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ARTICLE

Investigation of the Usability of Retrograded Flour in Meatball Production as A Structure Enhancer

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Abstract This study aimed to research the possibilities of using retrograded flour produced in the laboratory environment in meatballs and the characteristics of these meatballs. In the use of retrograded flour to produce meatballs, it was ensured that the meatball properties, with respect to chemical, physical and sensorial aspects, were comparable to those of meatballs produced with bread (traditional) and rusk flour (commercial). The cooking loss of meatballs produced with using retrograded flour was similar to that of commercial meatballs. Doses of retrograded flour from 5% to 20% led to a significant decrease in cooking loss, from 21.95% to 6.19%, and in the diameter of meatballs, from 18.60% to 12.74%, but to an increase in the thickness of meatballs, from 28.82% to 41.39% compared to the control. The increase of *a** and *b** values was shown in that the meatballs were browned on cooking with increasing retrograded flour doses because of non-enzymatic reactions. The springiness of the traditional meatballs was significantly higher than that of the other meatballs. This might have been due to the bread crumbs having a naturally springy structure. Moreover, the addition of retrograded flour in the meatballs significantly ($p<0.05$) affected the hardness, springiness and cohesiveness of the meatballs with respect to textural properties. Accordingly, it is considered that the use of 10% retrograded flour is ideal to improve the sensorial values of meatballs and the properties of their structure.

Keywords flour source, modified meatball, stale bread, texture modifier

Introduction

Dietary fibers are polymers, which are resistant to digestion and absorption in the small intestine of humans and which can be totally or partially fermented by probiotic microorganisms in the large intestine. The major dietary fiber compounds, which are also identified as polymeric structures, other than starch are cellulose, pectin, hemicellulose, lignin, inulin, gum materials and enzyme resistant starch (Jiménez-Colmenero et al., 2013). These compounds are generally found in the formulation of meat products, such as meatballs (Yılmaz and Geçgel, 2009), nuggets (Verma et al., 2009) and fermented sausages (Garcıa et al., 2002). In addition to making the product more nutritious and healthy, the dietary fiber minimizes changes in texture by increasing the water binding capacity and consequently provides an economic advantage both in terms of the consumer and the producer (Biswas et al., 2011).

The high viscosity structure caused as a result of the gelatinization of the starch is not stable and becomes a gel during storage. If the waiting period of the gel is longer, the interaction between the starch chains further increases, and the starch chains start to line up once again in a double-helix structure and become stronger due to their hydrogen bonds (Haralampu, 2000). Consequently a crystal structure is present again (Thomas, 1999), and this reorganization of polymers is called retrogradation. The crystal structure becomes more resistant to digestion enzymes. In other words, retrogradation is the recrystallization of the gelatinized starch and is a more resistant form against digestion enzymes. This resistant starch is not easily digested in the digestion system after being taken into the body, and, consequently, it acts as dietary fiber.

Retrograde starch is naturally found in cooked and cooled potato and bread and is also used in the compounds of numerous foods, such as breakfast cereals (Sajilata et al., 2006). Bread staling decreases consumer acceptance of bakery products and is caused by changes in the crumbs that are closely related to starch retrogradation (Bechtel et al., 1953). Stale breads and rusk made from bread are used traditionally in meatballs produced in Turkey as a structure enhancer (Ergezer et al., 2014; Serdaroğlu et al., 2005). In addition to staling, microbiological spoilage, such as ropiness and mold growth, are also observed during the storage of bread (Gray and Bemiller, 2003). Mold growth in bread can cause the formation off-flavors, the production of mycotoxins and allergenic compounds and huge economic losses. Therefore, it is considered that stale bread used in meatballs has a risk of food safety.

In recent years, retrograded flour, which has an important position in the food industry, has been used in numerous cereal products, such as breads and crackers, in order to add functional qualities to prevent intestine problems, inhibit the formation of diseased cells, balance the blood sugar level and decrease total cholesterol (Nyman and Svanberg, 2002). In the literature research, though there are numerous studies regarding the use of dietary fiber in meat products, there is a limited amount of research regarding the use of retrograded flour. There is a study on the optimization of resistant starch, β-glucan and starch used in prebiotic sausage formulation (Amini Sarteshnizi et al., 2015). Within a study performed on animals, the consumption of red meat together with resistant starch originating from potato had a positive effect on reducing the large intestine diseases (Paturi et al., 2012). This study researches the possibilities of using retrograded wheat flour in the meatball production and compares the chemical, physical and sensorial characteristics of these meatballs with commercial and traditional meatballs.

Materials and Methods

Materials

Minced beef meat with approximately 10% fat for the production of meatballs and additional ingredients, flour, bread, rusk flour, onion, salt, paprika, pepper and cumin, were obtained from well-known local supermarkets. Chemical materials were provided in analytic grade.

The production of retrograded flour

A certain amount of wheat flour (4 kg) was mixed with water (4 liter) and stirred until evenly mixed. The resulting slurry was spread in 1 cm thickness on a baking tray covered with baking paper and was put into an oven preheated to 85°C. With the help of a thermometer, the temperature of the dough center was constantly kept at above 65°C. After keeping the dough in the oven for 1 hour under these conditions, the starch inside was gelatinized. The gelatinized dough was taken out of the oven and kept in a ventilated environment with room temperature for 1 day to rest and was cut in thin sliced strips. These strips were then cut to even smaller sized strips that were left to dry in a ventilated environment. In order to prevent mold growth and for better drying, they were kept in an oven set to 65°C for 1 more hour. During these resting and drying processes, the gelatinized starch underwent retrogradation. The pieces of dough that were dried to have lower than 14% water content were then ground and transformed into flour (particle size <200 μ).

The production of bread flour for traditional meatballs

Stale bread was broken into small pieces and placed on a wide plate. This was kept waiting to dry under ambient conditions for 1-2 days in this manner. A blender (Waring Laboratory Science, Winsted, USA) was used for these pieces of dried bread to make flour. The flour was stored in tight-head containers in a refrigerator (4°C) until used in the study.

Preparation of the meatballs

The meatballs used in the research were prepared in three different compositions: traditional, commercial and modified. The formulations of the meatballs are given in Table 1. Differences in the formulation were sourced from flour source (bread flour, rusk flour and retrograded flour) and the doses of retrograded flour (0, 5, 10, 15 and up to 20%).

After the other ingredients were added to the minced beef meat, the mixture was kneaded by hand for five minutes, and homogeneous meatball dough was obtained. After the meatball dough was spread in 1 cm thickness, meatballs were shaped using petri dishes of 9 cm in diameter. The meatballs were cooked on a preheated pan until their midpoint temperature reached 72 ± 2°C. The midpoint temperature was controlled by a digital thermometer with sensor probe.

Table 1. Meatball formulas

Ingredient (%)	Traditional	Commercial	Modified (0%)	Modified (5%)	Modified (10%)	Modified (15%)	Modified (20%)
Ground meat	71	71	81	76	71	66	61
Bread flour	10	0	0	0	0	0	0
Rusk flour	0	10	0	0	0	0	0
Retrograded flour	0	0	0	5	10	15	20
Water	9	9	9	9	9	9	9
Onion	7	7	7	7	7	7	7
Salt	2	2	2	2	2	2	2
Black pepper	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Sweet paprika	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Chili paprika	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Cumin	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Chemical and physical analysis

The moisture content of the meatball samples was determined by using a drying method in an oven of 105°C (Memmert UNB 500, Schwabach, Germany), ash content was determined by combusting of samples at 550°C, the amount of protein was determined by using the Kjeldahl method, the amount of fat was determined by using the Soxhelet extraction method and the pH value was determined by a digital pH-meter (Hanna HI 2210, Woonsocket, RI, USA) (AOAC, 2000). The water activity value of the samples (a_w) was determined using a water activity meter (Decagon Devices Inc, USA). Analysis of resistant starch was performed to the standard method (AACC, 2009) by using a resistant starch enzyme kit (Megazyme Int. Wicklow, Ireland).

The cooking loss of samples was calculated by dividing the difference of the weight of the meatballs before and after they were cooked by the weight of the meatballs before they were cooked and was given as percentage. The dimension change of the samples was calculated by the difference of the diameter and thickness of the meatballs, measured with a caliper, before and after they were cooked (Mansour and Khalil, 1997).

The color of the meatball samples was measured by using a CR-400 Chromameter (Konica Minolta, Japan) at four different spots on their surfaces. Measured according to the CIE color system, the L^* value represents the brightness of the samples, the a^* value represents the red-green color value and the b^* value represents the yellow-blue color value. The color device was calibrated by using its white ceramic plate before actual use.

The texture profile of the meatball samples was determined using a TA.XTplus Texture Analysis Device (Stable Microsystems, UK). With the TPA from the meatball samples, hardness, fracturability, springiness, cohesiveness, gumminess and chewiness properties of the samples were determined. For the analysis, a 100 mm cylinder probe (P/100) and Heavy Duty Platform (HDP/90) accessories were used. Before and after the TPA test, the probe speed was set to 2 mm/sec, the test speed was set to 5 mm/sec, the waiting time was set to 2 seconds, the trigger strength was set to 5 g, the load cell was set to be 50 kg and the distance was set to the distance that would provide 40% deformation.

Sensory evaluation

In the sensory evaluation, the meatball samples were presented in a random order to 10 panelists; they were Masters science students in food science and were trained about sensory evaluation. Panelists evaluated the meatballs regarding their appearance, color, odor, flavor, tenderness and overall acceptability with a nine point hedonic scale (1: did not like at all, 9: liked very much) (Huang et al., 2005). Before trying another sample, the panelists were asked to consume water in order to neutralize the taste in their mouths.

Statistical analysis

In the research, three flour sources (bread, rusk and retrograded flour) and retrograded flour were used in five different percentages (0, 5, 10, 15 and up to 20%). The meatballs that included no retrograded flour (0%) were used as a control. The meatball production was made in two replicates, and the analyses of the samples were held in parallel. Variance analysis (ANOVA) was made for the data and a Duncan Multiple Comparison Test was applied to the important factors. All statistical calculations were done using SAS Statistics Software (v.7.00, SAS Institute Inc., Cary, NC, USA), and the values were given as mean ± standard error.

Results and Discussion

Chemical properties of the meatballs

The resistant starch, protein, fat, ash, moisture, water activity and pH results of the meatballs are shown in Table 2.

While the protein, ash, moisture contents, water activity and pH value of the meatballs were not affected (p>0.05), fat and resistant starch content were affected significantly (p<0.05) by the flour source. The fat and resistant starch contents of the meatballs produced with 10% of different added flour sources were determined as significantly different. Because each flour source had different fat contents and characteristics. Especially, each flour source had a different rate of resistant starch due its production technique. Bread and rusk flour were reproduced from bakery products, and their resistant starch came from retrogradation in storage after the first production (Hesso et al., 2015).

Table 2. Composition and chemical parameters of meatballs

	Protein (%)	Fat (%)	Moisture (%)	Ash (%)	Resistant starch (g/100g)	pH	a_w
Flour source							
Traditional	$16.37^{a} \pm 0.05$	$10.06^{a} \pm 0.00$	$60.82^{a} \pm 0.11$	$3.30^{a} \pm 0.00$	$0.15^{b} \pm 0.00$	$5.99^{a} \pm 0.02$	$0.961^{a} \pm 0.00$
Commercial	$16.76^{a} \pm 0.17$	$9.45^{a} \pm 0.21$	$60.46^{a} \pm 0.12$	$3.28^{a} \pm 0.00$	$0.20^{a} \pm 0.01$	$6.02^{a} \pm 0.00$	$0.968^{a} \pm 0.00$
Modified (10%)	$16.66^{a} \pm 0.23$	$8.14^{b} \pm 0.15$	$60.55^{a} \pm 0.26$	$3.20^{a} \pm 0.04$	$0.21^{a} \pm 0.01$	$6.01^{a} \pm 0.01$	$0.966^{a} \pm 0.00$
Flour dose in modified meatballs							
0% (control)	$21.20^{a} \pm 1.07$	$9.99^{a} \pm 0.01$	$66.11^{e} \pm 0.51$	$3.30^{a} \pm 0.00$	$0.07^{e} \pm 0.01$	$6.02^{a} \pm 0.00$	$0.969^{a} \pm 0.00$
5%	$18.92^{b} \pm 0.34$	$8.65^{b} \pm 0.16$	$63.47^{d} \pm 0.18$	$3.23^{a} \pm 0.02$	$0.11^{d} \pm 0.00$	$6.04^{a} \pm 0.03$	$0.968^{a} \pm 0.00$
10%	$16.66^{c} \pm 0.23$	$8.14^{b} \pm 0.15$	$60.55^{c} \pm 0.26$	$3.20^{a} \pm 0.04$	$0.21^{c} \pm 0.01$	$6.01^{a} \pm 0.01$	$0.966^{a} \pm 0.00$
15%	$15.25^{cd} \pm 0.37$	$8.18^{b} \pm 0.17$	$58.07^{b} \pm 0.15$	$3.02^{b} \pm 0.03$	$0.30^{b} \pm 0.00$	$5.99^{a} \pm 0.00$	$0.967^{a} \pm 0.00$
20%	$13.33^{d} \pm 0.53$	$8.03^{b} \pm 0.30$	$54.82^{a} \pm 0.28$	$2.99^{b} \pm 0.01$	$0.44^{a} \pm 0.00$	$5.98^{a} \pm 0.02$	$0.961^{a} \pm 0.00$

[a,b,c,d,e]Means with different online letters within the column indicating significant difference (p<0.05).

Except for pH and water activity values (p>0.05), the chemical properties of the meatballs were significantly (p<0.05, p<0.01) affected by the retrograded flour dose. It has been reported that the pH of an added fiber source affects the pH of meatballs containing dietary fiber (Mehta et al., 2013). Similar results were reported for beef patties with flaxseed flour (Bilek and Turhan, 2009) and for meatballs with whey powder (Serdaroğlu, 2006a). The protein, fat, ash and moisture contents decreased with the increase of the retrograded flour dose from 0% to 20%; this was due to the dilution effect because their concentration in the flour was lower than in the meat. In one study, it was reported that lower protein content in beef patties is influenced by different levels of flour (Bilek and Turhan, 2009). The fat content of the modified meatballs slightly decreased as the level of the retrograded flour increased or the protein content decreased. This may have been due to the decreasing protein content of the meatballs because proteins have a high capacity of fat binding. It was reported that protein is an excellent fat binder because of the capacity for fat interactions and interfacial film formation (Serdaroğlu et al., 2005). In another study, it was reported that the moisture and fat content of meatballs gradually decreased with the increase of added wheat and oat bran at percentages of 5, 10, 15 and 20 (Yasarlar et al., 2007). Also, as expected, the resistant starch content of the meatballs increased as the flour increased because increasing the flour rate provided an increased content of resistant starch.

Physical properties of the meatballs

The results for cooking loss (%), increase in thickness (%) and decrease in diameter (%) of the meatballs are in Table 3. These values of the meatballs were affected significantly (p<0.05) by the flour source and retrograded flour dose.

The cooking loss of meatballs produced with using retrograded flour was similar to that of commercial meatballs. These meatballs have an advantage with respect to cooking loss compared to traditional meatballs. Doses of retrograded flour from 5% to 20% led to a significant decrease in cooking loss, from 21.95% to 6.19%, compared to the control (26.23%). This may have been due to released water from the proteins of the meat holding on to the starch in the flour source during cooking. Because the cooking caused the denaturation and shrinkage of proteins, denatured protein released water. Simultaneously, the released water was trapped in the gelatinization of the starch during cooking. This phenomenon caused a decrease in the cooking loss of the meatballs with an increase in the flour dose.

Table 3. The cooking loss and changes in thickness and diameter of meatballs

	Cooking loss (%)	Increase in thickness (%)	Decrease in diameter (%)
Flour source			
Traditional	$15.49^{a} \pm 0.24$	$22.85^{c} \pm 0.02$	$-21.51^{a} \pm 0.31$
Commercial	$11.30^{b} \pm 1.55$	$23.94^{b} \pm 0.08$	$-19.19^{b} \pm 0.30$
Modified	$12.39^{ab} \pm 0.34$	$30.27^{a} \pm 0.14$	$-17.17^{c} \pm 0.36$
Flour dose in modified meatballs			
0% (control)	$26.23^{a} \pm 0.29$	$18.48^{e} \pm 0.15$	$-22.25^{a} \pm 0.58$
5%	$21.95^{b} \pm 0.11$	$28.82^{d} \pm 0.12$	$-18.60^{b} \pm 0.38$
10%	$12.39^{c} \pm 0.34$	$30.27^{c} \pm 0.14$	$-17.17^{c} \pm 0.36$
15%	$7.35^{d} \pm 0.11$	$35.83^{b} \pm 0.64$	$-15.47^{d} \pm 0.05$
20%	$6.19^{e} \pm 0.31$	$41.39^{a} \pm 0.11$	$-12.74^{e} \pm 0.09$

[a,b,c,d,e]Means with different online letters within the column indicating significant difference ($p<0.05$).

It was reported that cooking loss is influenced by fat and moisture content (Hughes et al., 1997). It was reported that water flows out of meatballs due to the shrinkage of proteins during cooking, but that added fibers in the formulation improve the cooking loss of meatballs by binding to the released water (Galanakis et al., 2010). These results are in agreement with studies using oat flour (Serdaroglu, 2006b), and bean flour and lentil flour (Serdaroğlu et al., 2005).

The decrease in the diameter of the meatballs produced with using retrograded flour was lower, 17.17%, than that of traditional and commercial meatballs. Additionally, doses of retrograded flour from 5% to 20% led to a significant decrease in the diameter of meatballs, from 18.60% to 12.74% compared to the control (22.25%). The decrease in the diameter may have been due to the structure of the meatballs being supported by the polymeric structure of the flour, such as protein and especially gelatinized starch, because the flour filled voids in the ground meat. The increase in the thickness of the meatballs was determined to be as high as 30.27% in all meatballs produced with using retrograded flour. Additionally, increasing doses of retrograded flour increased the thickness of the meatballs from 28.82% to 41.39%. This may have been due to swelling caused by entrapped vapor as water held in the gelatinized starch during the cooking of the meatballs.

The cooking of meatballs causes dimensional changes due to the denaturation of the meat proteins and the loss of water and fat (Serdaroğlu et al., 2005). The increase in the thickness of the modified meatballs was the highest, followed by the increase for commercial and traditional meatballs respectively compared to the control. In addition, less reduction ($p<0.05$) occurred in the modified meatball diameter during cooking, compared to the other meatballs. This might be due to the ability of fibers to form highly viscous solutions; therefore, these fibers are used as thickeners in meat products (Jiménez-Colmenero et al., 2013). A greater increase in the thickness and less of a decrease in the diameter of the modified meatballs were also observed for 20% flour, compared to the control. Similar results were observed in low fat hamburger patties produced with different formulations of various wheat fibers (Mansour and Khalil, 1997).

The color values of the meatballs are given in Table 4. The *L**, *a** and *b** color values of the meatballs were significantly (p<0.05) different, but the last color was very similar depending on the flour source. Regarding the increase in doses of retrograded flour, while the *L** value of the meatballs decreased, the *a** and *b** values increased (p<0.05). These results show that the meatballs were more browned on cooking, as expected, with the increase of retrograded flour doses because of non-enzymatic reactions such as the Maillard reaction and caramelization. It was reported that the *a** and *b** values of prebiotic sausage formulated by β-glucan increase because of Maillard browning that leads to a more reddish-brown product (Amini Sarteshnizi et al., 2015). A reduction in the brightness of beef patties made with the addition of flaxseed flour was also reported (Bilek and Turhan, 2009).

Table 4. Color values of meatballs

	*L** (brightness)	*a** (redness)	*b** (yellowness)
Flour source			
Traditional	39.31^{a} ± 0.13	11.67*b* ± 0.04	20.21^{a} ± 0.35
Commercial	36.81^{b} ± 0.06	11.98^{ab} ± 0.15	20.57^{a} ± 0.16
Modified	37.05^{b} ± 0.45	12.32^{a} ± 0.04	18.17^{b} ± 0.14
Flour dose in modified meatballs			
0% (control)	39.57^{a} ± 0.07	11.17^{d} ± 0.04	17.04^{c} ± 0.05
5%	38.13^{ab} ± 0.11	11.81^{c} ± 0.06	18.79^{b} ± 0.01
10%	37.05^{ab} ± 0.45	12.32^{b} ± 0.04	18.17^{b} ± 0.14
15%	35.71^{bc} ± 0.16	12.67^{a} ± 0.03	18.60^{b} ± 0.28
20%	34.13^{c} ± 1.57	12.65^{a} ± 0.09	19.55^{a} ± 0.35

[a,b,c,d]Means with different online letters within the column indicating significant difference (p<0.05).

The textural properties of the meatballs are given in Table 5. Except for springiness (p<0.05, p<0.01), the textural properties were not significantly (p>0.05) affected by the flour source. The springiness of the traditional meatballs was significantly higher than that of the others. This might have been due to the bread crumbs having a naturally springy structure.

Table 5. Textural properties of meatballs

	Hardness (N)	Fracturability (N) (g)	Springiness	Cohesiveness	Gumminess	Chewiness
Flour source						
Traditional	0.028^{a} ± 0.00	0.027^{a} ± 0.00	0.502^{a} ± 0.01	0.876^{a} ± 0.02	0.025^{a} ± 0.00	0.013^{a} ± 0.00
Commercial	0.035^{a} ± 0.00	0.027^{a} ± 0.00	0.387^{c} ± 0.00	0.886^{a} ± 0.00	0.031^{a} ± 0.00	0.012^{a} ± 0.00
Modified	0.030^{a} ± 0.00	0.034^{a} ± 0.00	0.458^{b} ± 0.00	0.847^{a} ± 0.00	0.025^{a} ± 0.00	0.012^{a} ± 0.00
Flour dose in modified meatballs						
0% (control)	0.024^{c} ± 0.00	0.027^{a} ± 0.00	0.651^{a} ± 0.01	0.866^{a} ± 0.01	0.021^{a} ± 0.00	0.014^{a} ± 0.00
5%	0.027^{bc} ± 0.00	0.030^{a} ± 0.00	0.582^{b} ± 0.01	0.843^{a} ± 0.01	0.022^{a} ± 0.00	0.013^{a} ± 0.00
10%	0.030^{bac} ± 0.00	0.034^{a} ± 0.00	0.458^{d} ± 0.00	0.847^{a} ± 0.00	0.025^{a} ± 0.00	0.012^{a} ± 0.00
15%	0.033^{ba} ± 0.00	0.034^{a} ± 0.00	0.485^{cd} ± 0.01	0.747^{b} ± 0.04	0.025^{a} ± 0.00	0.012^{a} ± 0.00
20%	0.036^{a} ± 0.00	0.034^{a} ± 0.00	0.498^{c} ± 0.01	0.719^{b} ± 0.03	0.026^{a} ± 0.00	0.013^{a} ± 0.00

[a,b,c,d]Means with different online letters within the column indicating significant difference (p<0.05).

The addition of retrograded flour in the meatballs significantly ($p<0.05$) affected the hardness, springiness and cohesiveness of the meatballs with respect to textural properties. It was determined that the springiness decreased and hardness increased; these results might be due to the decreasing moisture content (Table 2) with increased doses of retrograded flour. And also, cohesiveness was decreased with an increase in flour doses, possibly from a decrease in the formation of hydrogen bonding because of less moisture content. It was reported that the hardness of control samples was less than the hardness of meat products with tomato and beetroot fiber but similar to the hardness of meat products with inulin (Cava et al., 2012). In another study, the springiness of goat meat patties decreased as the level of soybean paste increased due to soybean paste exhibiting good water-binding characteristics. In addition, the cohesiveness of meat patties with 15-25% soybean paste was lower than that of a control (Das et al., 2007). It was also observed that the addition of rice fiber in meatballs increased hardness but did not affect springiness and cohesiveness (Huang et al., 2005).

The sensory properties of the meatballs

The effects of different flour sources and the addition of retrograded flour on the appearance, color, odor, flavor, tenderness and overall acceptability scores of meatballs are given in Table 6. The appearance and flavor scores of the meatballs produced with retrograded flour were significantly ($p<0.05$) higher than those of traditional and commercial meatballs while other scores were the same for all meatballs. It was pointed out that cereal and peach fibers added to meat products resulted in better sensory scores in texture and taste parameters (Biswas et al., 2011). It was reported that the tenderness and overall acceptability scores of beef patties with 2% glutinous rice flour were higher than a control (Yi et al., 2012).

Table 6. Sensory scores of meatballs

	Appearance	Color	Odor	Flavor	Tenderness	Overall
Flour source						
Traditional	$6.50^{ab}\pm0.25$	$6.50^{a}\pm0.00$	$6.13^{a}\pm0.13$	$4.88^{b}\pm0.13$	$5.13^{a}\pm0.38$	$5.38^{a}\pm0.38$
Commercial	$5.94^{b}\pm0.19$	$6.19^{a}\pm0.06$	$6.26^{a}\pm0.13$	$5.75^{ab}\pm0.25$	$5.88^{a}\pm0.25$	$5.51^{a}\pm0.38$
Modified	$7.44^{a}\pm0.31$	$6.69^{a}\pm0.69$	$6.45^{a}\pm0.30$	$6.50^{a}\pm0.50$	$6.44^{a}\pm0.56$	$6.75^{a}\pm0.75$
Flour dose in modified meatballs						
0% (control)	$6.75^{ab}\pm0.25$	$6.69^{a}\pm0.44$	$5.69^{b}\pm0.19$	$6.00^{ab}\pm0.00$	$5.69^{ab}\pm0.44$	$5.82^{ab}\pm0.19$
5%	$6.44^{ab}\pm0.44$	$6.38^{a}\pm0.38$	$5.63^{b}\pm0.25$	$6.32^{a}\pm0.44$	$6.26^{a}\pm0.38$	$6.63^{ab}\pm0.38$
10%	$7.44^{a}\pm0.31$	$6.69^{a}\pm0.69$	$6.45^{ab}\pm0.30$	$6.50^{a}\pm0.50$	$6.44^{a}\pm0.56$	$6.75^{a}\pm0.75$
15%	$5.75^{b}\pm0.25$	$6.38^{a}\pm0.13$	$7.19^{a}\pm0.06$	$5.63^{ab}\pm0.38$	$5.38^{ab}\pm0.25$	$5.82^{ab}\pm0.32$
20%	$5.75^{b}\pm0.50$	$6.07^{a}\pm0.19$	$6.32^{ab}\pm0.32$	$4.76^{b}\pm0.13$	$4.25^{b}\pm0.25$	$5.07^{b}\pm0.32$

[a,b]Means with different online letters within the column indicating significant difference ($p<0.05$).

The sensory scores of meatballs apart from color were significantly affected ($p<0.05$) by the addition of retrograde flour. It was determined that meatballs produced with 10% retrograded flour had the highest sensory scores. The addition of more than 10% flour had a negative effect on sensory properties because appearance, color, flavor, tenderness and overall acceptability were lower than that of meatballs containing 10% flour. Accordingly, it is considered that the use of 10% retrograded flour is ideal to improve the sensorial values of meatballs in terms of the properties of the structure. Meatballs with 5, 10, 15 and 20% bran addition were produced, and it was determined that samples with 10% added corn bran had the highest overall acceptability scores (Yılmaz and Dağlıoğlu, 2003). It has been also reported that the suitable amount of dietary fiber added to low-fat meatballs is no more than 10% (Huang et al., 2005).

Conclusion

For the use of retrograded flour to produce meatballs, it was ensured that their properties with respect to chemical, physical and sensorial aspects resembled those of meatballs produced with bread crumbs and rusk flour. Retrograded flour can be used instead of bread crumbs and rusk flour because the properties of meatballs produced with retrograded flour are similar to those of the other meatballs. Additionally, retrograded flour including resistant starch as a prebiotic results in more uniform meatballs and has no food safety risk with respect to mold toxins. It is known that bread crumbs and rusk flour are generally produced from returned bakery products.

In conclusion, the use of 10% retrograded flour provides high quality and acceptable textural and sensory properties for meatballs and is suitable for consumer friendly and healthy meatballs.

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