J. Agric. Sci. Mansoura Univ., 31 (1): 339 - 349, 2006

MALTODEXTRIN AS FAT REPLACER IN LOW FAT SAUSAGE

Gab Alla, Amal A.
Department of Food Technology, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt.

ABSTRACT

The effect of maltodextrin as fat replacer on the cholesterol content, thiobarbituric acid (TBA), colour, physical and chemical properties of low fat sausage were studied. The obtained results indicated that addition of 10% maltodextrin resulted in the energy value reduced by 27.37% and total cholesterol by 70.19, physical properties were improved and sensory properties were unaltered. The data also showed that reducing changes in colour and TBA values as compared to control sausage at any given time of cold storage. The results indicated that maltodextrin can be used as a suitable fat replacer in meat products.

INTRODUCTION

Fat as a food component, contributes to the flavour, texture and appearance of foods and increases the feeling of satiety during meals (Akoh, 1998; Caceres *et al.*, 2004). Therefore, fat reduction can *significantly* affect the acceptability of a product and increase the toughness of meat products (Giese, 1996; Crehan *et al.*, 2000). Fat also plays a great role in the rheological and structural properties of meat products and in the formation of a stable emulsion (Keeton, 1994).

However, fat intake is associated with increased risk of obesity, some types of cancer, high blood cholesterol and coronary heart disease. For these reasons, several health-related organizations (American Heart Association, American Cancer Society. World Health Organization) have proposed to limit total fat intake to no more than 30% of total calories (Jimenez Colmenero, 1996; Valsta *et al.*, 2005).

Several studies have been reported to retain sensory and textural attributes through fat reduction by replacing fat with water, proteins (soy, maize, egg white, wheat, cotton seed), carbohydrates (starch, pectin, cellulose, gums) and fat based substitutes (Chang and Carpenter, 1997; Hughes *et al.*, 1997; Sandrou and Arvanitoyannis, 2000; Garcia *et al.*, 2002; Caceres *et al.* 2004).

When fat was replaced with water on an equal weight basis, a product with high free moisture content was produced which affected sensory texture resulting in a mushy mouth feel. Such replacement also affected juiciness and specific flavour intensities of the frankfurters (Matulis *et al.*, 1995). Carbohydrate based fat replacers achieve their aim mainly by stabilizing substantial quantities of water in a gel-like matrix, resulting in lubricant and flow properties similar to those of fats (Yackel and Cox, 1992). The type of carbohydrate based replacer used will have a profound influence of the final flavour profile of the product. Maltodextrin, a non sweet starch hydrolysate fat substitute has the ability to bind water and in doing so improve juiciness and tenderness of meat products. When added as a thickener and binder, maltodextrin may also improve the stability of an emulsion and when used at high concentrations, maltodextrin contributes to mouthfeel and body of the product (Lucca and Tepper, 1994; Crehan *et al*., 2000). Maltodextrins are obtained by acid and/or enzymatic hydrolysis of starch. Maltodextrins are increasingly being used in the food industry especially in baby drinks and baby dried food as an alternative carbohydrate (Al-Khatib *et al*., 2001; Avaltroni *et al*., 2004).

The aim of this study was to examine the functionality of maltodextrin in reducing typical fat level in sausage based of preliminary investigation by Crehan *et al*. (2000).

MATERIALS AND METHODS

Materials:-

Raw meat, fat (from round cuts of hind quarter of cow carcass) and mutton casing obtained from the local market and transferred directly to Food Technology Department, Faculty of Agriculture, Suez Canal University. Mutton casing was prepared according to the method described by El-Deep (1987). Maltodextrin was obtained from National Company for Maize Products, 10 Th of Ramadan City, Egypt.

Preparation of sausage:-

Sausage sample used in this study consisted of 71% minced lean meat; 12% fat tissue; 2.0% sodium chloride; 13 water (as ice); 0.16 sodium glutamate; 0.6% garlic; 0.60 onion and 0.64% spices mixture (red pepper 11.5%, all spices 10%; black pepper 45%; coriander 12%; nutmeg 2.5%; commin 15% and clove 4%). Seven different sausage treatments were achieved by the addition of maltodextrin. In the experiment the percentage of fat to meat was reduced by addition of maltodextrin as a following: 0 (control, receiving no maltodextrin); 1, 2, 4, 6, 8 and 10%. When the added maltodextrin was increased to 10% the fat reduced to 2% with the same recipes of other ingredients. Sausage sample were prepared and stuffed in mutton casing according to the method described by El-Deep (1987).

Methods:-

Chemical analysis:-

Moisture, crude fat, protein and ash contents of each sample were determined by the standard methods as reported in the AOAC (1990). Total carbohydrates were calculated by difference and thiobarbituric acid (TBA) values were determined as described by Pearson (1981). The cholesterol content was determined according to the method described by El-Safty (1998).

Physical properties:-

The water holding capacity (WHC) was measured according to Volovinskaia and Merkoolova (1958). A sample of 0.3 g of sausage was put under an ashless filter paper (Whatman, No 41) and pressed for 10 min. using 1 kg weight. Two zones were formed on the filter paper and by planimeter their surface areas were measured. The area of the outer zone resulted from the water separated from pressed tissues, thus indicating the

WHC in Cm^2. each 1 Cm^2 of outer zone area is equivalent for 8.4 mg free water. Water holding capacity was calculated as follows:

$$WHC = \frac{moistur\ \text{content} - \dfrac{(8.4 \text{ x } Cm^2\, outer\ zone\ area)x100}{1000 \text{ x } 0.3}}{\text{moisture content}} \times 100$$

Texture indices such as protein water coefficient (PWC); water protein coefficient (WPC) and protein water fat coefficient (PWFC) were calculated according to Tsoladze (1972); Mostafa and GabAlla (1999). Such coefficient is calculated as follows:

$$PWC = \frac{\%\ \text{protein}}{\%\ \text{water}} \qquad WPC = \frac{\%\ \text{water}}{\%\ \text{protein}} \qquad PWFC = \frac{\%\ \text{protein}}{\%\ \text{water} + \%\ \text{fat}}$$

Thawing, cooking and frying losses:-

Thawing, cooking and frying losses were described by Mostafa and Gab-Alla (1999) as follows:

$$\text{Thawing loss} = \frac{\text{Weight before thawing - Weight after thawing}}{\text{Weight before thawing}} \times 100$$

Thawing loss was determined after freezing the samples for 45 days at -18°C.

$$\text{Cooking loss} = \frac{\text{Fresh sample weight - boiled sample weight}}{\text{Fresh sample weight}} \times 100$$

Cooking loss was determined after cooking in boiling water for 5 min.

$$Frying\ \text{loss} = \frac{\text{Boiled sample weight - Fried sample weight}}{\text{Boiled sample weigh}} \times 100$$

Energy values:-

Total calories (Kcal) were calculated in relation to samples of 100 g using the Atwater values corresponding to fat (9 K cal g^{-1}), protein (4.02 Kcal g^{-1}) and carbohydrates (3.87 Kcal g^{-1}) (Caceres *et al.*, 2004).

Colour intensity:-

The colour of samples was assessed according to Gab-Alla (1996). Ten grams of minced sample were homogenized with 40 ml of 80% acetone, centrifuged, filtered and the absorbance was determined spectrophotometrically at 540 nm.

Organoleptic evaluation:-

Organoleptic evaluation of aroma, taste, juiciness, colour, texture and over acceptability of prepared products were carried out by aid of 10 panelists, according to Klein and Bardy (1984), who recommended the following judging scale: 9-8 very good, 7-6 good, 5-4 fair, 3-2 poor and 1-0 very poor.

Statistical analysis:-

Standard error (SE) and significant differences between the mean values of the estimated tests were measured according to Ott (1992).

RESULTS AND DISCUSSION

Sausage composition:-

Proximate analysis indicated that low fat sausages with varying levels of maltodextrin showed the actual decrease in fat content. The fat levels ranged from 43.19% in control sample to 14.55% in reduced fat sausages with the highest maltodextrin levels. Hoffman and Mellett (2003) reported that the patties containing the pork fat had 6% higher total fat content than those containing the fat replacer (10% of modified starch and protein isolate). Total carbohydrates were estimated by difference and corresponded to those of the basic ingredients plus the maltodextrin substitute. Protein levels in the control and products with added maltodextrin were similar and ranged from 51.10 to 53.28% on dry weight (Table, 1). The data also showed that the addition of maltodextrin to sausages lead to increase moisture percent. The rise in moisture content with increasing levels of maltodextrin may be attributed to the higher water holding capacity of the maltodextrin. Similar conclusion reported by Lucca and Tepper (1994) who reported that maltodextrin, a non sweet starch hydrolysate fat substitute has the ability to bind water. Osburn and Keeton (2004) concluded that the rise in moisture content with increasing levels of Konjac flour can be attributed to the higher water holding capacity of the hydrocolloid gel.

Caloric values:-

Energy values showed a decrease related to the decrease in the fat levels. Accordingly, energy values decreased from 206.37 Kcal/100 g in the control to 149.88 Kcal/100 g in the reduced fat sausage with 10% added maltodextrin (Table, 1). Huffman and Egbert (1990) showed that incorporation of 0.5% carrageenan as a water binder into low fat ground beef patties can reduce caloric energy content by 230-251 kj/100 g. A similar situation was described by Mendoza *et al.* (2001), Careres *et al.* (2004) and Osburn and Keeton (2004). Thus, the real value of incorporating maltodextrin into a ground meat system is to economically reduce the total fat content.

Total cholesterol:-

In addition to fatty acids, cholesterol is nutritionally important component of meats. The cholesterol content of meats varies between 30 and 120 mg/100 g of food (Anon, 1998; Ovaskainen *et al.*, 2001; Valsta *et al.*, 2005).

Table (1): Chemical composition of experimental sausages (mean ± SE)

Component % / Samples	Moisture	Protein*	Fat*	Ash*	Total carbohydrate	Total cholesterol mg/100g	Energy Kcal/ 100g
0.0% M	65.81 ± 0.34	51.10 ± 0.08	43.19 ± 0.03	3.10 ± 0.07	2.43 ± 0.10	80.0 ± 0.31	206.37 ± 2.37
1% M	65.93 ± 0.29	51.28 ± 0.11	40.42 ± 0.15	3.11 ± 0.06	5.19 ± 0.08	74.31 ± 0.26	201.01 ± 3.57
2% M	66.10 ± 0.34	51.53 ± 0.18	37.67 ± 0.11	3.13 ± 0.07	7.67 ± 0.06	68.19 ± 0.11	195.22 ± 2.72
4% M	66.18 ± 0.39	51.66 ± 0.18	31.85 ± 0.21	3.13 ± 0.03	13.36 ± 0.11	56.33 ± 0.09	184.65 ± 2.62
6% M	66.41 ± 0.31	52.01 ± 0.10	26.11 ± 0.26	3.16 ± 0.10	17.52 ± 0.10	44.75 ± 0.13	173.59 ± 3.45
8% M	66.82 ± 0.31	52.65 ± 0.07	20.40 ± 0.15	3.19 ± 0.03	23.75 ± 0.08	34.12 ± 0.28	161.63 ± 3.22
10% M	67.21 ± 0.39	53.28 ± 0.08	14.55 ± 0.15	3.32 ± 0.11	28.94 ± 0.13	23.85 ± 0.26	149.88 ± 2.98

M: Maltodextrin SE: Standard error *: Dry weigh basis

From results in Table (1) it can be noticed that control samples had a high level of total cholesterol which was 80 mg/100 g. This may be due to high fat content of control sample comparing with other treatments, which was reflected on the total cholesterol of the final product. Saturated fatty acids are well known to raise total and low-density lipoprotein (LDL) cholesterol (Herman-Kunz and Thamm, 1999; Moschandreas and Kafatos, 1999). The data also showed that maltodextrin reduced pronouncedly the total cholesterol in all treatments (70.11% to 70.18%). According to Anon (1993) meat products with 20 mg/100 g or less of total cholesterol or showed more than 25% decrease of total cholesterol compared to control which may be referred as low cholesterol food. All samples containing 4% maltodextrin or more, as fat replacer, may be considered as low cholesterol foods, which they showed more than 25% reduction of total cholesterol (20 mg/100 g or less of total cholesterol). Willett (2001) reported that lean meats and low fat meat products are preferred and meat is recommended to be used sparingly as apart of a balanced diet.

Thiobarbituric acid values (TBA):-

TBA values of different treated products as influe..ced fat replacer during storage at 4°C are illustrated in Fig. (1). The data showed that TBA values for control samples increased at any given time of cold storage compared with an other treatment. During cold storage, however, malonaldehyde content was increased. This is due to lipids oxidation. Results for experimental samples also reflect the effect of maltodextrin as fat replacer on delaying the increase of TBA compared with control sample. This decrease in TBA values in treatment may be attributed to the decrease in fat content.

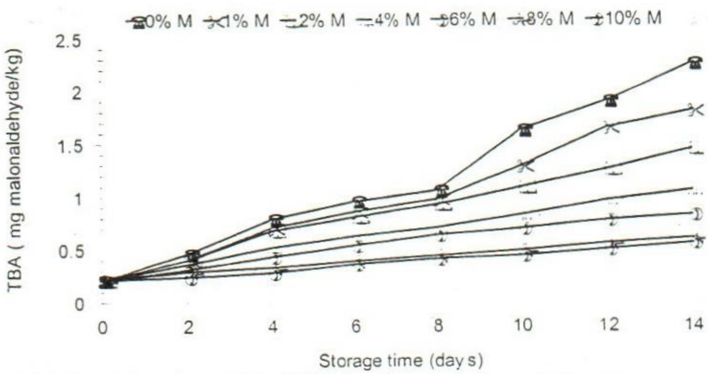

Fig. (1): Thiobarbituric acid (TBA) of experimental sausage samples during cold storage

Colour intensity:-

Colour measurement is a very interesting parameter in meat products because consumers associate this product with a bright and characteristic pink colour. Fat is known to affect the internal colour measurements of cooked frankfurters as reported by Hughes *et al.* (1997).

The data showed that colour intensity was 0.78 for control sample at zero time. The addition of maltodextrin as fat replacer to the formulation did not significantly affect on the colour intensity. Caceres *et al.* (2004) observed that an increase in intensity of colour at the higher concentrations of soluble dietetic fiber (SDF) as a consequence of the lack of fat. During cold storage at 4°C, the results showed a decrease in colour intensity which was more pronounced in control sample compared with the other treatment (Fig. 2). The decrease in red colour of samples during cold storage may be due to oxidation of oxymyoglobin to metmyoglobin and lipids oxidation in meat tissues has been reported to be catalyzed hematin compound (Ramamohona, 1981). On the other hand the difference in the oxidation rates of various meat during storage may be attributed to two major factors, the nature of the lipids, especially the degree of unsaturation of fatty acids present and the concentration of heme pigments and consequently the catalysis rate (Fox *et al.*, 1980). According to Crehan *et al.* (2000) reducing the fat content from 30 to 55 caused a significant decrease in the lightness of the frankfurters while a significant increase in the redness was evident. Hoffman and Mellett (2003) also found that the patties containing fat were all lighter than that containing the fat replacer within the same meat class.

Physical properties:-

Water holding capacity (WHC) as generally improved in sausage with maltodextrin than control. The improvement was more pronounced in treatments 8 and 10% maltodextrin than others. Therefore, the increase of WHC in samples could be ascribed to the effect of addition of maltodextrin. However, the higher binding capacity can be obtained with the 10% maltodextrin Table (2). Carbohydrate based fat replacers achieve their aim mainly by stabilizing substantial quantities of water in a gel-like matrix, resulting in lubricant and flow properties similar to those of fats (Yackel and

Cox, 1992). The type of carbohydrate based replacer used will have a profound influence on the final flavour profile of the product (Lucca and Tepper, 1994). Maltodextrin, a non sweet starch hydrolysate fat substitute has ability to bind water and in doing so improve juiciness and tenderness of meat products (Lucca and Tepper, 1994). Several studies have been reported to retain sensory and textural attributes through fat reduction by replacing fat with water, proteins (soy, maize, egg white, wheat, cotton), carbohydrates (starch, pectin, cellulose, gums, maltodexrins) and fat based substitutes Jimenez Colmenero (1996), Sandrou and Arvanitoyannis (2000).

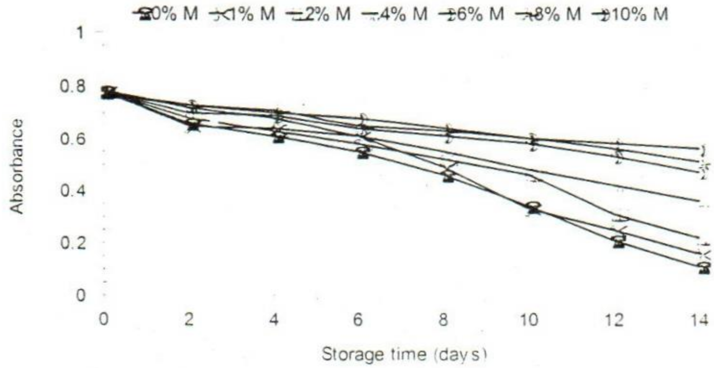

Fig. (2): Colour intensity (as absorbance) of experimental sausage samples during cold storage at 4°C

Table (2): Physical properties of experimental sausages

Indices	0% M	1% M	2% M	4% M	6% M	8% M	10% M
WHC	72.9	74.3	77.8	82.1	85.6	88.5	88.9
PWC	0.27	0.26	0.26	0.26	0.26	0.26	0.26
WPC	3.77	3.77	3.78	3.79	3.80	3.82	3.85
PWFC	0.22	0.22	0.22	0.23	0.24	0.24	0.24

M: Maltodextrin
WHC: Water holding capacity **PWC: Protein water coefficient**
WPC: Water protein coefficient **PWFC: Protein water fat coefficient**

Weight losses were subjected to determine the ability of sausages to bind moisture through preparing by boiling, frying and thawing after adding maltodextrin as fat replacer. From the data, it could be observed that the addition of maltodextrin reduced the cooking and frying loss and increased the yield. The loss was reduced by increase the maltodextrin percent (Table, 3). Similar results observed by Shehata (1998) who mentioned that addition 2% wheat flour decreased the processing loss and increased yield of frankfurter from 88.16 to 91.02%. Crehan *et al.* (2000) reported that frankfurters formulated with maltodextrin had significantly lower cook losses than controls with no added ingredient.

Table (3): Thawing, cooking and frying losses of experimental sausages

Loss (%)	Treatments						
	0.0% M ± SE	1% M ± SE	2% M ± SE	4% M ± SE	6% M ± SE	8% M ± SE	10% M ± SE
Thawing	3.9 ±0.03	4.0 ±0.08	4.2 ±0.13	4.6 ±0.11	4.6 ±0.18	5.1 ±0.10	5.3 ±0.01
Cooking	22.3 ±0.10	21.9 ±0.03	21.6 ±0.17	19.7 ±0.11	19.1 ±0.10	17.6 ±0.18	16.0 ±0.09
Frying	25.1 ±0.09	24.8 ±0.17	24.1 ±0.08	21.2 ±0.01	18.9 ±0.03	18.2 ±0.13	15.9 ±0.30

M: Maltodextrin percent SE: Standard Error

From the same table it can be noticed that thawing losses for treatment had 10% maltodextrin were the higher. Higher thawing losses in treatments had 10% maltodextrin which showed from the previous results that they had the higher retention water. These results were in accordance with those reported by Hertog *et al.* (1997) who concluded that water loss from meat during frozen storage is related to the intrinsic water holding capacity of the meat. However, the thawing losses in these treatments were slightly higher compared with the others even under these conditions of freezing. Similar results observed by Mostafa and Gab-Alla (1999); Homco-Ryan *et al.* (2004).

The calculated texture indices such as PWC, WPC and PWFC which were valid to evaluate quality of meat and sausage are presented in Table (2). Where, the tenderness of meat increases with decreasing of PWC and PWFC and increasing of WPC (Mostafa and Gab-Alla, 1999). The WPC was higher in the treatments 8 and 10% maltodextrin respectively. However, the data showed the lower values PWC and PWFC. These results indicated that, addition of maltodextrin improved the tenderness of sausage. The best product was obtained by addition of 10% of maltodextrin.

Sensory properties:

The effect of maltodextrin on the sensory properties of sausage is shown in Table (4). The data indicated that reducing the fat level from 14.80 (W.W) to 4.77% (W.W) by added maltodextrin. Juiciness scores increased with highest values noted in products formulated to contain 4.77% fat or 10% maltodextrin. This is probably due to the high moisture contents as a result of fat being replaced by added maltodextrin. Results from this study confirms work by Matulis *et al.* (1995) and Crehan *et al.* (2000) who reported that as the fat content increased the juiciness decreased. Maltodextrin addition resulted in similar hardness, flavour, texture and overall acceptability scores to control sausage. Confrades *et al.* (1997) found that high fat frankfurters were harder than low-fat frankfurters. On the other hand Crehen *et al.* (2000) reported that no significant change in hardness was recorded in reduced fat frankfurters due to the maltodextrin. Hoffman and Mellett (2003) concluded that fat replacers can be used successfully for the production of low fat ostrich patties without any negative quality attributes being perceived. Also Osburn and Keeton (2004) reported that a konjac flour (KF) gel incorporated at 10% had similar properties to a control low-fat desinewed lamb sausage, while KF at 20% could reduce toughening in low fat sausage products.

Conclusion:

This study demonstrates that maltodextrin incorporated at levels of 8 and 10% can be used as a fat replacer in low fat sausage. The addition of maltodextrin was beneficial in enhancing the cook yield of the sausage by reducing cook loss. Maltodextrin in the sausage formulation improve the organoleptical quality of reduced fat sausage.

Table (4): Effect of different levels of maltodextrin on the sensory properties of low fat sausages samples

Properties / Maltodextrin(%)	Flavour (10)	Colour (10)	Texture (10)	Juiciness (10)	Overall acceptability (10)
Control	9.2 a	8.7 a	8.9 a	7.3 a	8.8 a
1%	9.2 a	8.6 a	8.8 a	7.5 a	8.8 a
2%	9.4 a	8.7 a	9.0 a	7.4 a	9.1 a
4%	9.1 a	8.9 a	8.9 a	8.1 b	9.4 b
6%	9.0 a	9.1 b	9.1a	8.4 b	9.2 b
8%	9.1 a	9.0 a	9.3 b	8.9 c	9.3 b
10%	9.1 a	9.3 b	9.3 b	9.2 c	9.3 b

Mean in the same column with different superscripts are significantly difference at $P < 0.05$

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استخدام المالتودكسترين كبديل للدهن فى السجق منخفض الدهن

آمال جاب الله

قسم الصناعات الغذائية – كلية الزراعة – جامعة قناة السويس – الإسماعيلية

فى هذا البحث تم دراسة تأثير استخدام المالتودكسترين كبديل للدهن على محتوى الكوليسترول ، قيم حامض الثيوباربيتوريك ، اللون والخصائص الطبيعية والكيميائية للسجق منخفض الدهن.

وقد أوضحت النتائج أن استخدام المالتودكسترين حتى نسبة ١٠% أدى إلى خفض السعرات الحرارية والكوليسترول الكلى بنسبة ٢٧,٣٧ ، ٧٠,١٩% على التوالى ، ولوحظ تحسن الخصائص الطبيعية فى حين لم تتغير الخصائص الحسية مقارنة بالكنترول .

أوضحت النتائج أيضا انخفاض معدل تغيرات اللون وقيم TBA بالمقارنة بالكنترول خلال التخزين بالتبريد . يتضح من النتائج انه يمكن استخدام المالتودكسترين كبديل مناسب للدهن فى منتجات اللحوم.