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Fat reduction in the formulation of frankfurter sausages using inulin and pectin

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Abstract

The aim of this study was to evaluate the influence of different concentrations of inulin and pectin as fat substitutes on the chemical composition, texture, and sensory acceptance of frankfurter sausages. Six treatments were evaluated to test fat replacement: control (T0); low fat control (T1); low fat with 15% inulin (T2); low fat with 30% inulin (T3); low fat with 7.5% inulin and 7.5% pectin (T4); and low fat with 15% inulin and 15% pectin (T5). The addition of fibers increased the yield (T3 and T5; 98.96%), and the color parameters were slightly reduced (T3). Moisture (61.14%) and ashes (6.96%) of sausages with inulin and pectin were higher (T5), while shear force, hardness, fracturability, gumminess, and chewiness (T3 and T5) were slightly lower than those of the control. The addition of inulin (T2) increased the sensory acceptance of the sausages (5.75). Fat can be replaced with inulin and pectin in frankfurter sausages to produce healthy and functional products.

Keywords: fibers; texture; sensory acceptance; color; fat substitutes.

1 Introduction

Nowadays, obesity and cardiovascular diseases are changing food consumption habits; these changes have fostered the development of products with functional ingredients that meet the market demands for maintaining a healthy body (Jiménez-Colmenero et al., 2010a). Therefore, in recent years, these trends in health and lifestyle have been focused on reducing the consumption of animal fats (Ritzoulis et al., 2010). Therefore, the consumption of fat from meat products is associated with health problems (Muguerza et al., 2004), which has led to the reformulation of products with reduced fat content. Thus, reformulations in meat products seek to reduce fat, while maintaining product acceptance without affecting its appearance, smell, and flavor ensuring that these products can be considered functional foods, in some cases. Consequently, several scientific studies have developed and proposed meat products with minimum levels of fat. However, it is well known that the modification of this component reduces the sensory quality of the final product, mainly its texture and acceptance, but meat products can be formulated with low fat content by incorporating functional ingredients, such as dietary fibers. These ingredients cannot be digested nor absorbed in the human digestive tract (Roberfroid, 2007), and they have water binding capacity and the ability to replace functional characteristics of fat in meat products (Biswas et al., 2011).

Dietary fibers, particularly inulin and pectin, have been scarcely used in cooked meat products; however, they have the capacity to hold water, interact with fat, and provide texture; thus, they are suitable to be used as fat substitutes. Although it is known that the use of fat in emulsified products such as Frankfurt sausages may pose problems in their acceptance,

it is possible that the technological properties of dietary fiber can improve their sensory characteristics (García et al., 2006; Nowak et al., 2007). The use of inulin and pectin in frankfurter sausages have not been studied extensively, but the use of these fibers to develop healthy meat products should be investigated. Therefore, the aim of this research was to evaluate the contribution and effect of inulin and pectin as fat substitutes on the chemical composition, texture, and sensory acceptability of frankfurter sausages.

2 Materials and methods

2.1 Ingredients

BENEO-ORAFIT[®]GR Inulin (92% inulin, 8% glucose, fructose, and sucrose; Megafarma, S.A. de C.V., Mexico D.F.) and low methoxyl pectin (GRINDSTED[®]PECTIN LA-410; degree of esterification 30%; DANNOVA QUÍMICA, S.A. de C.V., Mexico D.F.) were used as fat substitutes. Meat byproducts (fat, pork, and beef) were obtained from the Meat Processing Unit of the Facultad de Zootecnia y Ecología, Universidad Autónoma de Chihuahua; the excess of fat content of the partially thawed meat was cut and separated. The meat was sliced into 1 cm² pieces before use. Polyphosphates, nitrites, ascorbate, and condiments were purchased from the company McCormick Pesa, S.A. de C.V.

2.2 Treatments

Six treatments were evaluated to test fat replacement (Table 1): control (T0); low fat control (T1); low fat with 15% inulin (T2); low fat with 30% inulin (T3); low fat with 7.5%

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Table 1. Formulation of sausages prepared with inulin and pectin.

Ingredients (%)	Treatments ¹					
	T0	T1	T2	T3	T4	T5
Beef	10.98	10.98	10.98	10.98	10.98	10.98
Pork	41.93	41.93	41.93	41.93	41.93	41.93
Fat	19.47	13.63	16.55	13.63	16.55	13.63
Ice	20.37	20.37	20.37	20.37	20.37	20.37
Inulin	0	0	2.92	5.84	1.46	2.92
Pectin	0	0	0	0	1.46	2.92
Starch	4.39	4.39	4.39	4.39	4.39	4.39
Salt	1.85	1.85	1.85	1.85	1.85	1.85
Polyphosphates	0.2	0.2	0.2	0.2	0.2	0.2
Nitrites	0.26	0.26	0.26	0.26	0.26	0.26
Sodium ascorbate	0.05	0.05	0.05	0.05	0.05	0.05
Sausage condiment	0.5	0.5	0.5	0.5	0.5	0.5

¹ T0: control, T1: low fat control, T2: 15.0% inulin, T3: 30.0% inulin, T4: 7.5% inulin + 7.5% pectin, T5: 15.0% inulin + 15.0% pectin.

inulin and 7.5% pectin (T4); and lastly, low fat with 15% inulin and 15% pectin (T5). Each sample was composed of 1.5 kg of meat, and the analyses were performed in triplicate, in three different time periods (three blocks). Fat and meat were significantly different in the three experimental blocks (treatments).

2.3 Preparation of sausages

Ingredients and raw materials were added per kg of product (Table 1). The formulation and the process were performed according to the method proposed by Deda et al. (2007), with some modifications; it consisted of the following stages: (1) beef and pork partially thawed were chopped using a HOBART®cutter (Hobart Corporation, Model 84145; Troy, OHIO, USA) for 3 min, and nitrites, ascorbate, and 1/3 of ice were added slowly; (2) then, polyphosphates and the remaining 1/3 of ice were incorporated, and the milling continued for 2 minutes; (3) next, the sausage condiment was added, and the process of emulsification continued for 2 more minutes, keeping the temperature below 11 °C; (4) the partially thawed pork fat was added and milled for 2 min; (5) the starch was added along with the rest of the ice, and the milling continued for 3 min; (6) once the meat dough was prepared, it was stuffed into 3 cm diameter cellulose casings using a TORREY®mill (Model M-22 R1; N.L., México) adapted with a mouthpiece, and the sausages were manually tied with a thread every 15 cm; (7) subsequently, the sausages were cooked in a water bath (RIVAL®20 Quart, Model RO220; China) and were wrapped with a polyethylene film to prevent the washing of ingredients until they reached an internal temperature of 68 °C; the sausages were then cooled in an ice bath (4 °C for 20 min), drained for 10 min, and refrigerated at 4 °C in polyethylene bags until analysis. For the preparation of the treatments T2 and T3, inulin powder was added in the third step after the sausage condiment was added; finally, to prepare T4 and T5, pectin powder was incorporated in the first step, one minute before milling, and inulin was added in the third step after the condiment was added.

2.4 Process yield (PY)

The PY of the sausages was determined in each treatment (Equation 1). The cooked and uncooked sausages were weighed, and the process yield was calculated as follows: the weight of the cooked sausage sample divided by the weight of the uncooked sausage sample multiplied by 100 (Yang et al., 2007).

$$\% \text{ PY} = \left[\frac{\text{Weight of the cooked sausage}}{\text{Weight of the uncooked sausage}} \right] \times 100 \quad (1)$$

2.5 pH

The pH of the sausages in each batch was determined 24 h after their preparation using an Orion 3 Star puncture potentiometer (Portable pH meter MA 01915, Thermo Fisher Scientific, U.S.A.). Measurements were performed in triplicate.

2.6 Water-holding capacity (WHC)

The WHC of the sausages was determined using the compression method proposed by Tsai & Ockerman (1981) and Dzudie et al. (2005) with some modifications. Approximately 0.3 g of sausage was placed between two filter papers and then placed between two 12 x 12 cm plexiglass plates, and a force of 4.0 kg was applied for 20 min. Due to the force exerted on the sample, the released liquids were impregnated in the paper, and they were considered as meat-free water; WHC was performed in triplicate, and the following Equations 2 and 3 were used:

$$\% \text{ of free water} = \left[\frac{(I_w - F_w)}{I_w} \right] \times 100 \quad (2)$$

$$\text{WHC} = 100 - \% \text{ of free water} \quad (3)$$

where I_w is the initial weight of the sample (0.3 g) and F_w is the final weight.

2.7 Color

Color was measured directly in the internal part of the sausages using a Minolta Chroma Meter 2002 colorimeter (CR-400/410, Konica Minolta Holdings, Inc., Tokyo, Japan) based on the CIE (L^* , a^* and b^*) system; the equipment was

calibrated before measurements. These were performed in triplicate in sections of 2.5 cm long and 3 cm diameter.

2.8 Proximate analysis

The proximate analysis of the sausages was performed 24 h after their preparation according to the AOAC (Association of Official Analytical Chemists, 1998): moisture, method 950.46; ashes, method 920.153; fat, method 985.15; and protein, Kjeldahl method 992.15. All the evaluations were performed in triplicate.

2.9 Shear force (SF) and texture profile analysis (TPA)

The SF and TPA were performed using a Texturometer (TA.XT2i Stable Micro Systems Serrey, England). For the SF, the Warner-Bratzler blade was adapted to texturometer (Su et al., 2000), and five central sections of each sample were used; these were standardized to 2.5 cm high and 3.0 diameter at a temperature of 4 °C; the conditions established for the test were: speed of 2 mms⁻¹ (pre-test), 2 mms⁻¹ (test), 10 mms⁻¹ (post-test), and a distance of 30 mm.

The TPA was performed using six central sections, standardized as 2.5 cm high and 3.0 cm diameter at 4 °C. A cylindrical piston was used to compress the sample during the two cycles of the test at 70% of the original height and a time interval of 5 s between the two compression cycles. Force-time deformation curves were obtained from the conditions established in the texturometer: speed of 1.0 mms⁻¹ (pre-test), of 5.0 mms⁻¹ (test), and of 5.0 mms⁻¹ (post-test); the following parameters were quantified and defined according to Bourne (1978) and other authors (Ayo et al., 2008; Álvarez et al., 2012): hardness (N), fracturability (N), adhesiveness (gs), springiness (mm), cohesiveness, gumminess (N), and chewiness (Nmm).

2.10 Sensory evaluation

An affective sensory test of attributes was conducted by measuring the level of satisfaction of 84 consumers. This process was approved by the Ethical Committee of the university. Each consumer received, in random order, two slices of each treatment sample (5 mm high at 4 °C), which were served on plastic dishes encoded with three-digit random numbers; they evaluated the following attributes: pinkness, appearance, smell, taste, and overall acceptance; a 7-point hedonic scale anchored by 7 = liked very much and 1 = disliked very much was used (Anzaldúa-Morales, 1994; Meilgaard et al., 2006).

2.11 Statistical analysis

The variables were analyzed using a randomized complete block design with the GLM procedure (SAS Institute, 2006) and the following statistical model (Equation 4):

$$y_{ij} = \mu + \tau_i + \beta_j + e_{ij} \quad (4)$$

where y_{ij} = variables measured in the products by effect of the treatment i and block j ; μ = treatments mean; τ_i = effect of the treatment i ; β_j = effect of the block j ; e_{ij} = residual error. The significance level used for all statistical analyses was 5%; the Tukey statistical test was performed to compare the means between treatments.

3 Results and discussion

3.1 Process yield (PY)

The addition of inulin and pectin showed a significant effect ($P < 0.05$) on the PY of the sausages. The addition of these ingredients increased more than 98.5% of the PY. T3 had the highest PY value, while T0 and T1 had the lowest values (Table 2). A similar behavior was found by Xiong et al. (1999); they attributed their results to the capacity of gums to bind and hold water due to their ability to form hydrogen bonds with water. García-García & Totosaus (2008) explain this behavior by the denaturation of meat proteins before gelatinization of other ingredients in the polysaccharide-meat system. On the other hand, Choi et al. (2010) reported that the yield depends on temperature, cooking time, ingredients, amount of fat in the products, and dietary fiber. Thus, the results obtained in this research indicate that dietary ingredients can improve the yield of the sausages.

3.2 pH

The dietary ingredients used had significant effects ($P < 0.05$) on the pH of the sausages (Table 2). The pH decreased with increased concentration of inulin and pectin. T5 had the lowest pH, and T0 had the highest. Xiong et al. (1999) reported that polysaccharides and proteins in food interact through electrostatic association (attraction and repulsion) between the polar and non-polar groups of gums and proteins, resulting in pH variations. Choi et al. (2009) obtained opposite results to those of the present study; they found higher pH (6.46 to 6.47) in sausages formulated with vegetable oil and rice bran fiber; these authors attributed this phenomenon to the minerals, such

Table 2. Influence of inulin and pectin on the quality of reduced-fat frankfurters.

Treatments ¹	Parameters					
	PY (%)	pH	WHC (%)	Lightness (L*)	Redness (a*)	Yellowness (b*)
T0	97.27±0.15 ^d	5.86±0.03 ^a	68.65±0.89 ^a	66.78±0.32 ^a	9.21 ± 0.14 ^b	11.47 ± 0.12 ^c
T1	97.63±0.15 ^{cd}	5.77±0.03 ^{ab}	65.25±0.89 ^{ab}	65.18±0.32 ^{bc}	10.08 ± 0.14 ^a	11.45 ± 0.12 ^c
T2	98.49±0.15 ^{ab}	5.79±0.03 ^{ab}	62.49±0.89 ^b	64.70±0.32 ^{bc}	9.98 ± 0.14 ^a	11.48 ± 0.12 ^c
T3	98.96±0.15 ^a	5.76±0.03 ^{ab}	59.43±0.89 ^c	64.14±0.32 ^c	9.95 ± 0.14 ^a	11.43 ± 0.12 ^c
T4	98.20±0.15 ^{bc}	5.71±0.03 ^{bc}	65.25±0.89 ^{ab}	66.65±0.32 ^a	9.74 ± 0.14 ^{ab}	12.48 ± 0.12 ^b
T5	98.68±0.15 ^{ab}	5.57±0.03 ^c	67.11±0.89 ^a	65.96±0.32 ^{ab}	9.87 ± 0.14 ^a	13.13 ± 0.12 ^a

^{a-c} Means (± standard error) in the same column with different letters are different ($P < 0.05$). ¹ T0: control, T1: low fat control, T2: 15.0% inulin, T3: 30.0% inulin, T4: 7.5% inulin + 7.5% pectin, T5: 15.0% inulin + 15.0% pectin.

as iron, phosphorus, and calcium, present in the fibers. However, López-López et al. (2009) obtained low pH using edible algae (5%; *Himantalia elongata*) in low-fat (10%) sausages; these authors attributed their results to low ionic strength, chemical composition of dietary fiber, and the protein content of the polysaccharides. Kim et al. (2011) stated that the decrease of pH in sausages is affected by the ingredients used in the formulation. In this research, the decrease in the sausage pH may be due to the pectin pH (4.3).

3.3 WHC

WHC was influenced ($P < 0.05$) by the addition of dietary fibers to the low fat sausages (Table 2); T5 and T0 had the highest WHC, and T3 had the lowest; these results showed that the addition of 15% inulin and pectin (T5) improve the water holding capacity. Cengiz & Gokoglu (2007) found increased WHC using citrus fiber in sausages with three fat levels (20, 10 and 5%); they reported that this result is due to the high fat levels and addition of fiber. Therefore, the results of this research showed that the addition of pectin improves WHC. On the other hand, according to López-López et al. (2009), water holding capacity of some fibers is related to the type and amount of their polysaccharides; large particles are associated with open structures that improve the properties of hydration and fat absorption capacity. This could explain the fact that the addition of inulin and pectin increased the WHC due to their ability to bind water molecules and retain fat.

3.4 Color

The addition of dietary fiber had significant effect ($P < 0.05$) on the color parameters of frankfurter sausages (Table 2). L^* was lower in T3 but higher in T4, which was not different from the L^* value of the control (T0). Accordingly, Cáceres et al. (2004) found similar color parameters values in sausages with fructooligosaccharides (2-12%); they reported that these differences are due to the lack of fat and incorporation of dietary fiber. Moreover, a^* was influenced by the addition of dietary ingredients; T2 and T3 were the highest. The b^* value was affected by inulin and pectin. T5 and T4 showed the highest values. This indicates that an increase in pectin concentration affected a^* and b^* values, whereas the addition of inulin did not have the same effect. Cáceres et al. (2004) stated that the a^* and b^* values were not affected by fructooligosaccharides since they were characterized as whitish and translucent.

Similar behavior was obtained by Özvural et al. (2009) using brewery's spent grain (1, 3 and 5%) in sausages. On the other hand, Ayo et al. (2008) highlighted that by reducing the fat content, L^* and b^* values decreased and a^* increased, but a number of variations can be found in color when the fat level and meat content (myoglobin) is changed (Jiménez-Colmenero et al., 2010b). Therefore, the addition of pectin and inulin affects the lightness, redness, and yellowness values.

3.5 Proximate analysis

Significant effects ($P < 0.05$) were found in moisture, fat, and ash contents, but there were no differences in the protein content (Table 3). The moisture of T5 was higher than that of T0, and T1 had the highest value. The addition of fibers increased moisture content; similar behavior was found by Vural et al. (2004), Choi et al. (2009) and Choi et al. (2010) using rice bran fiber; these authors reported that this fiber increases the water holding capacity and therefore the moisture content in the sausages. Fat level was the highest in T0 because it was formulated with the highest content of back fat (19.47%), while the other treatments had the lowest fat content because they were formulated with 16.55 and 13.63% of back fat and dietary fibers. Tobin et al. (2012) obtained similar results in sausages; they stated that the sausages prepared with high fat levels have high fat content. The ash content was higher in all low-fat sausages due to the addition of inulin and pectin. According to López-López et al. (2009) and Choi et al. (2010), ash increased with the incorporation of algae and rice bran fiber in low-fat products. Finally, the protein content of sausages was not influenced ($P > 0.05$) by the addition of inulin and pectin. Jiménez-Colmenero et al. (2010a) found similar changes in the composition of low-fat sausages prepared with konjac dietary fiber (10.5 and 19.3%) and seaweed (3.3%); these authors reported that this was due to the ability of dietary fiber to change the composition of the product.

3.6 Shear force (SF) and texture profile analysis (TPA)

The textural behavior of sausages with dietary fibers is shown in Table 4. SF of the sausages was influenced ($P < 0.05$); T1 had the highest value, and T3 had the lowest. This result shows that inulin and pectin could simulate the functional characteristics of fat in sausages, especially due to the high water absorption capacity of inulin. Totosaus & Pérez-Chabela (2009) obtained similar data in meat batters with gellan gum; they reported that reduced fat levels and the addition of gums

Table 3. Proximate composition of low-fat frankfurters with inulin and pectin.

Treatments ¹	Parameters (%)			
	Moisture	Protein	Fat	Ashes
T0	57.76 ± 0.73 ^c	10.24 ± 0.19	17.80 ± 0.33 ^a	5.88 ± 0.18 ^c
T1	61.90 ± 0.73 ^a	10.29 ± 0.19	8.90 ± 0.33 ^c	7.88 ± 0.18 ^a
T2	58.13 ± 0.73 ^{bc}	10.28 ± 0.19	12.51 ± 0.33 ^b	6.48 ± 0.18 ^{bc}
T3	59.87 ± 0.73 ^{abc}	10.94 ± 0.19	9.05 ± 0.33 ^c	6.35 ± 0.18 ^{bc}
T4	58.31 ± 0.73 ^{bc}	10.96 ± 0.19	13.35 ± 0.33 ^b	6.74 ± 0.18 ^b
T5	61.14 ± 0.73 ^{ab}	10.43 ± 0.19	9.26 ± 0.33 ^c	6.96 ± 0.18 ^b

^{a-c} Means (± standard error) in the same column with different letters are different ($P < 0.05$). ¹ T0: control, T1: low fat control, T2: 15.0% inulin, T3: 30.0% inulin, T4: 7.5% inulin + 7.5% pectin, T5: 15.0% inulin + 15.0% pectin.

in the presence of Ca^{2+} , resulted in hard gels, which changed the textural properties (Savadkoochi et al., 2014) and therefore SF high values could be obtained. According to González-Viñas et al. (2004), samples with high-fat and increased dry matter resulted in lower values of SF.

The effects of replacing backfat with different levels of inulin and pectin on the textural properties of sausages are presented in Table 4. In general, the results show significant differences ($P < 0.05$) in TPA. Hardness, cohesiveness, gumminess, and chewiness were lower in treatments with dietary fibers. For example, hardness was lower in T5, whereas T1 had the highest value. These differences could be attributed to the fat content and the dietary ingredients due to their high binding ability and water holding capacity (Choi et al., 2014); in the present study, the sausages with fibers were softer. According to Cierach et al. (2009), the hardness in the sausages is related to their fat content.

Fracturability was not different between the treatments ($P > 0.05$); however, low fat treatments with inulin and pectin had low values (Table 4). Moreover T1, T2, and T3 had the lowest adhesion values; therefore, inulin (T3) did not affect this parameter. Pereira et al. (2011) reported that this feature should be smooth and without adhesion. T1 had the lowest adhesiveness value; this suggests that fat and dietary fibers were responsible for restructuring the sausages. An effect of inulin and pectin on the springiness of the sausages was observed; treatments T0 and T4 were more elastic (Table 4). Xiong et al. (1999) highlighted that the increase in the charges of protein allows for electrostatic interactions between proteins and polysaccharides; therefore, this facilitates the formation of

more elastic gels in products. Similar results were obtained by Youssef & Barbut (2011), who stated that texture parameters vary due to the formation of a dense protein matrix and a rigid structure depending on the amount of lean meat used in the formulation. In this study, the sausages made with inulin and pectin were not statistically different from that in the T0; this could be attributed to the ability of dietary fibers to mimic the function of fat in the sausages.

3.7 Sensory evaluation

Table 5 presents the acceptance of the sensory attributes of the sausages. The addition of inulin and pectin influenced ($P < 0.05$) the sensory attributes. T2 was the most preferred due to its pinkness and appearance, while T3 was the least accepted. Cierach et al. (2009) reported that using carrageenan (0.41 and 0.70%) in sausages with 10 and 20% fat, increased preference of their pinkness, juiciness, hardness, and flavor; presumably caused by the dilution of myoglobin due to some ingredients. For example, in this research, pectin and inulin improved the acceptance of some attributes such as appearance and flavor. Özvural et al. (2009) reported that the addition of powered brewery's spent grains (1, 3, and 5%) in sausages (10% fat) decreased palatability and sensory scores; in this study, for example, higher levels of pectin affected the flavor and odor.

Smell and hardness exhibited similar behavior in the frankfurter sausages. T1 was the most accepted and T5 was the least accepted. With regard to the flavor and overall acceptance of the low-fat sausages, T2 was the most accepted, while T5 was less accepted. Tobin et al. (2012) reported that 10% fat in

Table 4. Effects on texture attributes of low-fat frankfurters with inulin and pectin.

Variable	Treatments ¹					
	T0	T1	T2	T3	T4	T5
SF (Kg_f)	1.54 ± 0.08 ^{ab}	1.59 ± 0.08 ^a	1.35 ± 0.08 ^{ab}	1.30 ± 0.08 ^b	1.41 ± 0.08 ^{ab}	1.34 ± 0.08 ^{ab}
Hardness (N)	86.00 ± 4.28 ^b	100.66 ± 4.28 ^a	79.48 ± 4.28 ^b	65.55 ± 4.28 ^{cd}	76.34 ± 4.28 ^{bc}	61.77 ± 4.28 ^d
Fracturability (N)	89.18 ± 6.31	91.04 ± 8.02	87.38 ± 5.35	83.56 ± 4.74	94.32 ± 5.13	77.19 ± 4.46
Adhesiveness (gs)	-20.59 ± 8.63 ^{ab}	-7.83 ± 9.34 ^a	-5.99 ± 10.93 ^a	-3.34 ± 8.64 ^a	-49.93 ± 8.69 ^b	-38.24 ± 8.39 ^{ab}
Springiness (mm)	0.81 ± 0.02 ^a	0.77 ± 0.02 ^{ab}	0.78 ± 0.02 ^a	0.76 ± 0.02 ^{ab}	0.82 ± 0.02 ^a	0.71 ± 0.02 ^b
Cohesiveness	0.23 ± 0.01 ^{ab}	0.25 ± 0.01 ^a	0.23 ± 0.01 ^{ab}	0.23 ± 0.01 ^{ab}	0.22 ± 0.01 ^{ab}	0.21 ± 0.01 ^b
Gumminess (N)	20.06 ± 1.34 ^b	24.24 ± 1.34 ^a	18.23 ± 1.30 ^{bc}	15.07 ± 1.30 ^{cd}	16.88 ± 1.30 ^{bc}	12.74 ± 1.30 ^d
Chewiness (Nmm)	16.19 ± 1.13 ^b	19.89 ± 1.13 ^a	14.38 ± 1.10 ^{bc}	11.65 ± 1.10 ^{cd}	13.92 ± 1.10 ^{bc}	9.01 ± 1.10 ^d

^{a-d} Means (± standard error) in the same column with different letters are different ($P < 0.05$). ¹ T0: control, T1: low fat control, T2: 15.0% inulin, T3: 30.0% inulin, T4: 7.5% inulin + 7.5% pectin, T5: 15.0% inulin + 15.0% pectin.

Table 5. Sensory evaluation of low-fat frankfurters with inulin and pectin.

Treatments ¹	Sensory attributes					
	Pinkness	Appearance	Smell	Hardness	Flavor	Overall Acceptance
T0	5.46 ± 0.92 ^{ab}	5.63 ± 0.90 ^{ab}	5.17 ± 0.89 ^{ab}	5.48 ± 0.90 ^a	5.37 ± 0.98 ^a	5.73 ± 0.84 ^a
T1	5.58 ± 1.09 ^{ab}	5.49 ± 1.23 ^{abc}	5.33 ± 0.91 ^a	5.46 ± 0.81 ^a	5.39 ± 0.82 ^a	5.67 ± 0.87 ^a
T2	5.75 ± 0.73 ^a	5.81 ± 0.69 ^a	5.18 ± 0.92 ^{ab}	5.42 ± 0.91 ^a	5.46 ± 0.91 ^a	5.75 ± 0.73 ^a
T3	5.36 ± 0.87 ^b	5.21 ± 1.01 ^c	5.04 ± 0.81 ^{abc}	4.85 ± 1.08 ^{bc}	4.69 ± 1.05 ^b	5.23 ± 0.87 ^b
T4	5.42 ± 1.03 ^{ab}	5.33 ± 1.03 ^{bc}	4.70 ± 1.03 ^c	5.19 ± 0.96 ^{ab}	4.80 ± 1.15 ^b	5.18 ± 0.89 ^b
T5	5.37 ± 1.22 ^{ab}	5.56 ± 1.07 ^{abc}	4.95 ± 0.90 ^{bc}	4.73 ± 1.24 ^c	3.98 ± 1.25 ^c	4.55 ± 1.09 ^c

^{a-c} Means (± standard error) in the same column with different letters are different ($P < 0.05$). ¹ T0: control, T1: low fat control, T2: 15.0% inulin, T3: 30.0% inulin, T4: 7.5% inulin + 7.5% pectin, T5: 15.0% inulin + 15.0% pectin.

sausages adversely affects the juiciness, while 25 and 15% fat are positively correlated to juiciness and flavor. Similar results were obtained by Huang et al. (2011) when studying the effect of the addition of inulin (3.5 and 7.0%) on the sensory properties of sausages; these authors suggested that the high solubility of inulin improved textural properties. Andrès et al. (2006) stated that the hydrocolloids improve product texture, notably the flavor. In the present study, T2 improved acceptance of flavor in the sausages. Similar behavior was found by Grizotto et al. (2012).

4 Conclusions

Inulin and pectin increased the yield and improved the color parameters associated with consumer acceptance. The proximate analysis of the sausages showed that meat products can be reformulated with fibers, preserving the protein content and the water holding capacity. The textural analysis and the sensory evaluation demonstrated that dietary fibers can be used in sausages as fat replacers and also as a source of prebiotic ingredients.

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