QUALITY CHARACTERISTICS OF MEATBALLS PRODUCED WITH JERUSALEM ARTICHOKE POWDER

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Abstract – The objective of this study was to investigate the effects of Jerusalem artichoke powder (JAP) utilization in meatballs on physical, technological and sensory quality. 4 treatment groups of meatballs were prepared as follows: CG: meatballs formulated with 5% breadcrumb and grilled, CO: meatballs formulated with 5% breadcrumb and oven-cooked, JG: meatballs formulated with 5% JAP and grilled, JO: meatballs formulated with 5% JAP and oven-cooked. No significant differences were recorded in pH values of meatballs. The highest fat and moisture retention was recorded in GC while the lowest was in CO samples (p<0.05). In JG and JO samples fat and moisture retention, and water-holding capacity remained similar to control groups, while cook loss and diameter changes were the highest in JO samples (p<0.05). No significant differences were recorded in L* values. a* and b* values were the highest in GC and lowest in JG group (p<0.05). The highest juiciness and texture scores were recorded in JG samples (p<0.05). There was no significant difference in colour, odour, flavour and general acceptability scores of treatments. The results showed that JAP utilization in meatballs were not as effective as inulin utilization, but could be promising to improve sensory quality.

Key Words – dietary fiber, inulin, Jerusalem artichoke, meat product

I. INTRODUCTION

Jerusalem artichoke (JA) (*Helianthus tuberosus*) is a natural raw material for the derivation of a number of functional food ingredients such as inulin, oligofructose and fructose [1]. JA is also a good source of minerals (calcium, iron, selenium, potassium, phosphorus) and vitamins (vitamin B complex, vitamin C and β-carotene) [2]. Today, there is a growing interest in utilization of prebiotics (inulin), dietary fiber and fiber-rich ingredients in the formulation of fresh, cooked and fermented meat products [3]. The most recent studies have reported the advantages of inulin incorporation in meat products, like reducing/replacing animal fat, enhancing texture, technological and sensory characteristics, while increasing dietary fiber content and functionality [4-8]. However, no studies have reported on JA utilization in meat product formulations so far. Since JA is an economical source of inulin, it is important to investigate the effects of added JA in meat products in terms of functionality and overall quality. This study aimed to determine the utilization opportunity of dried JA powder on some quality parameters of meatballs.

II. MATERIALS AND METHODS

Jerusalem artichoke powder (JAP) was produced from fresh and non-damaged tubers. The tubers were obtained from a local producer in İzmir, washed with tap water, peeled and sliced into 0.2 mm thickness. Slices were air-dried at 55-65°C for 5-8 hours. The dried slices were ground through a hammer mill (Brook Crompton, UK) and sieved through 0.5 mm. JAP was stored in glass jar prior to meatball production.

Meatballs are prepared with lean beef as boneless rounds and beef fat, supplied from a local market. Lean and fat were minced through a 3 mm plate grinder and mixed with 1,5% salt. The formulations of the treatments are presented in Table 1. Control batch was prepared with 5% bread crumb, while other treatment was prepared with 5% JAP. Ingredients were mixed and meatball portions (9.5 cm diameter and 1.5 cm thickness) were obtained by using a metal shaper. Control and JAP samples were heat-treated either in electric oven or electric grill until the internal temperature had reached 78±2°C. Samples were cooled to room temperature and stored at +4°C prior to analysis.

Table 1 Formulation of meatball treatments

Treatments*	Beef (g)	Fat (g)	Salt (g)	Bread crumb (g)	Jerusalem artichoke powder (g)
CG	1000.0	200.0	15.0	50.0	-
CO	1000.0	200.0	15.0	50.0	-
JG	1000.0	200.0	15.0	-	50.0
JO	1000.0	200.0	15.0	-	50.0

* CG: Meatballs formulated with 5% breadcrumb and grilled, CO: Meatballs formulated with 5% breadcrumb and oven-cooked, JG: Meatballs formulated with 5% JAP and grilled, JO: Meatballs formulated with 5% JAP and oven-cooked.

Moisture%, protein%, ash% [9] and fat% [10] content of the samples were determined. pH values of cooked meatballs were measured from three different points by using a pH-meter (WTW pH 330i/SET, Germany) penetration probe. Fat retention was calculated according to Murphy *et al.* [11] by the equation below:

Fat retention (%) = (Final fat content in meatball)*(Final weight) / (Initial fat content in meatball)*(Initial weight) *100

Moisture retention was calculated according to El-Magoli *et al.* [12] as follows:

Moisture retention (%) = (Cooking yield %)*(Moisture content of cooked meatball) / 100

Water-holding capacity (WHC) was determined according Hughes *et al*. [13]. 10 g raw meatball sample was weighed (W_1), placed into glass jars and heated in 90°C water bath for 10 minutes. After cooling, the samples were centrifuged at 1400 rpm for 15 minutes and weighed again (W_2). WHC was calculated from the equation below:

% WHC= 1- T/M * 100 = 1- (W1-W2)/M*100 (T: Water loss after heating and centrifugation, M: Total moisture content of the sample)

Cooking yield was determined according to Murphy *et al.* [11] by measuring the difference in the weight before and after cooking and calculated as follows:

Cooking yield (%) = (Weight of cooked meatballs) / (Weight of uncooked meatballs) * 100

Diameter changes (%) were calculated according to Serdaroğlu and Değirmencioğlu [14] as follows:

Diameter reduction (%) = (Initial weight of meatball-Final weight of meatball) / (Initial weight of meatball) * 100

The surface color of the samples were measured by using a portable colorimeter (CM-2600d/2500d, Konica Minolta, Germany) from four different points and expressed as Hunter L* (lightness), a* (redness), b* (yellowness). Sensory evaluation of meatballs was performed by application of a ranking test with 10 volunteered panelists. Totally 4 different samples were randomly coded and served warm to panelists. Samples were subjected to evaluation for appearance, colour, odour, flavour, juiciness, texture and overall acceptability and were ranked by panelists in increasing order (least-1 to most-4). Water and bread were served for cleaning the mouth between samples. The data was analyzed statistically by one way ANOVA using the SPSS for Windows statistical package program version 21.0, at a confidence interval of 95%.

III. RESULTS AND DISCUSSION

Chemical compositions of meatball treatments are presented in Table 1. No significant differences were recorded in moisture content. JO samples had the highest protein and fat content ($p<0.05$).

Table 1 Chemical composition of meatball samples

Treatments	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
CG	61.87±0.82	23.80±0.67^{b}	12.80±1.03^{b}	1.91±0.19^{ab}
CO	62.09±1.22	22.80±0.33^{c}	9.00±0.33	2.77±0.49^{a}
JG	62.04±1.39	24.32±0.23^{b}	9.91±0.89	2.19±0.77^{ab}
JO	61.60±1.06	25.96±1.24^{a}	12.11±1.19^{a}	1.47±0.40^{b}

Data are presented as the mean values of 3 replications ± SD. abc: Means with the different letter in the same column are significantly different ($p<0.05$).

pH, fat and moisture retention of meatballs are presented in Table 2. No significant differences were recorded in pH values of the samples, which ranged between 5.82-5.87. The highest fat retention % was recorded in CG group, while the lowest was in CO ($p<0.05$). It was seen that in control groups, oven cooking caused a decrement in fat retention, while in JAP groups the values were similar. GC samples also had the highest moisture retention (%) ($p<0.05$). In oven-cooked groups (CO and JO), moisture retentions were similar to each other.

Table 2 pH, fat retention, and moisture retention of meatball samples

Treatments	pH	Fat retention (%)	Moisture retention (%)
CG	5.87±0.28	72.19±17.48^{a}	55.52±4.02^{a}
CO	5.82±1.47	41.78±10.62^{b}	45.19±1.05^{b}
JG	5.86±1.54	54.52±9.37^{ab}	46.15±2.98^{b}
JO	5.87±2.14	54.01±4.58^{ab}	43.66±1.51^{b}

Data are presented as the mean values of 3 replications ± SD. ab: Means with the different letter in the same column are significantly different ($p<0.05$).

Water-holding capacity (WHC), cooking yield, and diameter changes of meatballs are presented in Table 3. WHC results showed that, in grilled samples JAP tend to decrease WHC, while in oven-cooked samples the values were similar. Cooking yield was the highest and diameter changes were the lowest in CG group ($p<0.05$). The results showed that compared to grilled samples with JAP, control grilled samples with breadcrumb were more effective to hold water and providing water retention upon cooking. However, in oven-cooked samples the results were similar to each other. In various studies, inulin had a promising effects on technological quality of meat products. In minced meat, inulin addition increased emulsion stability, in terms of increasing fat and water retention [7]. In pork, inulin usage for fat substitution reduced cook loss [4] and increased stability [8].

Table 3 Water-holding capacity, cooking yield and diameter changes of meatball samples

Treatments	WHC (%)	Cooking yield (%)	Diameter changes (%)
CG	95.82±0.27^{a}	89.79±7.47^{a}	10.21±7.47^{b}
CO	95.10±0.89^{ab}	72.77±0.44^{b}	27.23±0.44^{a}
JG	94.69±0.55^{b}	74.34±3.17^{b}	25.66±3.17^{a}
JO	94.94±0.27^{ab}	70.87±1.32^{b}	29.13±8.60^{a}

Data are presented as the mean values of 3 replications ± SD. ab: Means with the different letter in the same column are significantly different ($p<0.05$).

L*, a* and b* values of meatballs could be seen in Table 4, where the values were between 26.06-31.15, 4.20-5.49, and 4.88-6.74, respectively. No significant differences were recorded in L* values. a* and b* values were highest in GC and lowest in JG group ($p<0.05$). Therefore, it could be concluded that in grilled samples JAP tend to decrease redness and yellowness. In oven-cooked samples, the values were similar. Inulin was stated to improve colour in pork emulsions [4]. In fermented sausages, inulin increased L* and decreased a* values [15]. However, it did not change colour parameters in Chinese sausages [16]. Therefore, the effect on colour could show alterations depending on the kind of meat product and processing applications.

Table 4 Colour (L*, a*, b*) of meatball samples

Treatments	L*	a*	b*
CG	31.15±4.46	5.39±0.29^{a}	6.74±0.98^{a}
CO	30.44±2.73	5.49±0.46^{a}	6.23±0.50^{ab}
JG	26.06±1.73	4.20±0.63^{b}	4.88±0.79^{b}
JO	28.03±2.84	4.66±0.36^{ab}	5.69±0.88^{ab}

Data are presented as the mean values of 3 replications ± SD. ab: Means with the different letter in the same column are significantly different ($p<0.05$).

Sensory evaluation results are presented in Table 5. Appearance score was the lowest in CO group ($p<0.05$). There was no significant difference in colour, odour, flavour and general acceptability scores between the meatball groups. The highest juiciness and texture scores were recorded for JG ($p<0.05$). From this result, it could be concluded that JAP had a promising effect on improving mouthfeel and chewing parameters in grilled meat products. In previous studies, sensory quality was improved with inulin utilization in various meat products [5, 8, 17].

Table 5 Sensory evaluation scores of meatball samples

Treatments	Appearance	Colour	Odour
CG	3.10±0.74^{a}	2.70±0.95	2.80±1.14
CO	2.00±1.25^{b}	1.90±1.29	2.20±1.03
JG	2.30±1.16^{ab}	2.80±1.14	2.40±1.35
JO	2.60±1.17^{ab}	2.60±1.07	2.60±1.07

Treatments	Juiciness	Flavour	Texture	General acceptability
CG	2.90±0.88[a]	2.50±1.18	2.80±1.14[ab]	2.40±1.17
CO	1.80±0.92[b]	2.30±1.16	2.30±1.16[ab]	2.40±1.35
JG	3.30±0.95[a]	2.80±1.14	3.00±0.82[a]	2.40±1.17
JO	2.00±1.15[b]	2.40±1.17	1.90±1.20[b]	2.80±0.92

Data are presented as the mean values of 10 replications ± SD. ab: Means with the different letter in the same column are significantly different ($p<0.05$).

IV. CONCLUSION

The results of the study showed that although JAP addition to meatballs showed similar effects compared to control samples with breadcrumb in fat and moisture retention and water-holding capacity, control samples were more effective in reducing cook loss and diameter changes. L* values were similar in samples, where JAP in grilled samples lead decrements in a* and b* values. Sensory evaluation showed that JAP had a promising effect in improving juiciness and texture scores. Further studies and comprehensive analysis should be performed regarding addition of JAP to improve quality of meat products.

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