having the fatty foods specially meat products, therefore, reduced-fat meat products should be available for population with retaining traditional full-fat properties in these products. Full-fat sausage (control), reduced-fat sausage (control), reduced-fat sausages treated with iota-carrageenan (RFT_1), xanthan gum (RFT_2) and soy protein isolate (RFt_3) were processed under this study. Proximate chemical composition, cholesterol content, caloric content, physical and sensory properties were evaluated. Also, carrageenan and xanthan distribution in the finished products were investigated.

The results indicated that the differences in chemical composition of raw and cooked sausage products were nearly due to reducing the fat and increasing the added water in the reduced-fat sausages. The cooked reduced-fat sausage products recorded lower cholesterol contents than the cooked full-fat sausage. Any way, RFT_1 was the best treatment, whereas, it had no thawing loss of frozen batter, the lowest cholesterol and calories contents, the lowest cooking loss and the highest water holding capacity, in addition to good plasticity and color when compared to the other products under this study. According to the overall acceptability, the RFT_1 was the best treatment among all the treatments. On the other hand, in the cooked finished product, carrageenan distribution was preferred when compared to xanthan distribution.

Therefore, it can be concluded that the best treatment was RFT_1 which is recommended to produce the reduce-fat sausage and retaining traditional full-fat properties

INTRODUCTION

Today's consumers are not only interested in quality products which taste good and convenient but also are concerned with the nutrition, safety, and wholesomeness of the foods they consume. The anxiety over fatty foods is the major factor influencing consumer food choices today. Therefore, the amount of fat and cholesterol in the diet, especially from meat products such as sausages, frankfurters, patties and others, is of concern to most health-conscious consumers. Grundy (1986) reported that there is an apparent relationship between the amount and type of fat consumed and the incidence of coronary heart diseases (CHD), and it is known that the ingestion of most saturated fatty acids increases the concentration of plasma low density lipoprotein (LDL)-cholesterol in humans, and elevated levels of plasma LDL-cholesterol are correlated with increased risk of (CHD). As well as, the American Heart Association (AHA 1986) and other health organizations have promoted lowering intake of dietary fat and cholesterol as means of preventing cardiovascular heart diseases. Also, studies have shown that reductions in fat intake can result in a 10% reduction of the risk for heart disease, and if persons who are overweight lose weight in addition to modifying their diet, they can lower their risk for cardiovascular heart disease by 20% (Latta 1990). Moreover, Giese (1992) reported that the recommended diet is one in which no more than 30% of the calories are supplied from fats. Therefore, in the recent years, reduced-fat meat products should be available for population.

On the other hand, the flavor intensity, juiciness and tenderness of meat products, such as sausages, are directly related to fat content, consequently, reduction of fat to produce the reduced-fat meat produts reduces the overall acceptability for these products. To overcome these shortcomings, various ingredients such as soy protein isolate (USDA 1991) and carrageenan (Egbert *et al.* 1991) were added to the formulations of reduced-fat meat products. Giese (1992) reported that the most widely used binder in the series of current low-fat meat products is carrageenan due to its ability to retain moisture. Also, Trius (1994) concluded that carrageenan helped in reducing moisture loss of beef sausage. Also, Richard *et al.* (1995) reported that using soy protein to formulate the low-fat frankfurter increased the hardness and decreased the flavor intensity while the reverse trend was recorded by using carrageenan. Moreover, the flavor intensity and tenderness were increased in reduced fat sausage containing carrageenan (Ho *et al.* 1995). Generally, the low-fat meat products have generated a variety of strategies for reducing fat, but the final goal has been to reduce fat with retaining traditional full-fat flavor and texture.

The aim of this work is to produce the reduced-fat beef sausage products and evaluate them (chemically, physically, and organoleptically,) as affected by using some fat replacers, natural beef flavor and collagen cases.

MATERIALS AND METHODS

Materials:

Fresh lean beef and back fat were obtained from the private sector's shops in the local market at Giza. Lean beef was trimmed of all external fat. Both trimmed lean beef and fat were ground separately through 4.5 mm plate (twice). The ground meat was analyzed for fat content by diethyl ether extraction (AOAC 1990), then adjusted to contain 90% lean beef (10% fat). The fresh ground beef (90% lean) and fat were packaged under vacuum and stored at -20°C overnight before use. Three ingredients were used as fat replacers (the used level = 0.5%) including: iota-carrageenan (Viscarin SD 389) which was obtained from Marine Colloids Div. of FMC Corp. (Philadelphia, PA); xanthan gum from Kelco, (Rahway, NJ) and soy protein isolate from Archer Daniels Midland Co. (Decature, IL). Two kinds of casings were used for stuffing: mutton casings for controls while collagen casings were used for treatments. Natural beef flavor (obtained from China Meat Res. Center, Beigin) was used in treatments. Food grade salt, glucose, sodium nitrite, ascorbic acid and strarch were used. Spices mix was consisted of black, red and white pepper, ginger, nutmeg, clove, cinnamon and cardamon (equal weight from each), mixed together and added at level of 0.61% for all products.

2. Technological methods:

Formulations of full-fat sausage (control), reduced-fat sausage (control), reduced-fat sausage treated with carrageenand (RFT_1), reduced-fat sausage treated with xanthan gum (RFT_2) and reduced-fat sausage treated with soy protein isolate (RFT_3) are presented in Table 1. Meat and fat were thawed at 4°C for 48 hr. The initial processing of all formulations was made by chopping beef, one-half of the ice, and salt for 5 min in a bowl chopper (Hobart, model 84142). Batters temperature was checked, then the spices mix, nitrite, ascorbic acid, starch, glucose, fat replacer (either carrageenan, xanthan or soy protein isolate; according to the treatment), beef flavor (only for the treatments), fat and remaining ice were added and chopped for an additional 5 min. Final temperature did not exceed 12°C. Batters were stuffed into casings by using stuffing machine then, sausages placed in fibrous plates, packaged in polyethylene bags and held at -18°C until needed for subsequent analysis.

Table 1. Batter formulations.

Ingredient (%)	Full-fat control	Reduced-fat control	Reduced-fat treatments
Beef (90% lean)	70.56	63.55	63.55
Fat	14.04	1.91	1.91
Ice	6.91	17.25	17.25
Water	--	8.50	7.50
Sod. nitrite	0.01	0.01	0.01
Ascorbic acid	0.03	0.03	0.03
Starch	4.00	4.00	4.00
Salt	2.18	2.18	2.18
Glucose	1.96	1.96	1.96
Fat replacer*	--	--	0.50
Beef flavor	--	--	0.50
Spices mix.	0.61	0.61	0.61

* Iota carrageenan, xanthan gum, and soy protein isolate.

3. Analytical methods:

Moisture, fat and protein contents were determined by the methods of AOAC 1990). Caloric content (Kcal/100 g) was determined using the Atwater conversion method (Bogert *et al.* 1983). Cholesterol content of cooked samples was determined according to the method described by Rhee, *et al.* (1982).

Freeze/thaw stability of sausage batters was determined according to the method described by Trius *et al.* (1994) as follows: For both treatments, two polyethylene bags per treatment were filled with 100g of the sausage batter and frozen at -20^{o}C for 30 days then, samples were thawed at 2^{o}C for 24 hr, and thawing loss was determined by draining released fluids, reweighing samples, and expressing thawing loss as a percentage of initial weight. Cooking loss was calculated as the percentage of weight change from the raw to cooked state. Water holding capacity (WHC) and plasticity (cm2/0.3 g sample) were measured using filter-press method described by Soloviev (1966). Color of sausage samples was determined by measuring the absorbance at 542 nm according to the method described by Husaini *et al.* (1950). Carrageenan and xanthan distribution in the cooked product treated with carrageenan or xanthan was made according to the method of Bater *et al.* (1992). Organoleptic evaluation of sausages cooked in hot water at 85^{o}C for 15 min was

carried out according to Molander (1960). Ten judges evaluated odor, taste, texture, color, appearance, and the overall acceptability, based on the following scale:

Very good	8-9	Poor	2-3
Good	6-7	Very poor	0-1
Fair	4-5.		

Statistical analysis was made where the sensory scores were analyzed using the analysis of variance to evaluate the effect of treatments on the palatability scores of sausage. Means were compared by using the least significant difference (L.S.D.) at 0.5 level (Steel and Torrie 1980).

RESULTS AND DISCUSSION

Chemical analysis:

Table 2 show the results of the chemical composition of the two controls and the reduced-fat sausage treatments. From the results, which were calculated on wet weight bases, it can be seen that the reduced-fat control and treatments (RFt_1, RFt_2 and RFt_3) had higher moisture contents (73.61-73.85 - 73.71 and 72.65), lower fat contents (8.36-8.1 - 8.22 - 8.59%) and relatively lower ash and carbohydrate contents (3.39-3.47%) compared to the full-fat control which had 58.83% moisture, 21.91% fat and 4.2% ash and carbohydrate contents, respectively. Slight differences (0.42%) in protein content were found among all the treatments and controls with the exception of that RFt3 which had slightly higher protein content due to adding soy protein isolate. These differences in chemical composition of raw sausages (controls and treatments) are mainly due to reducing the fat in formulations of the reduced-fat sausages (about 8%) and high levels of added water (about 25%).

Also, from the same Table, it can be observed that the highest moisture and the lowest fat contents were recorded for the RFt_1 of raw or cooked products. These results are confirmed by the findings of Egbert *et al.* (1991).

Cholesterol content and calories:

Cholesterol content (mg/100 g cooked sausage) and calories (Kcal/100 g cooked sausage) of reduced-fat sausage as affected by using fat replacers (iota-carrageenan, xanthan gum and soy protein isolate), natural beef flavor and collagen casings are presented in Table 3. From these results, concerning cholesterol contents, it can be seen that all the reduced-fat sausages, either reduced-fat control or reduced-fat treatments (RFt_1, RFt_2, and RFt_3) had lower cholesterol contents

Table 2. Chemical analysis of control and reduced-fat sausage treatments.

Treatment / Analysis	Full-fat control	Reduced fat control	RFt1	RFt2	RFt3
Raw composition					
Moisture %	58.83	73.61	73.85	73.71	72.65
Fat %	21.91	8.36	8.10	8.22	8.59
Protein %	15.02	14.64	14.65	14.60	15.52
Ash and Carbohydrates %	4.24	3.39	3.47	3.47	3.24
Cooked composition					
Moisture %	54.25	66.35	69.00	67.80	66.67
Fat %	19.50	8.63	8.20	8.51	8.78
Protein %	20.81	20.10	18.60	19.19	20.15
Ash and	3.03	2.61	2.30	2.41	2.40
Carbohydrates %	2.41	2.31	1.90	2.06	2.00

RFt1 = Reduced-fat sausage treated with iota carrageenan + beef flavor and stuffed in collagen casings.

RFt2 = Reduced-fat sausage treated with iota xanthan + beef flavor and stuffed in collagen casings.

RFt3 = Reduced-fat sausage treated with soy protein isolate + beef flavor and stuffed in collagen casings.

Table 3. Cholesterol content and calories of reduced-fat sausage (cooked) as affected by using fat replacers, natural flavor and collagen casings (on wet weight basis).

Treatment*	Cholesterol (mg/100g)	Calories	
		Total (Kcal/100g)	Produced from fat only (%)
Full-fat control	71.70	268.38	65.39
Reduced-fat control	62.24	167.31	46.42
RFt1	61.86	155.80	47.36
RFt2	62.13	162.95	47.39
RFt3	62.16	167.62	47.14

* For explaination see table 2.

(61.86-62.24 mg/100 g cooked sample) compared to the full-fat control which contained higher cholesterol content (71.70 mg/100 g cooked sample).

Concerning the caloric content, it can be seen from the same Table that regardless of protein content (slight differences in protein contents among all the sausage products, about 2.2%) as well as carbohydrate content, the reduced-fat sausages had lower calories (155.8-167.62 Kcal/100g cooked sausage) than the full-fat control (268.38 Kcal/100g sample). Calories produced from fat only (calculated as a percentage of total calories) were lower for reduced-fat sausages (46.42 - 47.39%) than full-fat sausage (65.39%). This indicate the importance of reducing fat and subsequently decreasing calories content. These results are confirmed by the findings of AHA (1986) and Grundy (1986). Therefore, reduced-fat meat products such as sausages may be available for the population in Egypt.

Physical evaluation:

Data presented in Table 4 show the thawing loss of sausage batters, cooking loss, color (for raw and cooked sausages) and water holding capacity (WHC) and plasticity (cm^2/0.3 g sample) of reduced-fat sausage as affected by using fat replacers, natural beef flavor and collen casings.

Concerning the thawing loss % (freeze/thaw stability), freezing meat batters is not a normal handling process for such products, but freeze/thaw evaluations were conducted to determine how it would affect fat replacers used in sausage treatments (iota-carrageenan, xanthan gum and soy protein isolate). On thawing, no drip loss was observed for reduced fat sausage treated with iota-carrageenan (RFt_1), reduced-fat sausage treated with xanthan gum (RFt_2) and full-fat control. Reduced-fat sausage treated with soy protein isolate (RFt_3) indicated very slight thawing loss (0.28%) while reduced-fat control recorded relatively high thawing loss (1.6%). This may be due to the effect of carrageenan, xanthan and soy protein isolate in relation to water retaining ability in treated sausages compared to the reduced-fat control which was prepared without any fat replacer in presence of the high and low levels of added water and fat leading to drip on thawing.

From the same Table, it Can be noticed that the RFt_1, RFt_2 and RFt_3 had lower cooking loss (2.25, 5.8 and 8.35%) than reduced-fat control which had the highest cooking loss (11.52%). Also, RFt_1, RFt_2 had lower cooking loss while RFt3 recorded higher cooking loss than the full-fat control which had cooking loss of 6.25%. This indicate the effect of carrageenan and xanthan in reducing the cooking loss which may be due to the best function of moisture retention through the product (specially

iota-carrageenan). These results were confirmed by Egbert *et al.* (1991) who reported that iota-carrageenan's had the greatest function in meat system (unlike other binders that bind meat pieces together) in moisture retention within the product. Also, iota-carrageenan have very good freeze/thaw stability, which is essential in the commercial manufacturing of many meat products. Also from table 4, concerning the color measured as absorbance at 542 nm, it can be observed that the full-fat sausage had more light color (low absorbance value) than all reduced-fat sausages either the reduced-fat control or the reduced-fat treatments (raw or cooked state). this may be due to the high level of fat in full-fat sausage. Nevertheless, RFt_1, RFt_2 and RFt_3 had light color (low absorbance values; 0.26, 0.39 and 0.25 respectively for raw products) when compared to the reduced-fat control which had dark color (high absorbance value; 0.45).

For the water holding capacity (W.H.C) and plasticity of the control and studied treatents, it can be stated that the highest W.H.C. (least area of free water) was recorded for the RFt_1 (reduced-fat sausage-fat sausage prepared with xanthan), full-fat sausage, RFt_2 (reduced-fat sausage prepared with xanthan), full-fat sausage, RFt_3 (reduced-fat sausage prepared with soy protein isolate), and the reduced-fat sausage control. This indicate the effectiveness of using some fat replacers specially iota-carrageenan in improving the W.H.C. of reduced-fat products. The highest W.H.C. of RFt_1 was confirmed by the lowest cooking loss and non-thawing loss (freeze/thaw stability of batter) for the same treatment (RFt_1), this may be due to the highest water retention of iota-carrageenan. These results were also explained by Egbert *et al.* (1991) who reported that iota-carrageenan had very good properties which are beneficial in the production of low-fat beef products such as water retention, stability at low temperature and very good freeze/thaw stability compared to the other binders' functions. From the same Table 4, it can be observed that the same trend of W.H.C. (in concern to reduced-fat sausages, either control or treatments) was recorded for plasticity. On the other hand, the cooking process (hot water at 85^{o}C for 15 min) lead to decrease the W.H.C. and plasticity of all cooked sausages compared to raw sausages. Any way, according to the physical evaluation of the reduced-fat sausages, the RFt1 was the best treatment followed by RFt2, RFt3 then reduced-fat control.

Organoleptic evaluation and statistical analysis:

The organoleptic evaluation of reduced-fat sausage as affected by using fat replacers, natural beef flavor and collagen casings is presented in Table 5. From the results, it can be observed that the reduced-fat control had the lowest scores of

Table 4. Physical evaluation of reduced-fat sausage as affected by using fat replacers, natural beef flavor and collagen casing

Treatment*	Thawing loss (%) (of sausage batter)	Cooking loss (%)	Color		W.H.C. (cm2/0.3 g sample)		Color	
			Raw	Cooked	Raw	Cooked	Raw	Cooked
Full-fat control	--	6.26	0.1675	0.065	3.0	7.5	4.0	3.4
Reduced-fat control	1.6	11.52	0.4561	0.150	6.0	13.0	2.5	1.8
RFt1	--	2.25	0.2694	0.092	1.0	5.0	3.5	3.3
RFt2	--	5.80	0.3970	0.113	3.0	7.0	3.3	2.8
RFt3	0.28	8.35	0.2589	0.085	4.0	8.8	3.0	2.3

* For explanation see Table (2).

odor, taste, texture, color, appearance and overall acceptability due to reducing the fat by a about 62% than the full-fat control whereas the reduced-fat control and full-fat control were prepared to contain 8% and 21% fat respectively. On the other hand, all the reduced-fat treatments (RFt1, RFt2 and RFt3) were more preferable compared to the reduced-fat control. Also, in concern to odor, the reduced-fat treatments had higher scores (very good) than the full-fat control (good), this is probably due to the addition of natural beef flavor for the three fat reduced treatments (RFt_1, RFt_2 and RFt_3). Moreover, the best reduced-fat treatment was RFt1 which was prepared with iota-carrageenan and natural beef flavor as well as stuffed in collagen casings. Also, whereas the RFt_1 had very good scores with the exception of the color which was evaluated between good and very good while the full-fat control had very good scores with the exception of the odor and appearance which were evaluated also between good and very good, this may be due to using the natural beef flavor and collagen casings in the RFt1 which improved the odor and appearance compared to the full-fat control.

In general, according to the overall satisfaction, the sausage products under this investigation were arranged in a descending order as follows: Full-fat control and RFt_1 (very good), RFt_2 (good), RFt_1 (good) then reduced-fat control (fair). Similar results were found by Ho *et al.* (1995).

From the statistical analysis of the data presented in the same Table 5, it can be observed that there were highly significant differences between the full-fat control and reduced-fat control for all the factors (odor, taste, texture, color, appearance and overall satisfaction) and this was due to reducing fat. Also, the three treatments (RFt_1, RFt_2 and RFt_3) were preferable than the reduced-fat control with the presence of high significant differences. On the other hand, according to the sensory evaluation and statistical analysis, the best treatment was recorded for RFt_1, (when compared to full-fat control) whereas there were no significant differences nearly between the full-fat control and RFt_1 (reduced-fat sausage prepared with iota-carrageenan, natural beef flavor and stuffed in collagen casings) which is recommended for the commercial production as a healthy food.

Carrageenan and xanthan distribution:

Iota-carrageenan and xanthan distribution in the cooked RFt_1 (Cooked reduced-fat sausage prepared with iota-carrageenan) and RFt_2 (cooked reduced-fat sausage prepared with xanthan) as detected visually after staining and observations are indicated in Fig. (1). It could be observed that the iota-carrageenan and xanthan had dark blue, whereas meat had light blue color. Each of carrageenan and xanthan

showed specific distribution patterns. Iota-carrageenan formed well defined, arranged and clearly isolated spots, whereas xanthan treatment had a randomly pattern of spots. The different distribution patterns of the iota-carrageenan and xanthan colud be due to different solubilization temperatures. Future study will take this field into consideration and other investigations will be needed.

Table 5. Oragnoleptic evaluation of reduced-fat sausage as affected by using fat replacers, natural flavor and collagen casings .

Treatment*	Oder	Taste	Texture	Color	Appearance	Overall satisfaction
Full-fat control	7.5c	8.0a	9.0a	8.0a	7.5ac	8.0a
Reduced-fat control	5.5b	5.0b	4.5b	4.0b	5.5b	5.0b
RFt1	8.5a	8.0a	8.0c	7.5a	8.0a	8.0a
RFt2	8.0ac	7.0c	7.0d	6.0c	7.0c	7.0c
RFt3	8.0ac	6.0d	6.0e	6.0c	7.0c	6.6c

a, b, c, d, and e: Means with different letters in the same column are significantly different (at 0.05 significant level).

* For explanation see Table 2.

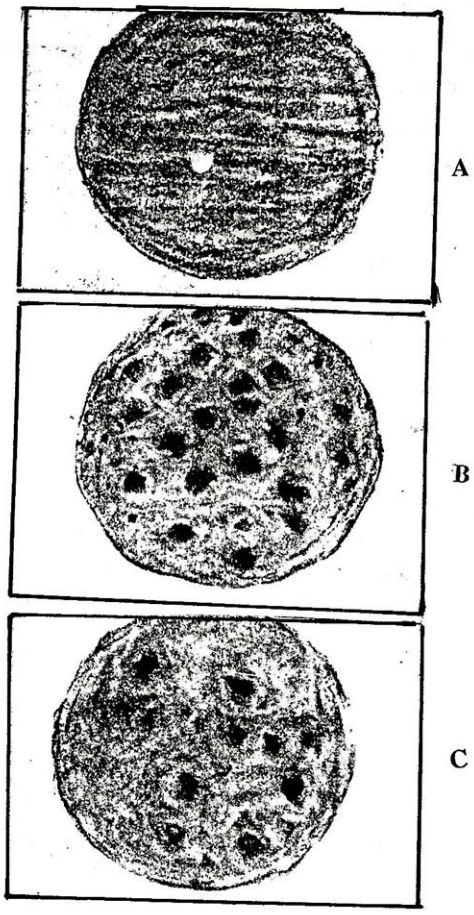

Fig. 1. Distribution of iota-carrageenan and xanthan in cooked sausage samples. Control (A), RFt1 (B), and RFt2 (c). (Cross sections in sausage units).

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منتجات السجق طبقا للقابلية العامة كما يلي : السجق الكامل الدهن (الكنترول) والسجق المقلل الدهن (RFt1) و المعامل بالكاراجينان (اللذان سجلا درجة جيد جيدا)، السجق المنخفض في الدهن المعامل بالذانثان (RFt2، بدرجة جيد)، السجق المنخفض في الدهن المعامل ببروتين الصويا المفصول (RFt3، بدرجة جيدا أيضا) والسجق المنخفض في الدهن بدون أي معاملات (الكنترول المنخفض في الدهن، أقل قابلية).

علاوة علي ذلك كان توزيع الكاراجينان أفضل عن توزيع الذانثان في المنتج النهائي المطبوخ.

مما سبق يتضح أن السجق المقلل الدهن المعامل بالكاراجينان هي المعاملة الأحسن والتي تقترح لإنتاج سجق مقلل الدهن مع الإبقاء علي خواص الدهن الكاملة فيه.