Effect of modified starch used alone or in combination with wheat flour on the sensory characteristics of beef sausage

Mehrdad Mohammadi[1], Firouz Oghabi[2], Tirang-Reza Neyestani[3,*], Iman Hasani[4]

[1]Students' Research Committee, Department of Food Technology Research, National Nutrition and Food Technology Research Institute, Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
[2]Department of Food Science and Technology, National Nutrition and Food Technology Research Institute, Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
[3]Department of Nutrition Research, National Nutrition and Food Technology Research Institute, Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
[4]Proteomics Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

*Corresponding Author: email address: neytr@yahoo.com (T. Neyestani)

ABSTRACT

The effects of modified waxy maize starch (MWMS) (1–3.25%) on the sensory characteristics of 60% beef sausages were investigated by replacing the varying levels of sunflower oil or both sunflower oil and wheat flour (WF). The addition of MWMS improved the red color, the palatability, and the overall acceptability compared to the control sausages. The Color was medially and positively correlated with firmness. The correlations between color and taste and between taste with juiciness and firmness were weak and positive. The significant correlations were not observed between palatability and overall acceptability and with the other sensory characteristics. Juiciness was negatively correlated with firmness but was not significantly different. As a result, MWMS offset the effects of lowering the fat content.

Keywords: Modified starch; Sensory characteristics; Sausage; Healthier food

INTRODUCTION

Increased knowledge of the correlation between diet and health and the need for reducing consumption of high energy foods due to our motionless lifestyles [1] have altered consumers' eating habits and preferences and have led to increasing demand for healthier foods with good sensory qualities [2]. The meat industry has also shown an interest in formulating and producing low-fat meat products [1, 3].

Fat is the contributing key factor in emulsifying properties, moisture absorption, heat transfer, pigment carrying [4], improving aroma, the flavour and acceptability of food [5], textural properties, palatability, the presentation of combined prediction of mouthfeel, and taste [6]. Therefore, it is not possible simply to reduce fat content with no effect on quality [1]. While the fat content of sausages is reduced, the manufactured product has several difficulties, such as additional firmness, rubbery properties, less acceptable darkness, and is less juicy [5, 7-9]. Fat replacers can help reduce fat and calorie levels in foods and improve these problems [10].

In the food industry, acceptance of each foodstuff by consumers and customers guarantees the manufacture of the product and its survival in market and trade. Therefore, sensory evaluations have a basic role in the selection of the best formulation. Thus, it is necessary to research the most appropriate production procedure for low-fat sausages with reduced fat that still satisfy the sensory characteristics. This present research was designed to investigate the addition of 1 to 3.25% modified waxy maize starch (MWMS) on the sensory characteristics of manufactured sausages in various ways. First, the varying levels of sunflower oil were replaced with a corresponding 1:3 MWMS-water mixture. Secondly, the same MWMS-water mixture replaced the varying levels of sunflower oil in combination with 100% wheat flour (WF). The main objective of the research was to evaluate the sensory characteristics of manufactured sausages by comparing them with those prepared with the currently used formulation in Iran.

MATERIALS AND METHODS

Food grade MWMS (FIRM-TEX, a chemically modified food starch refined from waxy maize, cross-linked, pH= 4.5–7, EU Classification: 1442) was purchased from the National Starch & Chemical Co. (Manchester, United Kingdom). The meat ingredient was fresh frozen boneless beef forequarters slaughtered according to Islamic rites (AIBP International, Brazil). Except for the MWMS, the Gooshtiran Company (Tehran, Iran) donated all other ingredients. Sodium polyphosphate (E452, Budenheim Fabrica Chemische, Germany); sodium nitrite (E250, BASF Aktiengesellschaft, Germany); ascorbic acid (Muhlenchemie, Germany); sunflower oil (Nazgol, Kermanshah Mahidasht Co., Iran); WF (Cereal Organization, Iran); skim milk powder (Dairy Pak Co., Iran); and a six spice ground mixture, containing red and black peppers, nutmeg, ginger, cardamom and cinnamon (Malaysia and Sri Lanka), were kept ready for the preparation of the sausages.

Preparation of MWMS

The 20% (weight volume^{-1} (w v^{-1})) MWMS slurry was prepared following Hachmeister and Herald [11]. An appropriate amount of starch was dispersed in 5 times the amount of distilled water. It was then mixed in a container at room temperature (approximately at 25°C) for 2 min.

Sausage preparation

The 60% beef lean sausage was prepared according to the following procedure. For each batch, 60% ground lean beef and 1.5% salt were comminuted in a 10 L bowl cutter (Seydelmann, Aalen Stuttgart K21 Ras 83132, Germany) at 8–10°C for 3–4 min at 1700–1800 rpm to extract the salt soluble protein. During comminuting, the following non-meat ingredients were added in order: sunflower oil (10%, 6%, 4%, or 2%) to replace the beef fat due to the compiled Iranian Standard for Meat Products; half the ice; 0.4% sodium polyphosphate; 0.05% ascorbic acid; 0.012% sodium nitrite; 0.72% six spices; and 1% garlic. The appropriate slurry of MWMS and the remaining ice were added in a bowl cutter and comminuted thoroughly for another 30 s. Skim milk powder (2%) and 5% WF (if required) were then added, and the batter was mixed until the emulsion was complete. The final temperature of the sausage batter never exceeded 12°C. Since the meat content in all formulae was constant, and WF and MWMS were not protein-based ingredients, the meat protein content was approximately 13% in all formulations [12, 13].

Immediately after chopping, the sausage batter was scraped from the bowl cutter and stuffed into synthetic polyamide casings (approximately 90 mm in diameter and 300 mm in length) using a stuffer (Handtmann VF 200, Germany). The stuffed raw sausages were heated in a steam chamber for 2–2.5 h. The final internal temperature was monitored throughout heating by means of thermocouples inserted in the sausages (thermal center) connected to a recorder (Testo, 0–100°C range, Germany). Following the cooking, the sausages were cooled and stored at 0–4°C. Iranian-style beef sausages (controls) were prepared in the same manner but without the addition of MWMS. All ingredients except for the amount of oil, flour, MWMS, and ice remained constant (Table 1). The formulae were produced in triplicate and in total, 21 treatments were manufactured with the same raw materials.

Untrained sensory analysis

Fifty untrained assessors among food and nutrition science-majored students, staff and faculty members of the institute and university campus [10] (age ranging from 18 to 40 years, both sexes) carried out (in-house) sensory analysis 7 days after sausage manufacturing and storage at 4°C. The panel was interested sausage consumers who were aware of the testing method. The assessors were selected randomly based on their participant interest and ability to understand the test procedure [14]. Before testing, the refrigerated sausages were maintained at room temperature (~25°C) for 15 min. Then the corresponding sausages from each formula were cut into 3-mm thick slices. Two pieces of each formula were served on a white and odorless disposal plate. The plates were coded with a 3-digit randomized number. The plates were presented to each assessor in a different random sequence.

The assessors sat in individual booths under white and yellow fluorescent lights (similar to light of day) and were asked to state their judgment of the samples regarding their overall acceptability. Room temperature bottled drinking water and unsalted biscuits were provided to clean the palate between samples. They recorded their responses on an evaluation sheet designed to indicate the rank of the sample of each formula. Data collection was performed in order such that a value 1 was assigned to highest overall acceptability and a value of 7 to lowest overall acceptability [15].

Trained sensory analysis

Ten experienced assessors from members of the R&D department and research laboratory of Gooshtiran Company, where HACCP and ISO 22000 (Food safety) certification was undertaken carried out a trained (experienced) sensory analysis. These assessors were trained in general sensory analysis and determination of sensory attributes in Iranian-style sausages and were selected by the team leader of HACCP. Sensory analyses of the samples took place on day 7 after the sausage was manufactured and stored at 4°C.

The assessors were asked to evaluate each sample for color, taste, juiciness, firmness, and palatability. An evaluation sheet with a 1–8 scale was utilized for each attribute to indicate the score of the sample of each formula [14] in which extremely grey, bland, dry, soft, unpleasant equaled = 1, and extremely pink/red, tasty, juicy, firm and pleasant equaled = 8. Sample serving and sensory conditions were similar to those for the untrained assessors. The analysis was performed in the laboratory prepared with individually partitioned booths in duplicate, with a 3 h break between sessions.

Statistical analysis

The data from the sensory evaluation were subjected to Kruskal-Wallis H non-parametric test. A Mann-Whitney U test was used to determine the statistical significance among the means. To determine the existence of a correlation between sensory attributes, data from the sensory evaluation were subjected to correlation analysis using a one-way Spearman's correlation coefficient. A 95% ($P<0.05$) significant level was considered in all comparisons.

RESULTS AND DISCUSION

Untrained sensory evaluation

Table 2 shows overall acceptability ranks. Overall acceptability in low-fat formulae was higher than for the controls, and the MWMS-containing formulae (F2, F4, and F6) were higher than the MWMS and WF-containing formulae (F1, F3, and F5). There was a significant difference between the overall acceptability in the controls and the MWMS-containing formulae (F2, F4, and F6) ($P<0.05$). There was no significant difference in overall acceptability between F2–F6, which is in accordance with the results reported by Maghsoudi [16], who noted untrained (in-house) assessors determined no significant difference between overall acceptability in control (19.17% fat) and low-fat formulae (8.40–8.65% fat) containing 0, 0.5%, 1%, and 1.5% carboxymethyl cellulose.

Helgesen, Solheim, and Næs [17] reported that the dry fermented lamb sausages containing the lowest fat levels were rated as the most liked sausages. Also, Giese [18] indicated consumer acceptance is based more on perceived rather than on real product differences.

Trained sensory evaluation

Table 2 lists the sensory attributes scores of all sausages manufactured. The red color scores in F2–F6 were significantly higher than for the control and increased as the content of MWMS increased. The MWMS formed a translucent gel when heated with water because the amylopectin present in this component is smaller than the wavelength of light (250 nm). Thus, light was not scattered and the resulting translucency transmitted redder color [19].

In this study, in which meat protein content was constant, fat content and added water influenced the color. The controls with further fat were lighter than the low-fat ones, and the red color increased as the fat content decreased. This was due to a reduction in the overall light scattering related to the scattering properties of fat [20]. F3 and F5 had a numerically but not statistically significant higher red color score than F4 and F5, respectively as it is higher in carbohydrate, with an occurrence of a higher nonenzymatic browning reaction in the meat due to the reactivity between the starch and the protein [14].

Fat reduction in meat products is associated with changes in sensory attributes. Maghsoudi [16] improved the taste of low-fat meat products and recommended the application of flavors and modification of seasoning mixtures. In this study, the variety and quantity of the spice mixture remained constant in all sausages manufactured. The control sausages did not have significantly different taste scores than all other formulae, which can be attributed to the entrapping of the flavor component in the helical configurations of starch [21]. Taste scores in the MWMS and WF-containing formulae (F1, F3, and F5) were a numerically but not statistically significant lower than the MWMS-containing formulae (F2, F4, and F6), which is due to the lower moisture content and taste resulting from the WF.

The low-fat formulae had numerically but not statistically significant higher juiciness scores and these increased as the content of MWMS and water increased. This is because the protein-protein interactions and resultant cross-bridges decreased [21]. Juiciness in the MWMS and WF-containing formulae was lower than in the MWMS-containing formulae because of higher WHC results from the proteins and carbohydrates found in WF. Khalil [14] attributed increasing juiciness to the improving water binding ability of modified cornstarch. But, Ordonez, Rovira, and Jaime [22] attributed juiciness to the fat-to-water ratio.

Firmness scores in the MWMS and WF-containing formulae were numerically but not statistically significantly higher than the MWMS-containing formulae due to the proteins found in WF. This is because the effect of protein on firmness is greater than starch due to the gel/emulsion matrix formation [11]. These results are in good agreement with the results reported by Pietrasik [20], who reported that the protein content plays a key function in the firmness, and a higher protein content increases the hardness, regardless of the fat and starch contents. Firmness was also attributed to the nonmeat ingredients absorbing some of moisture available to the meat protein [23] and to the increasing water-binding because of the swelling of the starch granules embedded in the protein gel matrix and the formation of a stronger structure during heating [12]. Firmness in F2 was numerically the highest since it had the lowest WHC. F6 had a significantly higher palatability score and was tastier (P<0.05) than for the control sausages. Hoffman and Mellett [24] reported that differences in sensory attributes could be negligible since manufactured products are generally served between two slices of a bread roll with dressings.

Table 1. Quantities of ingredients (%) used in the formulation of sausages batters

Formulae[A]	Oil	WF	MWMS	Ice flakes/Water
Control[B]	10	5	–	19.33
F1[C]	6	5	1	22.33
F2[D]	6	–	2.25	26.08
F3[C]	4	5	1.5	23.83
F4[D]	4	–	2.75	25.58
F5[C]	2	5	2	25.33
F6[D]	2	–	3.25	29.08

[A] All sausages contained 60% lean beef meat (Lean beef contain 7.13% fat), 2% dried skim milk, 1.5% salt, 1% garlic, 0.72% spice mixture.
[B] Control (conventional Iranian style sausage with reduced fat, containing WF but without MWMS).
[C] MWMS and WF-containing formulae (F1, F3 and F5): replaced varying levels of oil (40, 60 and 80%) by equal amounts of MWMS/water combination at a 1:3 ratio.
[D] MWMS-containing formulae (F2, F4 and F6): replaced varying levels of oil (40, 60 and 80%) and WF (100%) by equal amounts of MWMS/water combination at a 1:3 ratio.

Table 2. Sensory attributes of sausages formulated with varying levels of oil, WF, MWMS and water

Formulae[A]	Untrained sensory evaluation	Trained sensory evaluation				
	Overall acceptability[B,C,D]	Color[E]	Taste	Juiciness	Firmness	Palatability
Control	4.90 ± 2.31^{a}	4.88 ± 0.64^{a}	4.25 ± 1.49^{a}	5.00 ± 0.76^{a}	4.75 ± 1.04^{a}	5.38 ± 0.74^{a}
F1	4.35 ± 1.76^{a}	4.75 ± 0.71^{a}	4.38 ± 0.92^{a}	5.25 ± 1.16^{ab}	4.88 ± 0.99^{a}	5.25 ± 1.04^{a}
F2	3.45 ± 1.75^{b}	5.63 ± 0.74^{b}	4.50 ± 1.31^{a}	5.50 ± 1.07^{ab}	5.38 ± 0.74^{a}	5.38 ± 1.06^{ab}
F3	4.16 ± 2.03^{ab}	6.00 ± 1.20^{b}	4.75 ± 1.39^{a}	5.13 ± 0.64^{a}	5.25 ± 0.71^{a}	5.50 ± 1.20^{ab}
F4	3.65 ± 2.09^{b}	5.75 ± 1.39^{b}	5.25 ± 1.49^{a}	6.00 ± 0.76^{b}	5.13 ± 0.83^{a}	5.63 ± 0.74^{ab}
F5	3.97 ± 1.87^{ab}	6.50 ± 1.07^{b}	4.88 ± 1.36^{a}	5.00 ± 1.41^{ab}	5.50 ± 1.20^{a}	5.50 ± 0.76^{ab}
F6	3.52 ± 1.93^{b}	6.13 ± 1.13^{b}	5.00 ± 1.60^{a}	5.50 ± 0.93^{ab}	5.00 ± 0.76^{a}	6.38 ± 0.92^{b}

[A] For formula descriptions see Table 1.
[B] Variation of the means represents standard deviations of ranks for each formula by fifty assessors (fifty repetition for each formula).
[C] Means ± SD within a same column (different formulae) with different letters (a–b) are significantly different (P<0.05).
[D] A lower value for the ranks indicates a higher overall acceptability.
[E] Variation of the means represents standard deviations of duplicate of scores for each formula by ten assessors (twenty repetition for each formula).

Table 3. Correlation coefficients between sensory attributes of sausages formulated with varying levels of oil, WF, MWMS and water

	Color[A]	Taste	Juiciness	Firmness	Palatability	Overall acceptability
Color	1					
Taste	0.47[a]	1				
Juiciness	0	0.41[a]	1			
Firmness	0.55[a]	0.38[a]	-0.13	1		
Palatability	-0.06	0.12	0.22	0.06	1	
Overall acceptability	-0.07	0.06	-0.10	-0.04	0.15	1

[A] Sensory attributes with letters (a) have significantly one-way Spearman's correlation (P<0.05).

Correlation between sensory attributes

Table 3 presents the result for correlation coefficients. Color was significantly and positively correlated with firmness (P<0.05). The correlation between color and taste and correlations between taste with juiciness and firmness were significantly weak and positive (P<0.05). The significant correlations were not observed between palatability and overall acceptability and with the other sensory characteristics. Juiciness was negatively correlated with firmness but was not significantly different. Yang, Keeton, Beilken, and Trout [25] reported that juiciness is highly and negatively correlated with firmness. The same authors also reported that palatability is correlated to textural parameters, but Homer, Matthews, and Warkup [26] reported that palatability is more related to flavor than textural attributes, while we observed no significant correlations between palatability and overall acceptability and with other sensory characteristics in this study.

CONCLUSION

F5 with 2% oil, 5% WF, 2% MWMS, and 25.33% water and F6 with 2% oil, 3.25% MWMS, and 29.08% water had the best sensory results. As a result, MWMS can be successfully applied as fat-replacing agent in low-fat sausages with the offset effects of lowering the fat content.

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