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ORIGINAL ARTICLE

Effects of xanthan, guar, carrageenan and locust bean gum addition on physical, chemical and sensory properties of meatballs

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Abstract This study evaluated the effects of xanthan gum, guar gum, carrageenan and locust bean gum on physical, chemical and sensory properties of meatballs. Meatball samples were produced with three different formulations including of 0.5, 1, and 1.5% each gum addition and gum added samples were compared with the control meatballs. Physical and chemical analyses were carried out on raw and cooked samples separately. Moisture contents of raw samples decreased by addition of gums. There were significant decreases ($p<0.05$) in moisture and fat contents of raw and cooked meatball samples formulated with gum when compared with control. Ash contents and texture values increased with gum addition to meatballs. Meatball redness decreased with more gum addition in raw and cooked meatball samples, which means that addition of gums resulted in a lighter-coloured product. According to sensory analysis results, locust bean gum added (1%) samples were much preferred by the panelists.

Keywords Meatball · Xanthan · Guar · Carrageenan · Locust bean · Quality characteristics

Introduction

Many researchers have been done on applications of various edible gum-hydrates in meat products as meat binders, texture stabilizers and fat substitutes. When hydrocolloids are used in low-fat meat formulation, a certain amount of water (around 10–20% depending on product type) needs to be added. Extra water addition provides an environment for a desirable texture by interacting with hydrocolloids. However, water addition might result in decreased storage stability of these products due to higher water activity (Egbert et al. 1992a, b; Hsu and Chung 1999; Hsu and Chung 2000; Modi et al. 2009).

During the manufacture of low-fat meat products, fat may be partly replaced by water and non-meat ingredients such as dietary fiber (Garcia et al. 2002; Verma and Banerjee 2010), carrageenan (Hsu and Chung 2001), rice bran (Choi et al. 2007), wheat bran (Yılmaz 2005), rye bran (Yılmaz 2004a), oat bran (Yılmaz and Dağlıoğlu 2003) starch (Hughes et al. 1998), and maltodextrins (Crehan et al. 2000), which improve the rheological properties and stability of the product.

Gums have wide applications in the food industry and are used as stabilizing, suspending, thickening, gelling and emulsifying agents and to give products their desired textural properties, especially when little fat is present in the formulation (Simeone et al. 2004). The functions of gums like improving quality of products, supporting the usage of new technologies and practicing of production process equipments in these technologies are the important reasons of this wide application area.

Xanthan gum is a microbial polysaccharide obtained by the bacteria *Xanthomonas campestris*, and has excellent rheological properties. The major advantages of xanthan gum as a commercial polymer include high yield of production, high viscosity solutions at low gum concentrations, high pseudoplastic flow behavior, and stability over wide ranges of pH, temperature and salt concentration. Industrial production of xanthan is important for evaluation of the industrial waste products economically and also for addition to economy (Arıcı et al. 2007).

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Locust bean gum is obtained from carob bean (*Ceratonia siliqua*), a Mediterranean tree. This gum is soluble in cold water and does not form a gel. Maximum viscosity is obtained at 95 °C. Synergistic effects appear when it is mixed with other hydrocolloids. Locust bean and xanthan gum do not form gels on their own they only increase viscosity. However, addition of both compounds together produces, after heating and cooling a very elastic gel (Dea 1979; Pedersen 1979; Symes 1980).

Carrageenan (E409) is a water soluble polysaccharide produced from red seaweeds (*Rhodophyceae*). It is hydrocolloid consisting of potassium, sodium, magnesium and calcium sulphate esters of galactose and 3,6-anhydrogalactose (AG) copolymers (Bloukas et al. 1997; Cofrades et al. 2000; van de Velde 2008). It is widely used in the food industry for a broad range of applications because of its water binding, thickening and gelling properties. In the meat industry, carrageenan is used as a gelling agent in canned meats and petfoods and it allows reduction in fat content in comminuted meat products like frankfurters (Candoğan and Kolsarici 2003a, b). In cooked sliced meat products carrageenan is used to improve moisture retention, cooking yields, slicing properties, mouth-feel and juiciness (Imeson 2000).

Guar gum is water-soluble non-ionic polysaccharide from the ground endosperm of guar (*Cyamopsis tetragonoloba*) seeds. Guar gum has a main chain of (1–4)-linked b-D-mannopyranosyl units, bearing single a-D-galactopyranosyl units attached to O-6 of the main-chain units (Whistler and BeMiller 1997). Guar gum is widely used in a variety of industrial applications because of its low cost and its ability to produce a highly viscous solution even at low concentrations. The high viscosity of guar gum solutions arises from the high molecular weight of guar gum (up to 2 million and further) (Vijayendran and Bone 1984)

The aim of this study is to investigate the effect of adding different levels of xanthan gum guar gum, carrageenan and locust bean gum on physical, chemical and sensory properties of meatballs.

Material and methods

Xanhtan gum, guar gum, locust bean gum and carrageenan were added in to the meatball samples and each gum was incorporated at the level of 0.5, 1, and 1.5%, respectively. Meatball samples were produced according to following traditional recipe. The veal (including 20% fat) was ground, and different seasonings (ground blackpepper 0.1%, red pepper 2% and cumin 0.4%) and some other ingredients (onion 3%, garlic 0.5%, and salt 2%) were added to the ground veal. The mix was kneaded for 15 min by hand and the meatball dough obtained was divided into thirteen equal portions. Analyses were conducted as 3 replications and totally 13 meatball samples were analyzed including control sample plus gum added 12 samples. Physical and chemical analyses were carried out on raw and cooked samples separately. Each portion was kneaded for additional 15 min to obtain homogeneous doughs. Meatball doughs were stored in a cold room (4 °C) for one day, and then shaped into 2 cm diameter meatballs with a weight of 18–20 g before cooking. Raw meatball samples separated for analysis. The meatball samples were cooked in preheated (160 °C) electric grill and cooked 3 min on one side, turned over and cooked for a further 3 min.

Moisture, protein, fat, ash contents and pH measurements were measured as described by AOAC (1990).

The color of the meatballs were measured using a DP-900 D25 Aoptical Sensor Reston (Virginia, USA), which was used to determine Commission International de l'Eclairage (CIE) *L* (lightness), *a* (redness), and *b* (yellowness) values.

Warner-Bratzler shear-force (WBS) was determined using an Instron Universal Testing Machine (Model Series IX; Instron Co., Norwood, MA, USA) equipped with a Warner-Bratzler shearing device, where the WBS is used as an indicator of meatball firmness. Six cores (1.3 cm diameters), parallel to the longitudinal orientation of the meatball samples, were taken from each meatball. The samples were sheared perpendicular to the long axis of the core. The mean WBS force value for each steak was used for analysis.

Samples were weighed before and after cooking. Total weight loss in the meatballs after cooking was expressed as weight losses.

Sensory evaluation was conducted according to the testing procedures of AMSA (1978) and IFT (1985). Meatball samples were cooked to 80 °C internally and were served in random order at a temperature of approximately 60 °C to a trained consumer panel of 11 volunteers from the food engineering department. Samples were evaluated for firmness (9, extremely firm; 1, extremely soft), flavour intensity (9, extremely strong; 1, extremely weak to unpleasant), juiciness (9, extremely juicy; 1, extremely dry) overall palatability (9, palatable; 1, unpalatable) using a nine-point scale. Each attribute was discussed and tests were initiated after panelists were familiarized with the scales.

The data obtained from three replications were analyzed by ANOVA using the SPSS statistical package program, and differences among means were compared using the Duncan's multiple range test (Soysal 1992).

Results and discussion

Moisture The chemical compositions of the meatballs are shown in Table 1. The differences in moisture, protein, fat,

Table 1 Physicochemical composition of gum added and control meatball samples (n=3)

	Xanthan gum			Guar gum			Carrageenan gum
	0.5%	1%	1.5%	0.5%	1%	1.5%	0.5%
Raw meatball							
pH	6.9±0.05^{abc}	6.7±0.01^{c}	6.8±0.01^{bc}	6.9±0.20^{abc}	6.8±0.01^{abc}	6.9±0.32^{ab}	6.9±0.21^{abc}
Moisture (%)	54.8±1.32^{e}	55.3±0.85^{d}	54.0±0.76^{h}	54.6±0.30^{efg}	54.0±2.42^{h}	53.2±1.05^{j}	55.9±1.86^{c}
Protein (%)	19.0±0.52^{ef}	19.0±0.34^{def}	19.3±0.09^{d}	18.4±0.52^{g}	20.0±0.43^{c}	19.2±0.35^{de}	18.9±0.61^{f}
Fat (%)	19.0±1.04^{b}	18.8±0.59^{bc}	17.6±0.52^{e}	19.0±2.76^{b}	18.5±1.46^{cd}	18.4±1.16^{cd}	18.3±1.04^{d}
Ash (%)	1.9±0.09^{abc}	1.9±0.77^{abc}	1.9±0.40^{abc}	1.8±0.15^{bc}	1.8±0.01^{bc}	1.8±0.00^{abc}	1.8±0.44^{bc}
Hunter L	37.8±2.49	36.7±1.46	38.2±2.10	38.6±3.80	35.4±0.59	37.2±0.35	37.7±1.46
a	5.0±0.15^{c}	5.13±0.44^{c}	4.5±0.09^{d}	4.2±0.01^{e}	4.5±0.02^{d}	4.3±0.02^{e}	5.4±0.10^{b}
b	11.2±0.75^{c}	10.8±0.68^{de}	11.3±0.65^{c}	11.5±0.23^{b}	10.4±0.77^{f}	10.9±0.44^{d}	11.2±0.21^{c}
Texture (g)	74.4±2.37^{ı}	86.5±1.73^{g}	95.1±1.41^{e}	79.9±1.47^{h}	92.0±1.05^{f}	95.1±1.05^{e}	93.6±3.20^{ef}
Cooked meatball							
pH	6.8±0.03^{a}	6.8±0.08^{ab}	6.7±0^{b}	6.8±0.01^{a}	6.8±0.01^{a}	6.81±0.01^{a}	6.9±0.01^{a}
Moisture (%)	51.8±1.54^{def}	51.3±0.43^{def}	50.5±0.60^{f}	54.0±1.11^{ab}	51.6±0.31^{def}	52.6±2.54^{bcd}	54.6±5.30^{a}
Protein (%)	20.8±1.25^{f}	21.7±2.32^{cde}	22.0±2.77^{bcd}	18.3±0.54^{g}	23.1±0.42^{a}	20.1±1.58^{f}	20.7±3.22^{f}
Fat (%)	17.6±0.37^{bc}	17.3±0.01^{de}	16.9±1.10^{f}	17.4±1.22^{cd}	17.4±4.18^{de}	17.2±0.05^{e}	17.7±0.80^{b}
Ash (%)	1.9±0.02^{ef}	1.9±0.01^{def}	2.0±0.01^{cde}	2.0±0.04^{bcde}	2.1±0.05^{abcd}	2.1±0.01^{abcd}	2.0±0.02^{abcd}
Cooking loss (%)	20.1±3.22b	20.0±2.10^{b}	18.4±2.92^{c}	20.7±2.55^{b}	18.8±1.46^{c}	17.7±1.40^{d}	20.2±4.55^{b}
Hunter L	25.1±2.48^{d}	24.7±3.80^{d}	21.2±2.64^{f}	24.4±2.76^{d}	23.3±1.04^{e}	27.1±1.29^{c}	28.9±2.93^{ab}
a	2.9±0.45^{de}	2.7±1.70^{fg}	3.2±1.76^{c}	2.1±2.25^{j}	2.6±0.38^{fgh}	2.7±0.01^{ef}	2.3±0.17^{ıj}
b	8.9±1.25^{d}	8.4±1.05^{e}	7.5±2.33^{g}	7.4±1.46^{h}	7.3±0.45^{ı}	9.1±2.25^{c}	8.9±1.75^{d}
Texture (g)	85.2±5.25^{h}	96.6±6.05^{g}	110.1±3.22^{d}	80.7±4.15^{ı}	96.1±2.84^{g}	108.5±2.95^{e}	108.6±5.12^{de}

	Carrageenan gum		Locust bean gum			Control
	1%	1.5%	0.5%	1%	1.5%	
Raw meatball						
pH	6.9±0.10^{a}	6.8±0.02^{abc}	6.8±0.40^{abc}	6.9±0.21^{abc}	6.8±0.05^{abc}	6.8±0.30^{bc}
Moisture (%)	56.8±0.05^{b}	54.4±0.48^{g}	54.5±0.61^{fg}	53.6±0.71^{ı}	54.7±0.45^{ef}	58.3±1.89^{a}
Protein (%)	21.1±1.10^{a}	19.1±1.12^{def}	20.8±0.38^{b}	18.1±0.50^{gh}	18.1±0.25^{h}	18.2±0.28^{g}h
Fat (%)	17.8±0.55^{e}	16.6±0.48^{f}	19.10±0.65^{ab}	17.8±0.75^{e}	16.8±0.74^{f}	19.4±0.65^{a}
Ash (%)	1.8±0.01^{abc}	1.8±0.02^{abc}	1.9±0.01^{abc}	1.9±0.03^{abc}	1.9±0.40^{abc}	1.8±0.02^{bc}
Hunter L	41.2±1.35	36.6±0.85	38.2±1.46	36.4±0.55	37.9±1.32	36.1±3.25
a	4.3±0.12^{e}	4.6±0.35^{d}	3.8±0.01^{f}	4.6±0.02^{d}	4.2±0.00^{e}	5.8±1.05^{a}
b	12.7±0.18^{a}	10.8±1.00^{de}	11.7±1.10^{b}	10.6±0.55^{ef}	11.2±0.61^{c}	11.2±0.45^{c}
Texture (g)	101.8±3.86^{c}	112.6±4.65^{b}	99.5±3.70^{d}	100.3±2.35^{cd}	120.6±2.85^{a}	74.7±2.46ı
Cooked meatball						
pH	6.9±0.00^{a}	6.8±0.01^{ab}	6.8±0.01^{a}	6.9±0.00^{a}	6.9±0.02^{a}	6.9±0.07^{a}

Table 1 (continued)

	Carrageenan gum		Locust bean gum			Control
	1%	1.5%	0.5%	1%	1.5%	
Moisture (%)	52.9±0.43^{bcd}	54.0±1.41^{ab}	53.4±0.22^{abc}	51.0±0.88^{ef}	51.4±2.68^{def}	52.2±1.04^{cde}
Protein (%)	21.3±1.80^{def}	22.1±2.05^{abc}	21.0±1.08^{ef}	20.9±1.85^{ef}	22.8±1.70^{ab}	21.3 d±2.38^{ef}
Fat (%)	16.9±1.42^{f}	16.4±4.62^{g}	17.4±1.21^{de}	16.6±0.58^{g}	15.7±0.43^{h}	18.5±0.60^{a}
Ash (%)	2.1±0.05^{abc}	2.1±0.06^{abc}	2.1±0.05^{abcd}	2.2±0.03^{ab}	2.2±0.01^{a}	1.8±0.02^{f}
Cooking loss (%)	19.4±3.76^{bc}	18.7±0.05^{c}	22.0±1.09^{ab}	21.5±2.33^{ab}	20.4±2.87^{b}	23.3±2.15^{a}
Hunter L	24.4±1.44^{d}	28.3±0.82^{b}	18.3±1.32^{g}	26.3±1.12^{c}	29.4±2.34^{a}	26.8±2.42^{c}
a	3.5±0.25^{b}	3.7±0.02^{ab}	3.1±0.07^{cd}	2.4 h±0.35^{i}	2.5±1.32^{ghi}	3.7±1.15^{a}
b	9.4±0.05^{b}	9.8±1.10^{a}	6.1±1.22^{j}	8.1±0.75^{f}	9.4±0.76^{b}	9.4±0.08^{b}
Texture (g)	115.5±2.22^{c}	120.1±2.85^{b}	105.0±3.86^{f}	114.1±1.76^{c}	130.4±5.02^{a}	85.9±4.37^{h}

$^{a–l}$ Means within a row with different letters are significantly different ($P<0.05$)

and ash contents of the various meatballs were statistically significant ($p<0.05$). Raw meatball samples had a moisture content ranging from 53.2 to 58.3%. The moisture content was higher in samples containing gum than in the control. On the other hand the raw meatballs produced with the addition of 1.5% guar gum had the lowest ($P<0.05$) moisture content. The moisture contents of the samples decreased with more gum addition. Similar findings have been reported previously for various types of meat product, such as meatballs (Yılmaz and Dağlıoğlu 2003; Yılmaz 2004a, 2005; Yaşarlar et al. 2007) frankfurters (Hughes et al. 1997; Cengiz and Gokoglu 2005; Yılmaz 2004b; Yoo et al. 2007) beef steak (Jimenez-Colmenero et al. 2003), and breakfast sausages (Mittal and Barbut 1993). Significant differences were detected between the moisture contents of the raw and cooked meatballs. Cooked meatball samples had a moisture content ranging from 50.5 to 54.6%. Meatballs with added carrageenan have higher moisture during cooking than meatballs with other gums. Our results are disagreement with those reported by Ulu (2006). All meatball samples were within the Turkish Uncooked Meatball Standard limits (TSE 1992) in respect to moisture content. According to this standard, all meatballs are allowed up to the 65% moisture content.

Protein The protein levels of raw meatball samples with added gum ranged from 18.1% to 21.1% with significant difference among the different formulations ($p<0.05$). The lowest protein content was 18.1% for locust bean gum added (1%) meatball. Cooked meatball samples exhibited protein contents higher than raw meatball samples. Results clearly showed that cooking increased protein and ash content and decreased fat and moisture contents. The protein contents of all meatballs were within the limits of Turkish Uncooked Meatball Standard. Similar results were reported by Hsu and Yu (1999), Yılmaz and Dağlıoğlu (2003) and Ulu (2006).

Fat content The fat contents of the raw and cooked meatball samples were given in Table 1. The moisture content of meatballs containing gum was lower than those without added gum, and the addition of gum also significantly reduced the fat content. The most effective method in lowering calorie levels is to reduce the fat content in meat products. Gum addition at the level of 1.5% resulted in a significant ($p<0.05$) reduction in the fat content. Therefore, the highest fat content was obtained from the control meatballs but the values for all samples were within the limits of Turkish Uncooked Meatball Standard. Yılmaz (2004a) and Ulu (2006) reported similar results in the meatball samples. These results agree with those reported by Yang et al. (2007) and Garcia et al. (2002) who reported significantly decreased fat contents for pork sausages and dry fermented sausages with added dietary fiber to reduce the fat content.

Ash content Results of statistical analyses indicated that ash contents of the samples were significantly ($p<0.05$) affected by gum addition. Ash contents increased with more gum addition. The highest value was obtained in 1.5% of locust bean gum added samples and the lowest in the raw and cooked control meatballs which exhibited ash contents of 1.8% and 1.9%, respectively. Similar results were reported by Yılmaz and Dağlıoğlu (2003) and Ulu (2006).

Colour Table 1 shows the Hunter L (lightness), a (redness) and b (yellowness) color values of meatball samples. Carrageenan added samples (1%) had the highest ($p<0.05$) L and b values. Results of statistical analyses indicated that Hunter L, a, and b values were significantly ($p<0.05$) affected by the addition of gum. Meatball lightness, as measured by Hunter-L value, increased with more gum addition. Highest L values (lightness) were observed for 1.5% addition locust bean gum in cooked meatball samples. Similar results were reported by Yılmaz (2004a). Andrés et al. (2006) reported that adding whey protein content rate to low fat chicken sausages resulted in increased lightness.

Values for a (redness) also showed significant difference ($p<0.05$) among the various levels of gum and starting at 5.8 in the control group ($p<0.05$), meatball redness generally decreased with more gum addition in raw and cooked meatball samples, which means that addition of gums resulted in a lighter-coloured product. Similar results were reported by Yılmaz and Dağlıoğlu (2003) and Lin and Huang (2003). This might be as a result of carotenoid pigments of gums. Hughes et al. (1997) and Yılmaz and Dağlıoğlu (2003) obtained similar results in oat fibre added of frankfurters and meatballs in respect to yellowness. The b value of the samples increased with more carrageenan gum addition ($p<0.05$). Candoğan and Kolsarici (2003a) reported that no significant effect of carrageenan addition on b value was observed as compared with the control frankfurters. Our results were disagreement with Candoğan and Kolsarici (2003a) for low fat frankfurters.

pH The pH values of raw and cooked meatball samples are shown in Table 1. Although the pH of both uncooked and cooked meatball samples formulated with different gum levels were ranged from 6.7 to 6.9 the pH revealed a slight decrease when the meatball samples were cooked. Bradford et al. (1993) also reported a reduction in pH of pork sausages formulated with 0.4% carrageenan. Candoğan and Kolsarici (2003a) reported that there was no significant effect of carrageenan and pectin addition on the pH of frankfurters.

Cooking loss The differences among the weight losses of the meatballs were significant ($P<0.05$). High fat meatballs had the highest weight losses (Table 1). Cooking loss of the high-fat control (19.4%) was higher than the gum added meatball samples. Roth et al. (1997) also reported that high-fat sausages exhibited greater cook loss than low-fat sausages. The lowest weight loss was obtained from the 1.5% guar gum added samples. The highest cooking loss was from the control meatball sample, due to the high loss of fat and moisture during cooking. The cooking losses of the samples decreased with gum addition. Similar results were obtained by Hsu and Chung (1999), Anderson and Berry (2001), Yılmaz (2004a, 2005) and Luruena-Martinez and Vivar-Quintana (2004).

Table 2 Sensory properties of gum added and control meatball samples (n=11 panelists)

Samples	%	Colour	Flavour intensity	Taste	Juiciness	Hardness	Overall Palatability
Xanthan Gum	0.5	6.5 ± 0.01^{g}	6.4±0.01	6.6 ± 0.10^{c}	6.4±0.20	6.7 ± 0.12^{b}	6.5 ± 0.02^{b}
	1	6.6 ± 0.20^{e}	6.5±0.25	5.9 ± 0.15^{h}	6.3±0.31	6.3 ± 0.45^{f}	6.3 ± 0.10^{b}
	1.5	6.3 ± 0.48^{h}	6.0±0.61	5.5 ± 0.85^{l}	5.8±1.10	6.3 ± 1.25^{f}	6.0 ± 1.05^{c}
Guar Gum	0.5	6.8 ± 0.02^{c}	6.4±0.17	6.5 ± 0.06^{d}	6.1±0.02	$6.4\pm0{,}45^{e}$	6.4 ± 1.24^{b}
	1	7.2 ± 0.01^{b}	6.0±0.14	5.8 ± 0.08^{i}	6.0±0.14	6.6 ± 0.25^{c}	6.3 ± 0.20^{b}
	1.5	6.7 ± 0.15^{d}	5.9±0.01	5.6 ± 0.05^{k}	5.6±0.05	6.3 ± 0.05^{f}	6.0 ± 0.06^{c}
Carrageenan Gum	0.5	6.5 ± 0.18^{g}	6.2±0.12	6.4 ± 0.01^{e}	6.2±0.12	6.5 ± 0.02^{d}	6.3 ± 0.04^{b}
	1	6.6 ± 0.13^{f}	6.3±0.13	6.2 ± 0.02^{g}	6.2±0.01	6.6 ± 0.01^{c}	6.4 ± 0.01^{b}
	1.5	6.8 ± 0.04^{c}	6.4±0.08	5.7 ± 0.01^{j}	5.9±0.04	6.1 ± 0.45^{g}	6.2 ± 0.02^{bc}
Locust Bean Gum	0.5	6.6 ± 0.21^{f}	6.5±0.07	6.3 ± 0.07^{f}	5.6±0.06	6.6 ± 0.35^{c}	6.3 ± 0.01^{b}
	1	7.4 ± 0.04^{a}	6.8±0.01	6.9 ± 0.16^{a}	6.6±0.14	7.3 ± 0.06^{a}	7.0 ± 0.04^{a}
	1.5	6.8 ± 0.02^{c}	6.5±0.02	6.2 ± 0.12^{g}	6.0±0.12	6.3 ± 0.05^{f}	6.3 ± 0.08^{b}
Control		6.8 ± 0.16^{c}	6.4±0.12	6.6 ± 0.12^{b}	6.5±0.05	6.7 ± 0.14^{b}	6.6 ± 0.25^{ab}

[a–l;] Means within a column with different letters are significantly different ($P<0.05$).

Firmness When gum addition level was increased, firmness increased in raw and cooked meatball samples. The control meatballs had the lowest ($p<0.05$) firmness value. Gum addition resulted in improved firmness in meatball samples as compared to control. On the other hand, the meatball produced with the addition of 1.5% locust bean gum had the highest ($p<0.05$) firmness value (120.6 g). Fox et al. (1983) reported that xanthan gum and carrageenan could stabilize the texture of pickled frankfurters while guar, Arabic and locust bean gums had no such effect. Carrageenans have also been used in comminuted meat products to improve stability and texture, especially in low-fat products (Candoğan and Kolsarici 2003a). Carrageenan significantly increased product hardness, chewiness and gumminess (Hsu and Chung 2001). The firmness of raw meatball samples increased with gum addition. Cooking led to a dramatic increase in firmness in meatball samples. Similar results were obtained by Hsu and Chung (2001), Ulu (2006), Yılmaz and Gecgel (2009) and Talukder and Sharma (2010).

Sensory analysis Sensory traits for cooked meatballs with different gum levels are shown in Table 2. The locust bean gum (1%) improved the sensory preferences on colour, flavour intensity, taste and overall palatability. Preference scores showed that some of the meatball samples made in this study were less acceptable in their sensory qualities. Increase in xanthan, guar and carrageenan gum addition levels significantly decreased ($p<0.05$) colour, taste, hardness and overall palatability. The locust bean gum (1%) also received the highest flavor intensity and taste scores. Overall acceptability scores for all meatball samples were in the range of 5.96–6.98. The highest scores of overall acceptability were 7.0, 6.6, and 6.5, respectively, for the locust bean gum (1%), control and xanthan gum (0.5%) ($p<0.05$). Similar results were obtained by Turhan et al. (2005) for low-fat beef burgers with added hazelnut pellicle and Yılmaz (2005) for low-fat meatballs containing wheat bran. Foegeding and Ramsey (1986) reported that ι-carrageenan, k-carrageenan, guar gum, locust bean gum and k- carrageenan/locust bean gum mixture can be used to make acceptable low fat frankfurters.

Conclusion

Gum addition was found to significantly affect certain quality parameters of the meatball. Gum addition was also found to be effective in improving the reduction in cooking losses of meatball. Moisture contents of raw samples decreased by addition of gums. Therefore, control samples had the highest moisture content. Ash contents and shear force values increased with gum addition to meatballs. Raw and cooked control samples had the highest a value. Meatball redness decreased with more gum addition in raw and cooked meatball samples, which means that addition of gums resulted in a lighter-coloured product. According to sensory analysis results, control and locust bean gum added (1%) samples were much preferred by the panelists. The addition of 1% locust bean gum to meatballs results in acceptable and desirable quality characteristics.

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