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USE OF MAIZE, SOY AND RICE BREADCRUMBS IN THE FORMULATION OF THE GLUTEN FREE MEATBALLS

UDC 664.641.4 : 543.5

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The effect of replacing the wheat with the maize, soy and rice flour and breadcrumbs in the formulation of the gluten-free coating mixture for fried food products was investigated. Six different coating butters were prepared by mixing water and egg white with wheat (control), maize, soy and rice flour, as well as with the mixture of maize and soy flour (50:50) and maize and rice flour (50:50), respectively. Dry breadcrumbs from the previously baked wheat, maize, soy and rice bread were also prepared. Turkey nuggets, made from minced turkey breasts, were dipped in the prepared wet coating batters and breadcrumbs and deep-fried in the palm oil for 3 minutes. Sensory evaluation, colour determination, oil uptake and texture profile analysis (hardness, springiness cohesiveness, chewiness and resilience) of turkey nuggets were performed. In addition to that, textural properties of fried coating that was removed from nuggets were also determined. Results showed that only the addition of soy flour decreased the acceptability of nuggets. Replacing the wheat flour and breadcrumbs with that of maize and rice did not deteriorate the fried nuggets characteristics and some of the properties (colour, appearance and total sensory score) were even better when maize and maize/rice mixture were used. In conclusion, in order to benefit consumers with celiac disease and gluten intolerance, maize and rice flour could be used as an excellent replacement for wheat which is traditionally used in the formulation of the coating mixture for fried food products.

Key words: gluten-free meatballs, maize breadcrumbs, rice breadcrumbs, texture profile analysis, sensory evaluation

INTRODUCTION

Traditional Croatian meatballs are prepared from minced pork and beef, bread crumbs, and a mixture of various herbs and spices, including onion and black pepper.

The preparation of value-added meat products enables incorporation of various binders/extenders. These processes not only bring down the cost of production but also improve palatability and yield of products. Majority of the consumers prefer slight to

medium extended meat products compared to full-meat products. Fillers like starches, flours and potato increases the juiciness of the product due to their high water absorption [1]. Different flour types other than wheat can also be used as an optional ingredient. Further, enrobing of meat products provides advantages such as preserving the nutritive value, preventing moisture and weight loss, improving tenderness and juiciness. Breading on the fried product enhances texture, flavour and appearance of the product [2].

Flour functionality in batter and breading systems depends largely on the two major constituents of all flours, starch and protein. It is known that the main microstructural changes produced during frying includes starch gelatinization and protein denaturation [3]. Therefore, different flours with variable composition of starch and protein will have different influence on microstructure and their combination may also provide special effects [4, 5].

Rice flour is often used in batter systems since it is known to be a healthier alternative providing fewer calories [6]. It reduces oil absorption better than wheat flour although it is less effective as a thickening agent. Legumes are important ingredients of a balanced human diet in many parts of the world, due to their high protein contents. Soy flour based batters provides lower moisture loss and fat absorption compared to rice flour based batters [7, 8]. It was reported that replacing part of wheat flour with rice flour and soy flour enhanced the nutritive value due to the complementary nature of the amino acids in these raw materials [9, 10].

Since traditional meatballs in their composition contain wheat bread crumbs, there are not suitable for patients who suffer from celiac disease. Celiac disease is genetically based autoimmune condition that is characterized by intolerance to gluten, a component in wheat, barley, and rye which affects approximately 1% Americans and from 1 in 130 and 1 in 300 Europeans [11]. Because of the need for gluten-free products to meet market needs, this experiment was designed to determine the formulation of meatballs with satisfactory properties without wheat. The effect of replacing the wheat with the maize, soy and rice breadcrumbs in the formulation of the gluten-free meatballs were investigated. Four different formulations of meatballs were prepared by mixing the minced meat (pork and beef, 50 : 50) with 20% of wheat (control), maize, soy and rice breadcrumbs, eggs and spices, respectively.

MATERIALS AND METHODS

Material

Meatballs were prepared from minced lean pork and beef (50 : 50) with addition of 6% of egg, 6% of onion, 2.4% of salt, 0.2% of black pepper and with 20% of wheat (control), maize, soy and rice breadcrumbs. Dry breadcrumbs from the previously baked wheat, maize, soy and rice bread were prepared. The wheat, maize, soy and rice flours were purchased from local supermarket. Weight of each sample was checked to have a uniform range of 60 ± 1 g. Meatballs 80 mm in diameter and 25 mm thick were fried in

the pan on the sunflower oil for 5 minutes on both sides. Samples were fried at 180 °C in commercial bench-top deep-fat fryer (Moulinex, Bagnolet, France) containing 2.5 l of palm oil. Six nuggets were deposited in the frying oil each time. Samples were fried for 3 min.

Methods

Textural analysis (TPA). Texture profile analysis (TPA) tests were performed using a TA.XT2i SMS Stable Micro Systems Texture Analyzer (Stable Microsystems Ltd., Surrey, England). TPA test included double compression of whole meatball to 60% of their thickness with a cylindrical probe P 75.

For TPA tests force-time curves were recorded at across-head speed of 1 mms-1 and the recording speed was also 1 mms^{-1}. The following parameters were quantified [12]: hardness (g), the maximum force required to compress the sample, springiness (mm), the ability of the sample to recover its original form after the deforming force was removed and cohesiveness, the extent to which the sample could be deformed prior to rupture, chewiness (g.mm) which is calculated as gumminess x springiness and resilience which is the ratio of work returned by the sample as compressive strain is removed. TPA test were conducted one hour after frying.

Determination of colour. Colour measurements (*L**, *a**, and *b**values) were taken using a Hunter-Lab Mini ScanXE (A60-1010-615 Model Colorimeter, Hunter-Lab, Reston, VA, USA). The Hunter *L**, *a**, and *b** values correspond to brightness (0-100), greenness (-a) or redness (+a), and blueness (-b) or yellowness (+b), respectively. The colour measurements were performed at room temperature (20±2 °C).

Sensory analysis. A random 1-digit number was incorporated to identify the samples, and each panellist evaluated 6 treatment samples (1 nugget per treatment). The samples were evaluated using a 5- point hedonic scale for four properties (Appearance, Odour, Consistency and Taste). The category definitions were defined as 1 = dislike, 2= dislike moderately, 3 = neither like nor dislike, 4 = like moderately, 5 = like very much.

Data analysis. Three determinations for texture and six for colour parameters were measured from each sample. Experimental data were analyzed by the analysis of variance (ANOVA) and Fisher's least significant difference (LSD), with significance defined at $p < 0.05$. Statistical analysis was carried out with Statistica ver. 7.0 StatSoft Inc. Tulsa, OK. USA.

RESULTS AND DISCUSSION

Table 1. shows the effect of different breadcrumbs on textural properties of meatballs. There were not statistically significant differences between textural properties among the meatballs prepared with wheat, maize, soy and rice breadcrumbs except in springiness, cohesiveness and resilience of meatballs with rice breadcrumbs that had significantly lower values. The highest value of hardness had a sample with maize breadcrumbs.

These results were similar with those of Altunakar *et al*. [13].

Table 1. Texture profile analysis of meatballs with different breadcrumbs

Sample	Hardness(g)	Springiness	Cohesiveness	Chewiness	Resilience
Wheat	16228.3a ± 345.3	0.92ab± 0.01	0.89a ± 0.07	13374.3a ± 117.7	0.46abc ± 0.0
Maize	215717.4a± 375.7	0.93a ± 0.0	0.88ab ± 0.10	12774.9a ± 378.4	0.53a ± 0.03
Soy	16458.6a ± 524.3	0.92a ± 0.05	0.83b ± 0.02	12570.5a ± 222.8	0.48b± 0.05
Rice	18129.1a ± 990.9	0.88b ± 0.03	0.75c ± 0.05	119156a ± 398.5	0.43c ± 0.03

Values are means ± SD of three measurements. Values in the same column with different superscripts (a-c) are significantly different ($p < 0.05$).

The effect of breadcrumb types on the colour of deep-fat fried meatballs was examined in terms of L^*, a^* and b^* values (Table 2). Soy breadcrumbs was found to provide the darkest and most yellow colored meatballs which is in agreement with the results of Dogan *et al*. [14], who investigated the influence of soy batters on colour properties of chicken nuggets. This could be related to the high amount of protein in soy flour undergoing Maillard reactions. Relatively high L^* and b^* values for the sample with maize breadcrumbs could be related to higher carotenid content in maize flour. The wheat and the rice breadcrumb formulations gave a lighter and less yellow product.

Table 2. Instrumental colour measurement of meatballs with different breadcrumbs

Sample	L^*	a^*	b^*
Wheat	54.28c ± 2.34	4.85 ± 0.91	18.96b ± 0.75
Maize	59.33b ±1.43	4.65a ±1.12	19.51b ±1.93
Soy	61.18a ± 2.81	4.73a ±1.94	20.44a ± 3.91
Rice	58.22b ± 2.42	4.48a ± 0.62	19.16b ± 2.03

Values are means ± SD of six measurements.
Values in the same column with different superscripts (a-c) are significantly different ($p < 0.05$).

Table 3. Sensory analysis of meatballs with different breadcrumbs

Sample	Appearance	Odour	Consistency	Taste	Total score
Wheat	4.80a ± 0.63	5.00a ± 0.48	4.80a ± 0.58	4.40a ± 0.58	4.75a ± 0.38
Maize	4.60a ± 0.00	5.00a ± 0.58	4.40a ± 0.00	4.60a ± 0.58	4.65a ± 0.29
Soy	3.40b ± 0.85	4.60b ± 0.85	4.20a ± 0.00	3.00b ± 0.82	3.80b ± 0.38
Rice	4.60a ± 0.58	5.00a ± 0.96	4.40b ± 0.58	4.20a ±1.15	4.55a ± 0.69

Values are means ± SD of three measurements. Values in the same column with different superscripts (a-c) are significantly different ($p < 0.05$).

There were not statistically significant differences between sensory properties among the meatballs prepared with wheat, maize and rice breadcrumbs (Table 3). Samples with soy breadcrumbs had the lowest score for all examined sensory parameters.

CONCLUSIONS

The textural properties of examined meatballs were quite similar. Sensory analysis showed that the panellists gave the highest score for overall quality to meatballs with addition of wheat, maize and rice breadcrumbs. Only the addition of soy breadcrumbs decreased the acceptability of meatballs. In order to benefit consumers with celiac disease and gluten intolerance, maize and rice breadcrumbs could be used as an excellent replacement for wheat that is traditionally used in the formulation of the meatballs.

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