IMPROVING BEEF MEATBALL CHARACTERISTICS BY ADDING POTATO PUREE AND CARRAGEENAN

Meltem SERDAROĞLU, Gülen YILDIZ TURP*, Haluk ERGEZER, Tolga AKCAN, Pelin BARIŞ

Department of Food Engineering, Engineering Faculty, Ege University, İzmir-TURKEY

*Corresponding author (phone: +90-232-3884000/3038; fax: +90-232-3427592; e-mail: gulen.yildiz.turp@ege.edu.tr)

Abstract

Turkish style meatballs (koefte) are produced mainly from ground meat (beef and lamb), fat (beef fat and/or lamb tallow fat) and various spices. Rusk, moistened or dried bread crumbs are usually used as binders and extenders. The purpose of this research was to evaluate the effects of adding different levels of potato puree (10% and 20%) and carrageenan (0.5% and 1%) as an extender and binder on the physical, chemical and sensory properties of beef meatballs. Cooking yields and moisture retention values of meatballs were significantly increased with using of carrageenan and potato puree in meatball formulations when compared with control samples ($p<0.05$). Using 20% potato puree and 1% carrageenan significantly increased redness (a*) value and hardness of meatballs. Sensory properties of meatballs improved with using potato and carrageenan.

Key Words: **Carrageenan, meatball, potato, cooking characteristics.**

I. INTRODUCTION

Most people prefer to consume meat in the ground form in Turkey. Therefore, many meat products, such as patties, meatballs, and kebabs prepared from ground meat, are consumed in Turkey (Ulu, 2004; Yılmaz and Dağlıoğlu, 2003). Turkish style meatballs (koefte) are produced mainly from ground meat (beef and lamb), fat (beef fat and/or lamb tallow fat) and various spices. Extension of meat and meat products with vegetables and fruits could reduce production costs and improve the nutritional qualities of the products. Some fiber applications had been successful in improving cooking yield and enhancing texture in food products (Jimenez-Colmenero, 1996). A variety of plant sources such as pepper puree (Yıldız-Turp, Serdaroğlu & Ergezer, 2007), tomato puree (Candogan, 2002), carrot and spinach (Pizzocaro, Senesi, Veronese & Gasparolo, 1998) have been used as fat replacers, binders and extenders in comminuted meat products.

Potato is one of the main vegetables consumed in Turkey. One medium potato with the skin contributes two grams of fiber or eight percent of the daily value. The content of protein in potato is around 3%; however the nutritional value of proteins is high. Potato is also an important source of vitamins and minerals, such as calcium, potassium and phosphorus, but its value in the human diet, particularly as a source of ascorbic acid, is often underestimated or ignored. Studies have indicated that potato tubers contain phenolic compounds, such as chlorogenic acid, which have been shown to possess free radical-scavenging activity in vitro (Friedman, 1997).

Hydrocolloids with their unique characteristics are of great interest in processed meat due to their ability to bind water and form gels. One of the most interesting hydrocolloids gums, which could be used in meat industries, is carrageenan (Candogan and Kolsarici, 2003). In cooked sliced meat products carrageenan is used to improve moisture retention, cooking yields, slicing properties, mouth-feel and juiciness (Imeson, 2000). Hsu and Chung (2001) observed an increase in cooking yield, hardness, and other textural profile analysis parameters by adding up to 2% carrageenan to low-fat emulsified meatballs.

The main objective of this study was to evaluate the effects of the addition of different levels of potato puree and carrageenan on some characteristics of beef meatballs.

II. MATERIALS AND METHODS

Potatoes were boiled for 1 hour and after that minced with peel to obtain potato puree. Lean meat and fat were ground through a 3.5 mm plate grinder. Meatball samples were produced according to following recipe. The minced lean beef was mixed with 7% beef fat, 1.5% salt, 0.3% black pepper and 0.3 % red pepper. The mix was kneaded and obtained meatball dough was divided into five equal portions. These mixtures were shaped to obtain meatballs of 1 cm thickness and 5 cm diameter. Meatballs were cooked in an electric oven at 180º C for 35 min.

Treatment groups were as following;
Control: Meatballs with 0% potato puree and 0% carrageenan
P10/C0.5: Meatballs with 10% potato puree and 0.5% carrageenan
P10/C1: Meatballs with 10% potato puree and 1% carrageenan

P20/C0.5:Meatballs with 20% potato puree and 0.5% carrageenan
P20/C1: Meatballs with 20% potato puree and 1% carrageenan

Percent cooking yield was determined by calculating weight differences for samples before and after cooking (Murphy, Criner & Grey, 1975).

$$\text{Cooking Yield}(\%) = \frac{(\text{Cooked meatball weight})}{(\text{Uncooked meatball weight})} \times 100$$

The fat retention value represents the amount of fat retained in the product after cooking. Fat retention was calculated according to Murphy, Criner & Grey (1975).

$$\text{Fat retention}(\%) = \left[\frac{(\text{Cooked weight}) \times (\%\ \text{Fat in cooked meatball})}{(\text{Raw weight}) \times (\%\ \text{Fat in raw meatball})}\right] \times 100$$

The moisture retention value represents the amount of moisture retained in the cooked product per 0.1 kg of sample and was determined according to El-Magoli, Laroia & Hansen (1996).

$$\text{Moisture retention}(\%) = \frac{(\%\ \text{Yield} \times \%\ \text{Moisture in cooked meatball})}{100}$$

Objective measurement of colour (*L**, *a**, *b**) was performed at the surface of raw meatballs using a HunterLab Colorflex model Colorimetre (Management Company, USA). A Sommer Runge-Model, KG PNR- 6 penetrometer equipped with a total 100 g load weight was used to evaluate cooked meatballs for hardness. The percentage of free liquid was evaluated by the filter press method described by Wierbicki and Deatherage (1958).
Meatballs were served warm after cooking to 10 panellist for sensory attributes of appearance, colour, hardness, flavour, juiciness and overall acceptability. An eight point scale was used for appearance, juiciness and flavour where, 1.0 corresponded to the lowest score for each attribute and 8.0 the highest, for hardness evaluation, 1.0 denoted extremely soft and 8.0 extremely hard. Colour attributes of meatballs were evaluated according to five point scale that 5.0 represented extremely intense colour and 1.0 extremely poor colour.
The data obtained from two replications were analysed by ANOVA using the SPSS statistical package version 11 (SPSS, 2001). Differences among the means were compared using Duncan's Multiple Range test. A significance level of $P \leq 0.05$ was used for all mean evaluations.

III. RESULTS AND DISCUSSION

Results of cooking characteristics of meatballs are presented in Table 1. Cooking yield results are the most important test for the meat industry to predict the behaviour of the products during cooking due to non-meat ingredients or other factors (Pietrasik & Li-Chan, 2002).Cooking yield varied between 59.73-78.76 %. Cooking yields of the meatballs were significantly increased with using of carrageenan and potato puree in meatball formulations when compared with control samples ($p<0.05$). The improvement in cooking performance due to potato and carrageenan addition appears to be related with their moisture retention. The presence of potato and carrageenan did not modified the fat retention of meatballs. It is obvious that these yield values are related to water retention.

Table1. Cooking characteristics of meatballs

Sample	Yield(%)	Moisture Retention	Fat Retention
Control	$59.73^{b}\pm1.52$	$76.46^{b}\pm3.26$	$93.47^{a}\pm1.45$
P10/C0.5	$76.35^{a}\pm0.46$	$93.25^{a}\pm3.45$	$88.06^{b}\pm1.28$
P10/C1	$78.76^{a}\pm0.75$	$95.49^{a}\pm1.45$	$85.46^{b}\pm3.43$
P20/C0.5	$76.58^{a}\pm1.89$	$92.58^{a}\pm2.43$	$86.21^{b}\pm3.24$
P20/C1	$76.52^{a}\pm2.76$	$94.41^{a}\pm1.53$	$74.51^{c}\pm1.59$

a–c Different superscripts in the same column indicate significant differences ($p < 0.05$).

There were no significant differences in L* values of samples ($p>0.05$). Meatballs extended with 20% potato and 1% carrageenan had lower a* values than the other samples. P20 samples had higher b* values than the other formulations,

because of the yellow colour of potatoes, however no significant differences were found in b* values. The results of free water in accordance with the cooking yield value of samples, so P20/C0.5 and P20/C1 samples had significantly higher free water values than control samples ($p<0.05$). Nuñez de Gonzalez, Hafley, Boleman, Miller, Rhee and Keeton (2008), reported that roast beef injected with plum material up to 5% had less available water. One important property of any non-meat additive is its ability to bind water (Reitmer and Prusa, 1991).

Meatballs with added potato and carrageenan except P20/C1were less hard ($P<0.05$) than the control. This hardness reduction could be related to the softer texture of potato puree and moisture retention effect of carrageenan. Hardness value of P20/C1sample was found significantly lower than the P20/C0.5 sample. Similarly, Ulu (2004) determined that hardness of the low fat meatball,with the addition of 1% carrageenan after cooking, increased significantly. Also, Ayadi, Kechaou, Makni and Attia (2009) determined a significant increase in sausage hardness at high added levels of carrageenan (0.8% and 1.5%) and explained that this increase in hardness can be the result of additional carrageenan gel network formation.

Table 2. Colour (L*, a* and b*) free water (%) and penetrometer (mm) values of raw meatballs

Sample	L*	a*	b*	Free water(%)	Penetrometer Value
Control	$38.59^{a}\pm0.94$	$14.11^{b}\pm1.86$	$17.30^{a}\pm0.58$	$32.62^{a}\pm0.78$	$22.57^{ab}\pm1.62$
P10/C0.5	$37.86^{a}\pm2.95$	$17.19^{ab}\pm2.65$	$17.70^{a}\pm2.31$	$29.07^{bc}\pm1.79$	$23.12^{ab}\pm2.71$
P10/C1	$37.97^{a}\pm4.03$	$17.46^{ab}\pm2.30$	$17.87^{a}\pm2.26$	$30.22^{ab}\pm1.08$	$24.25^{a}\pm1.73$
P20/C0.5	$39.81^{a}\pm2.69$	$17.32^{ab}\pm2.04$	$18.85^{a}\pm1.44$	$26.59^{cd}\pm1.59$	$24.32^{a}\pm0.86$
P20/C1	$37.79^{a}\pm3.34$	$19.05^{a}\pm1.16$	$19.58^{a}\pm1.28$	$26.29^{d}\pm1.81$	$21.82^{b}\pm0.23$

a–d Different superscripts in the same column indicate significant differences ($p < 0.05$).

According to sensory results (Table 3), appearance and colour values of samples were not presented significantly differences attributed to the added potato and carrageenan. The highest score ($p< 0.05$) of texture were obtained for control samples (6.43) and lowest score for P20/C1 samples (4.87). Similarly, He and Sebranek (1996) reported that kappa-carrageenan increased texture scores of frankfurters. Desmond and Troy (1998) also found that carrageenan improved overall texture of low-fat beef burgers.

Potato puree and carrageenan improved the juiciness scores of samples in accordance with free water content results. Control and P10/C1 samples had significantly lower flavour scores from other samples ($p< 0.05$). Higher flavour scores were obtained from using 20% amount potato puree and 0.5% level carrageenan in meatball formulations. Increased amount of juiciness of meatballs with potato and carrageenan improved the flavour characteristics. Overall acceptability was lowest in control samples (3.66) and the most acceptable sample was P20/C1 (6.37).

Table 3. Sensory properties of cooked meatballs

Sample	Appearance	Colour	Texture	Juiciness	Flavour	Overall Acceptability
Control	$5.51^{a}\pm0.85$	$3.04^{a}\pm0.52$	$6.43^{a}\pm0.23$	$3.56^{b}\pm0.64$	$4.22^{b}\pm0.31$	$3.66^{c}\pm0.23$
P10/C0.5	$6.87^{a}\pm0.25$	$3.12^{a}\pm0.47$	$5.87^{ab}\pm1.31$	$5.25^{a}\pm1.19$	$6.00^{a}\pm1.47$	$5.75^{ab}\pm0.95$
P10/C1	$5.12^{a}\pm2.28$	$3.75^{a}\pm1.04$	$5.87^{ab}\pm1.18$	$4.50^{ab}\pm0.70$	$4.50^{b}\pm0.70$	$4.37^{bc}\pm1.10$
P20/C0.5	$6.00^{a}\pm0.00$	$3.37^{a}\pm0.25$	$5.12^{ab}\pm0.85$	$5.87^{a}\pm0.85$	$6.12^{a}\pm0.85$	$5.75^{ab}\pm1.19$
P20/C1	$5.75^{a}\pm0.64$	$3.50^{a}\pm0.91$	$4.87^{b}\pm0.25$	$5.75^{a}\pm0.86$	$5.87^{a}\pm0.47$	$6.37^{a}\pm0.47$

a–d Different superscripts in the same column indicate significant differences ($p < 0.05$).

IV. CONCLUSION

The results indicated that using potato puree and carrageenan in beef meatball formulation significantly improved cooking characteristics and sensory properties but increased redness value (a*) of samples. The most acceptable sample was P20/C1 according to sensory evaluation. However this sample was harder than P20/C0.5 according to penetrometer value. The use of potato puree with carrageenan could be attractive to consumers as a positive alternative to conventional fillers in meatball production.

REFERENCES

Ayadi, A., Kechaou,I., Makni, I., Attia, H., (2009). Influence of carrageenan addition on turkey meat sausages properties. Journal of Food Engineering, 93: 278-283.

Candogan, K. (2002). The effects of tomato puree on some quality characteristics of beef patties during refrigerated storage. *European Food Research Technology*, 215:305–309.

Candoğan, K. And Kolsarici, (2003). Storage stability of low-fat beef frankfurters formulated with carrageenan or carrageenan with pectin. Meat Science 64 (2003) 207–214.

Desmond, E. M., & Troy, D. J. (1998). Comparative studies of nonmeat adjuncts used in the manufacture of low-fat beef burgers. Journal of Muscle Foods, 9, 221–241.

El-Magoli, S., Laroia, S., & Hansen, P. M. T. (1996). Flavor and texture characteristics of low fat ground beef patties formulated with whey protein concentrate. Meat Science, 42(2), 179–193.

Friedman, M. (1997). Chemistry, biochemistry, and dietary role of potato polyphenols: A review. Journal of Agricultural and Food Chemistry, 45, 1523–1540.

He, Y., & Sebranek, J. G. (1996). Frankfurters with lean finely textured tissue as affected by ingredients. Journal of Food Science, 61(6), 1275–1280.

Hsu, S. Y., & Chung, H.-Y. (2001). Effects of κ-carrageenan, salt, phosphates and fat on qualities of low emulsified meatballs. Journal of Food Engineering, 47, 115–121.

Imeson, A.P., 2000. Carrageenan. In: Phillips, G.O., Williams, P.A. (Eds.), Handbook of Hydrocolloids. Woodhead Publishing Ltd., Cambridge, pp. 87–102.

Jimenez-Colmenero, F. (1996). Technologies for developing low-fat meat products. Trends in Food Science and Technology, 7, 41–48.

Murphy, E. W., Criner, P. E., & Grey, B. C. (1975). Comparison of methods for calculating retentions of nutrients in cooked foods. Journal of Agricultural Food Chemistry, 23: 1153–1157.

Nuñez de Gonzalez M.T., Hafley, B.S., Boleman, R.M., Miller, R.K., Rhee, K.S. Keeton, J.T (2008). Antioxidant properties of plum concentrates and powder in precooked roast beef to reduce lipid oxidation. *Meat Science*, 80: 997-1007.

Pietrasik, Z., & Li-Chan, E. C. Y. (2002). Binding and textural properties of beef gels as affected by protein, κ-carrageenan and microbial transglutaminase addition. Food Research International, 35, 91–98.

Pizzocaro, F., Senesi, E., Veronese, P., & Gasparolo, A. (1998). Mechanically deboned poultry meat hamburgers. II. Protective and antioxidant effect of the carrot and spinach tissues during frozen storage. *Industrie Alimentari*, 37, 710.

Reitmer, C. A., & Prusa, K. J. (1991). Composition, cooking loss, colour and compression of ground pork with dry and wet-milled corn germ proteins. *Journal of Food Science*, 56: 216–219.

Ulu, H. (2004). Effect of wheat flour, whey protein concentrate and soya protein isolate on oxidative processes and textural properties of cooked meatballs. Food Chemistry, 87, 523–529.

Ulu, H., (2006). Effects of carrageenam and guar gum on the cooking and textual properties of low fat meatballs. Food Chemistry ,95: 600–605.

SPSS, 2001, SPSS Statistical package for windows, ver. 11.0, Chicago: SPSS, Inc.

Yıldız-Turp,G., Serdaroğlu, M & Ergezer, H. The effects of red pepper puree on some characteristics of turkey meatball. 2nd International Congress on Food and Nutrition. 24-26 October 2007, İstanbul, pp 194.

Yılmaz, I. & Dağlıoğlu, O. (2003). The effect of replacing fat with oat bran on fatty acid composition and hysicochemical properties of meatballs. Meat Science, 65, 819–823.