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Review Article
Indonesian Traditional Meatball

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Abstract: Indonesian traditional meat balls (bakso) can be classified as traditional restructured meat and it is produced by mixing fine ground meat, cooking salt, garlic and tapioca starch into a batter which is then formed into balls ranging in size from a marble to a ping-pong ball before they are cooked in boiling water. The consumer's acceptances were influenced by the quality of *bakso*, location of sale, price and product accessibility. Whilst the "unique taste and promotional tools strategies" offered by cottage meatballs processors were positively related to their education level. Early and late post mortem meats as well as frozen meat are suitable as the main raw material in *bakso* production. *Bakso* made from late post mortem (LPM) had similar textural properties compared to the one prepared using early post mortem meat (EPM) although it had a higher elasticity especially when 15% tapioca starch added during preparation of those products. The micrograph of EPM and LPM *bakso* showed that myosin and actomyosin network appears as thin thread lines or protein strands that interconnect between one another, forming a web-like net matrix, while the tapioca granules appear as dense granules aggregated into one another. The non-meat ingredients especially tapioca starch and other starches which can be used as substitution material of tapioca starch were also discussed. The addition of 10–15% tapioca starch and boiling temperature of 90^{o}C gave the best *bakso* quality.

Keywords: Traditional meatballs, meat, tapioca starch

INTRODUCTION

Variability in preparation and meat consumption vary in different parts of the world and are also affected by the needs and demands of the consumers (Romans *et al.*, 1994). Furthermore Romans *et al.* (1994) and Sloan (2003) noted that the growing complexity and hectic metropolitan life have developed demands for ready-to-eat prepared foods known as convenience foods.

Some of the restructured meat products are convenience foods which are prepared from a mixture of comminuted meat, protein, fat particles, water and carbohydrate (Barbut, 1995). Romans *et al.* (1994) reported that during processing the meat is mixed with cooking salt, phosphates and protein or carbohydrate binders that will bind the particles directly or indirectly. The mixture is then formed to the desired shape and this shape is retained after freezing or cooking. Fischer (1996) noted that meatball is prepared from ground meat formed in balls and boiled, and it is very important to consider the formula of the batter. Usually it consist of 53% lean beef, 17% fat and some other ingredients such as phosphate, salt, monosodium glutamate (MSG) and 30% ice cubes to prevent the increase of batter temperature during grounding and mixing, sometimes starches are added.

Meatballs are processed comminuted meat which can be classified as restructured meat and it is very popular among some countries within the Asian region and certain European countries. These products include Polpette of Italy, Koningsberger Klopse or meatballs in lemon and carper of Germany, Swedish meatballs of Swedia, Koefte of Turky, Nunh Hoa of Vietnam, Curried Kofter of India and Chinese meatballs of China (Fulton, 1983; Duong and Kiesel, 1991; Redden and Chen, 1995; Serdaroglu and Degirmencioglu, 2004).

The Asian type meatballs are commonly produced by emulsifying fine ground meat with starch of some sort, mixing salt and certain herbs specific to the ethnic cuisine and finally shaping into balls. It is then cooked in boiling water, steam or deep fried depending on the cuisine (Purnomo, 1990).

Indonesian traditional meatballs is one of the comminuted meat products and its popularity in all classes of Indonesian society especially the youngsters has attracted interest of the meat processors as a business opportunity. Therefore, the meat processors are integrating this product

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into their production line and making it fully industrial hence the home industry type production is fully scaled to mass production of meatballs packed in vacuum packaging and sold frozen at supermarkets or grocery stores (Rahardiyan, 2002).

Indonesian Traditional Meatballs (Bakso)

Indonesian traditional meatballs or known as bakso are produced from a mixture of finely ground meat with cooking salt, tapioca starch and garlic. This batter is formed into balls ranging in size from a marble to a ping-pong ball and then cooked in boiling water, and it is served with other stuff such as noodles, steamed/deep fried tofu filled with minced meat or steamed/deep fried chow mien (a Chinese mixed spicy flour and minced meat in thin dough sheet) or bakso itself in chicken/beef stock/soup. This product is usually distributed by peddlers on a pushcart or small outlets along the pedestrian walk paths on corners or in restaurants (Pandesurya, 1988; Triatmojo, 1992; Purnomo, 1999).

It can be prepared using beef, chicken, pork or fish meat and the one that is very popular and widely found in the market is beef bakso (Widyastuti, 1999; Purnomo, 1999). Triatmojo (1992) reported that the price range and quality of *bakso* in the market are also influenced by the amount of filler or binder added.

Consumer Acceptance

A study on consumer behaviour and food processor response towards ethnic food in East Java, Indonesia found that younger consumers (aged <30 years old) considered freshness and appearance of *bakso* as important and beside those considerations they preferred Malang bakso with a "halal" label (as the majority of the consumers have Islamic faith. The influence of other people and the female household members has been shown to cause an increase in consumers choosing Malang bakso (Utami, 2004). It was also noted that the availability of *bakso* in the food outlets can increase consumer demand for this product. Whilst Hermanianto and Andayani (2002) reported the results of consumers survey in Jakarta metropolitan area which showed that there were four factors which affected consumer preference for *bakso* namely quality, location of sale, price and product accessibility.

Utami *et al.* (2007) also reported that meatball processor's education had a positive relationship to offering of a "unique taste and promotional tools strategies". Their research results showed that the cottage meatballs processors in Malang city, who have a high level of education (secondary school and beyond) may increase the offering of a "unique taste and promotional tool strategies" such as using a branch's name, a "halal food" label (as the majority of the consumers are Muslims) and inserting advertisements. This marketing strategy had been adapted and used for a long time. Furthermore, they noted that Malang cottage meatballs processors who have the experience in *bakso* production for more than 10 years and using the marketing strategy are consistent in their expectations and confidence to rely on their experiences in evaluating the marketing strategy practices. Utami *et al.* (2007) also stated that meatballs are representative of ethnic food and to preserve the existence of such food, the producers should have a better understanding, because they are using very simple technology and reorient their marketing activities on a day-to-day basis which is usually controlled by family members to supply local consumers.

The Indonesian National Standard (Standard Nasional Indonesia – SNI 01-3818, 1995) for *bakso* are moisture content approximately 70%, fat content maximum 2%, protein content minimum 6%, ash content maximum 3% and no borax detected in the product (Widyastuti, 1999).

Meat as Major Ingredient

Traditional bakso are prepared using pre-rigor mortis beef meat which is obtained from traditional butchers and local traditional market places (Astawan and Astawan, 1989; Triatmojo, 1992; Wibowo, 2000). On the contrary, home industry *bakso* producers in Malang regency bought fine ground pre-rigor meat from traditional local markets and transport it in 3 kg plastic pouches to the production site (Mahastuti, 2001).

Early Post Mortem and Late Post Mortem Meat Bakso

It is difficult for bigger meat processors to get pre-rigor/early post mortem (EPM) meat in large quantities as there are only small slaughter houses with limited slaughter frequency. Therefore, the large scale industries use the late post mortem (LPM) meat or frozen meat as raw material for their *bakso* production (Rahardiyan, 2002).

Elasticity and gel strength (hardness) of bakso balls made from early postmortem meat (EPM) were slightly higher, but not different ($p<0.05$), than *bakso* from late postmortem meat (LPM). The gel shear force values of *bakso* were also higher ($p<0.05$) for EPM compared to LPM as shown in Table 1 (Rahardiyan, 2002).

Data represents means and standard errors (SEM) of the 3 replicates. Different superscripts among means indicates differences, while nd = no difference ($p<0.05$).

The tougher texture of early post mortem bakso samples suggested that EPM had slightly

Table 1: Proximate analysis and rheological means of *bakso* made from early and late postmortem meat

Meat Conditions	Moisture (%)	Fat (%)	Elasticity (min/g)	Gel strength (N)	Shear force (N)
Late postmortem	73.40	0.22	0.499	36.365	20.604[a]
Early postmortem	73.68	0.20	0.573	37.747	21.433[b]
SEM	0.474[nd]	0.024[nd]	0.041[nd]	0.720[nd]	0.107

Data represents means and standard errors (SEM) of the 3 replicates.
Different superscripts among means indicates differences, while nd = no difference ($p<0.05$).

improved emulsifying capacity and more extracted myosin than that of LPM. This condition is possibly due to the myofibrillar proteins which are responsible for the three dimensional network of protein fibres and promote the structural rigidity. Lan *et al.* (1995) reported that these myofibrillar proteins consist of free myosin in pre-rigor meat and actomyosin in post-rigor meat. Free myosin forms excellent gels, while free actin implicates the gels in a synergistic manner or in an antagonistic manner depending on the significance of its presence. Furthermore Ramirez *et al.* (2000) noted that myosin is the protein fragment that is responsible for gelation, while other fragments, such as actin, do not form gel, but regulate the viscoelastic properties of the gel.

Hidayati (2002) studied the effects of Sodium Tri Poly Phosphate (STPP) and sodium alginate on the rheological properties of bakso and obtained elasticity ranging from 0.518 to 0.540 minutes/gram using Lloyd Universal Testing Instruments, and hardness of *bakso* ranged between 24.237 to 59.410N. The results of texture analysis in those studies were also relatively uniform, which concurred with the present results.

The results in Table 1 also showed that *bakso* made from EPM had slightly higher moisture and slightly lower fat than bakso from LPM. Xiong and Brekke (1991) reported that EPM had more extracted myofibrillar protein (recovery) and improved water retention than LPM. This would explain the slightly higher water content of *bakso* from EPM than bakso from LPM.

The higher moisture and the stable moisture content of *bakso* were also probably influenced by the water-binding effect of actomyosin gelation after extraction with salt (1.6% of the formula) and Sodium Tri Poly Phosphate (STPP) (0.6%) and also by tapioca starch gelation. NaCl (sodium chloride) extracts the actomyosin proteins, exposing chemical groups for binding. An increase in NaCl content from 1.5% to 2.5% doubles the amount of extractable proteins resulting in more stable batters in the case of comminuted products (Barbut, 1995).

The slightly lower fat content in the samples made from early post mortem meat as shown in Table 1 was probably because the fat in the batter is stabilized by the formation of a protein film around the fat globule known as the interfacial protein film (IPF). The film acts as a barrier that prevents coalescence of water and fat in the meat batter, and under heating the fat loss is followed by moisture loss.

Rahardiyan and McMillin (2004) found that *bakso* from LPM had similar textural properties compared to those prepared using EPM. However, it had a higher elasticity with 15% than 5 or 10% tapioca starch added to the fine ground LPM or EPM during the production of *bakso*. Rahardiyan *et al.* (2005) noted that the substitution of LPM for EPM with a mixture of 0.6% Sodium Tri-Poly-Phosphate (STPP), 1.6% NaCl and 15% tapioca starch gave a minimal composition and texture differences. It was concluded that late post mortem meat (LPM) and/or frozen meat of 2 or 4 months storage were still suitable as raw material in the production of *bakso*.

According to Rahardiyan (2002), EPM used in *bakso* production results in more desired texture properties and by adding 15% tapioca starch the *bakso* has the highest elasticity, which is the sought *bakso* rheological traits. Combination of rigor meat and starch concentration indicated that LPM can also be used to produce *bakso* with sufficient textural traits if 15% tapioca starch is incorporated. This suggests that a replacement of early post mortem (EPM) with late post mortem meat (LPM) in *bakso* can be implemented in mass production in large scale meat processors. Scanning electron micrographs of *bakso* illustrate the physical appearance of *bakso*'s spongy three dimensional structures as shown in Figure 1.

The micrograph in Figure 1(MC1TS1)–(MC2TS3) shows the myosin and actomyosin network and the tapioca granules. Myosin and actomyosin network appears as thin thread lines or protein strands that interconnect between one another, forming a web-like net matrix, while the tapioca granules appear as dense granules aggregated into one another. Yuliati (1999) also reported appearances of starch granules as spherical aggregates in a study on the effects of canning on *bakso* quality. The dense, aggregate, and

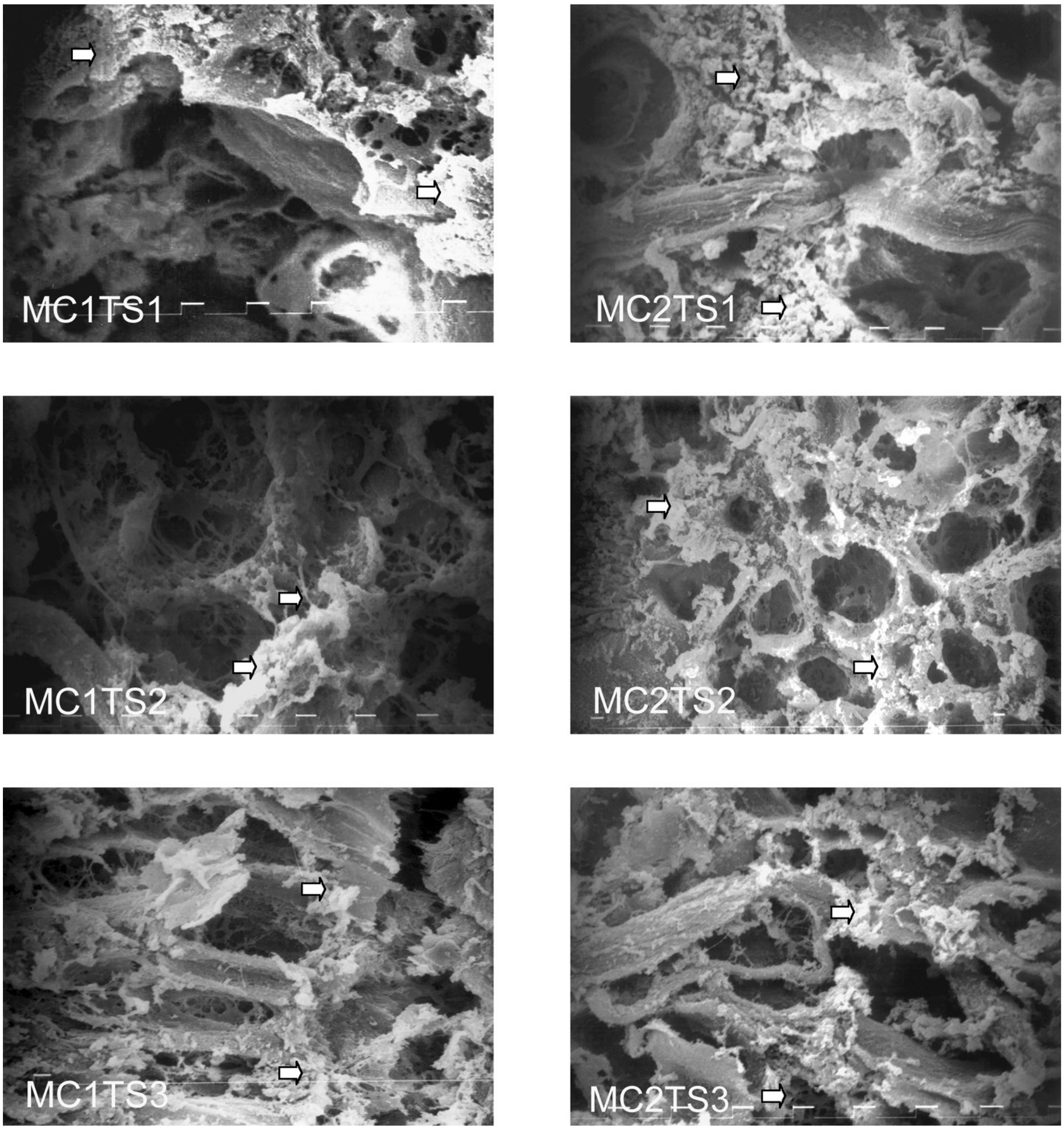

Figure 1: Scanning electron microscope of bakso from early and late post-mortem(EPM and LPM) meat at 1500x magnifications (MC1TS1= early post-mortem(EPM) and 5% tapioca starch; MC1TS2= early post-mortem(EPM) and 10% tapioca starch; MC1TS3= early post-mortem(EPM) and 15% tapioca starch; MC2TS1= late post-mortem(LPM) and 5% tapioca starch; MC2TS2= late post-mortem(LPM) and 10% tapioca starch; MC2TS3= late post-mortem(LPM) and 15% tapioca starch (Rahardiyan, 2002); arrows indicate starch granules.

non-swelled appearance of tapioca starch granules according to Hood *et al.* (1974) may be the result of the high vacuum of the scanning electron microscope column. Barbut (1995) reported that the protein matrix as a sponge-like matrix consisting of protein strands interconnected to form a coherent three dimensional structure.

The actomyosin network of *bakso* from early post mortem meat (EPM) and 10% tapioca starch concentration at 1500x magnification is shown in Figure 1-MC1TS2. Starch granules appear rough and sparsely cover the actomyosin matrix. This micrograph captures a section of the *bakso* that is not as dense in starch as shown in Figure 1 (MC1TS1), where the actomyosin matrix is demonstrated more effectively. Protein strands in the three dimension sponge structure are shown clearly in Figure 1 (MC1TS2). The less homogenized cutting and mixing of the batter during processing could affect the uniformity of starch distribution (Rahardiyan, 2002).

The more open space and coarse structure of the three dimension network are assumed to be the remaining set and physical rearrangement of the actomyosin network (Rahardiyan, 2002). The "fat out" phenomena of the emulsion structure leaving an empty space of interfacial film protein (IFP) and the effects of cooking shrinkage to the network proteins are suggested to be the reasons for this matrix rearrangement. Considering the emulsion theory of comminuted products, Smith (1988) reported that in finely comminuted products the role of emulsification becomes important as fat cells are disrupted; fat melts and spaces of various droplet sizes are formed as the matrix protein sets.

The micrograph of MC1TS3 captures an unhomogenized section where actomyosin matrix and starch granules are present, and it was found that fat spaces are present, leaving strands of protein forming the three dimensional actomyosin networks. Throughout emulsification, fat dispersion and IFP were considered as an aspect that is responsible for comminuted meat emulsion stability, but fat dispersion and IFP are not sole aspects responsible for stability. According to Acton *et al.* (1983), water binding that occurs through myofibrillar extraction and during entrapment within the gel matrix is another aspect that should be taken into account in terms of emulsion stability.

As reported by Rahardiyan (2002), the micrographs of *bakso* from late post mortem meat (LPM) with 5%, 10% and 15% starch concentration, respectively, illustrate a less complex protein networking and the pores appear to have more large voids than that of early post mortem (EPM). It has a sponge structure that appears to have less threaded lines of protein strand to build a network unlike *bakso* from early post mortem meat that appear to be rigor meat or meat that has not been aged which is considered to have better emulsifying properties than post-rigor meat or aged meat, due to the loss of myosin filament-forming ability during aging and the loss of textural qualities (Smith, 1988).

Non-Meat Ingredients

Type of Starch Used in **Bakso** *Production*

Starches which are added during *bakso* production have an important role in the quality of the final product. The interaction of myofibrils and starch gelation where starch molecules will fill the spaces in the myofibril matrix gave a rigid structure and increase the myofibril gels (Yulianti, 1999; Hidayati, 2002). It is also assumed that starch gelation could replace the loss of elasticity of muscle protein degradation in the rigor mortis process (McWilliams, 1997).

Other starches with similar qualities of tapioca according to Triatmojo *et al.* (1995) are corn and sago, but these starches result in *bakso* texture which is not acceptable to consumers compared to the one using tapioca starch. Serdaroglu and Degirmencioglu (2004) reported that incorporation of corn flour in Turkish type meatballs could increase the cooking yield and fat retention and had no detrimental effect on its sensory properties except appearance.

Asyahari (1992) claimed that the addition of tapioca starch up to 25% in *bakso* production is still acceptable, whilst Triatmojo (1992) suggested that bakso can incorporate up to 50% tapioca starch and still have acceptable sensory properties although the protein content is decreased.

Substitution of tapioca starch with soya flour had been reported by Purnomo (1997) and it was found that the soya flour substituted in *bakso* could raise the protein content. However, it was not recommended to incorporate soya flour in *bakso* production, because lypoxygenase enzymes were released and activated after contact with water and oxygen forming ethyl-phenyl-ketones that delivered an unpleasant odor, which will affect the consumer's preference. The combination with tapioca starch still could not mask the unpleasant odor, therefore it was concluded that tapioca starch itself is the most suitable hydrocolloid filler and texture improver of *bakso*.

Sodium alginate as *bakso* filler had also been studied by Hidayati (2002) and it was concluded that sodium alginate had a gelling property that prevented shrinkage but it could decrease the hardness of *bakso* causing the product to loose its original texture. Riyanti (2002) studied the substitution of tapioca starch with wheat bran (5%, 15%, 25% and 35% w/w of tapioca starch) in *bakso* production and it was found that the higher the concentration of wheat bran substituted, the lower the *bakso* quality in terms of gel strength, elasticity and its sensory properties. Substitution of 5% wheat bran gave an acceptable texture, taste and dietary fiber content of *bakso*.

Modified starches have stable gel properties and a low gelling temperature, and it could also withstand high temperatures. Yuliati (1999) reported that modified potato starch which was incorporated in canned *bakso* could maintain the texture properties although *bakso* was processed using autoclave temperature. This condition is possible as the modified potato starch in these *bakso* could endure high temperature abuse.

Widyastuti (1999) studied the addition of native tapioca and potato starches, and modified tapioca (perfectamyl TAC) and potato (perfectamyl PAC) starches, and its combination in *bakso* production. The samples were produced using native tapioca: perfectamyl TAC = 1.00 : 0.00; native tapioca : perfectamyl TAC = 0.05 : 0.05; native tapioca : perfectamyl TAC = 0.00 : 1.00; and native potato starch : perfectamyl PAC = 1.00 : 0.00.

Table 2: Moisture content, protein content, pH, water holding capacity (WHC) and texture of *bakso* produced using different tapioca starches

Starches	Moisture (%)	Protein (%)	pH	WHC (%)	Shear force (N)
Native tapioca	69.52[a]	13.38	6.14[b]	43.67[a]	10.81[a]
Native tapioca + Perfectamyl TAC*	69.55[a]	13.55	6.07[a]	49.58[b]	11.32[a]
Perfectamyl TAC	70.36[b]	13.53	6.02[a]	53.09[c]	9.93[b]

*Perfectamyl TAC = modified tapioca starch
Data represents means of 3 replicates, and different superscripts among means indicates significant differences ($p<0.05$).

Table 3: Moisture content, protein content, pH, water holding capacity (WHC) and texture of *bakso* produced using different potato starches

Starches	Moisture (%)	Protein (%)	pH	WHC (%)	Shear force (N)
Native potato	71.46[q]	14.05	6.16[q]	41.92[p]	9.54[p]
Native potato + Perfectamyl PAC*	71.17[pq]	14.36	6.11[q]	43.18[q]	10.98[pq]
Perfectamyl PAC*	70.64[p]	14.44	6.04[p]	44.71[r]	12.21[q]

*Perfectamyl PAC = modified potato starch,
Data represents means of the 3 replicates, and different superscripts among means indicates significant differences ($p<0.05$).

native potato starch : perfectamyl PAC = 0.05 : 0.05, native potato starch: perfectamyl PAC = 0.00 : 1.00 respectively. It was found that starch concentration and boiling temperature affected the meatballs quality in terms of physical and chemical properties as shown in Tables 2 and 3.

Perfectamyl TAC (modified tapioca starch) tended to increase the moisture content of the samples (Table 2), whilst Perfectamyl PAC (modified potato starch) tended to decrease its moisture content (Table 3). It is believed that the water absorption capacity and possibly moisture losses during boiling were also different. According to Wurzburg (1989) starches which are modified through a crosslinked or acetylated process have different chemical and physical properties compared to the native one. Yadav *et al.* (2007) reported that incorporating modified potato starch could increase the hardness of the samples and acetylated samples showed reduced gelatinization temperature and enthalpy compared to native samples.

Widyastuti (1999) also noted that the protein content of the samples were not affected by incorporating Perfectamyl TAC or Perfectamyl PAC, however she found that the protein content of samples with Perfectamyl TAC were slightly lower than the one incorporating Perfectamyl PAC. This is possibly due to the higher gelatization temperature of modified tapioca starch and caused more heat denaturation of protein samples before the protein matrix were formed. Aguilera and Rojas (1996) reported that in general the protein denaturation could occurr between 60 to 80^{o}C, whilst tapioca starch gelatinization temperature was 73^{o}C. The gelatinization temperature of modified tapioca starch was in the range of 60 to 65^{o}C and modified potato starch was in the range of 58 to 69^{o}C (Anonymous, 2004).

Results in Tables 2 and 3 also showed that by increasing the concentration of both modified starches, decreases in pH and increase in WHC occurred (Widyastuti, 1999). Wurzburg (1989) noted that the modified starches which were prepared using cross linking or acetylation process with heating treatment could reduced the pH value of the final product. According to Mc William (1997) the addition of hydroxyethyl at atom C No 2, 3 and 6 of acetylated tapioca amylose affected the hydrogen bonding to ease the absorption of water during the heating process compared to the native tapioca starch. Ma *et al.* (1996) also noted that potato starch has a lower gelatinization temperature and bound much more water. These phenomena could explain the difference of moisture content of samples prepared with native tapioca or native potato starches.

Widyastuti (1999) also reported that incorporating Perfectamil TAC affected the texture of *bakso* measured using Universal Instrument Machine Model Lloyd (Table 2) in different phenomena compared to the one incorporating Perfectamyl PAC (Table 3).

The incorporation of modified starches as either modified tapioca starch or modified potato starch could enhance the bakso quality, and the best quality *bakso* was obtained from incorporating 10% modified tapioca starch or 5% modified potato starch and boiled at 90°C. Redden and Chen (1995) reported a similar result and claimed that incorporating 5% modified potato starch could give the best texture quality of pork meatballs.

Purnomo (1995) explained that non-meat such as tapioca starch addition throughout the heating and boiling process could increase the ability of binding meat and this gives a more compact and slight elastic texture to the final product.

CONCLUSION

Early post mortem (EPM), late post mortem (LPM) meat and frozen meat are suitable as raw materials for mass *bakso* production. Since big quantities of raw material and processing time schedule in mass production of *bakso* are the problem when early post mortem meat (EPM) are used, late post mortem meat (LPM) and/or frozen meat can be used instead and 15% tapioca starch should be incorporated to get best quality *bakso*. The addition of 10 - 15% tapioca starch and boiling temperature of 90°C resulted in the best *bakso* quality, whilst modified tapioca and/or potato starches could enhance the texture traits of *bakso*.

REFERENCES

Acton, J.C., Ziegler, R.G. and Burge Jr., D.L. 1983. Functionality of muscle constituent in the processing of comminuted meat products. CRC Critical Reviews in Food Science and Nutrition, 18(2): 99-121.

Aguilera, J.M. and Rojas, E. 1996. Rheological,thermal and microstructure properties of whey protein – cassava starch gels. Journal of Food Science, 6(4): 962-966.

Anonymous. 2004. Food starch technology a global commitment (online). http://www.foodstarch.com/productsservices/ foodtech/pnsfstart.asp. dated 08-12- 2004 cited on 26 – 10 - 2007.

Astawan, M.W. and Astawan, M. 1989. Teknologi pengolahan pangan hewani tepat guna (Applicative processing muscle food technology). 1st edn. Jakarta: C.V.Akademika Pressindo.

Asyahari, F. 1992. Studi tentang proses pembuatan bakso di RW 2, Kelurahan Kesatrian, Kecamatan Blimbing, Kota Madya Malang (A study on the process of bakso production in RW 2, Kestarian Village, Blimbing Suburb, Malang Municiple), Malang: Brawijaya University, Intern Report.

Barbut, S. 1995. Importance of fat emulsification and protein matrix characterization in meat batter stability. Journal Muscle Foods, 6: 161 -177.

Dewan Standardisasi Indonesia (Board of National Standardization). 1995. *Bakso daging* (Beef meat ball). *Dewan Standardisasi Nasional* (DSN; Board of Nasional Standardisation), SNI 01-3818, Jakarta.

Duong, B. and Kiesel, M. 1991. Simple art of Vietnamese cooking. Melbourne: Prentice Hall Press.

Fischer, A. 1996. Classification and quality aspects of German processed meat. Short Course Manual. Malang: Faculty of Animal Husbandry, Brawijaya University.

Fulton, M. 1983. Encyclopedia of food and cookery. Melbourne: Octopus Book Pty.

Hermanianto, J. and Andayani, Y. 2002. Studi perilaku konsumen dan identifikasi parameter bakso sapi berdasarkan preferensi konsumen di wilayah DKI Jakarta (Study of consumer behaviour and identification of beef meatballs characteristics based on consumer preferences in DKI Jakarta). Jurnal Teknologi dan Industri Pangan, XIII (1):1–10.

Hidayati, L. 2002. Pengaruh penggunaan sodium alginate dan sodium Tripoli fosfat terhadap tekstur (hardness dan elastisitas), sifat organoleptik *bakso* daging sapi (effects of sodium alginate and sodium tripoly- phosphate in the texture of hardness and elasticity and sensory traits of beef bakso), Malang: Brawijaya University, Bachelor Thesis.

Hood, L.F., Seifried, A.S. and Meyer, L. 1974. Microstructure of modified tapioca starch-milk gels. Journal of Food Science, 39: 117-120.

Lan, Y.H., Novakofski, J., McCusker, R.H., Brewer, M.S., Carr, T.R. and McKieth. 1995. Thermal gelation properties of protein fraction from pork and chicken breast muscles. Journal of Food Science, 60(4): 742-747.

Ma, A., Grove., L. and Canovas, B. 1996. Viscoelastic characterization of surimi gel: Effect of setting and starch. Journal of Food Science, 61: 881 – 889.

Mahastuti, E. 2001. Penanganan sanitasi pada pembuatan bakso daging sapi skala produksi rumah tangga di bakso duro Kepanjen, Malang (Sanitation handling in home industry scale of beef bakso processing in bakso duro Kepanjen, Malang). Malang: Brawijaya University, Intern Report.

Mc Williams, M. 1997. Food experiments perspective. New Jersey: Merril, an imprint of Prentice Hill Upper Saddle River.

Pandesurya, C. 1988. Pengaruh jenis daging dan penambahan tepung terhadap mutu bakso (Effects of meat type and the additions of flour towards bakso quality). Bogor: Bogor Agriculture Institute, Bachelor Thesis.

Purnomo, H. 1990. Kajian mutu bakso daging, bakso urat dan bakso aci di daerah Bogor (A study of beef bakso, tendon bakso and "aci' bakso in Bogor area). Bogor: Bogor Agriculture Institute, Bachelor Thesis.

Purnomo, H. 1995. Studi pengalengan bakso (A study of the canning bakso). Malang: Brawijaya University, Research Report.

Purnomo, H. 1997. Pengaruh substitusi tepung tapioka dengan tepung kedelai terhadap kualitas bakso (Effects of tapioca starch substitution with soya flour towards the quality of bakso). Agrivita, 20 (3): 138 – 141.

Purnomo, H. 1999. Food and food research in Indonesia. Fukuoka: Fukuoka University of Education, Keynote speaker paper in the International symposium on food and its education in Asia.

Rahardiyan, D. 2002. Bakso (Indonesian traditional meatballs) properties with rigor condition and frozen storage. Baton Rouge : Louisiana State University, M.Sc. Thesis.

Rahardiyan, D. and McMillin, K. W. 2004. Indonesian bakso meatball properties with postmortem meat time and tapioca starch concentration. International Congress Meat Science and Technology Proceedings, 50: 949 – 951.

Rahardiyan, D., Brock, A.P. and McMillin, K.W., 2005. Indonesian bakso meatball composition, texture, and structure with frozen meat and product storage times. International Congress Meat Science and Technology Proceedings, 5: 807– 810.

RamÌrez, J.A., MartÌn-Polo, M.O. and Bandmand, E. 2000. Fish myosin aggregation as affected by freezing and initial physical state. Journal of Food Science, 65(4): 556-660.

Redden, V.R. and Chen, T. 1995. The potential Chinese meatballs and dried meat as value added PSE pork product. Food Australia, 47: 323 – 326.

Riyanti, W.Y. 2002. Pemanfaatan wheat bran dalam pembuatan bakso daging sapi (The utilization of wheat bran in beef bakso production). Malang: Brawijaya University, Bachelor Thesis.

Romans, J. R., Castello, W.J., Carlson, C.W., Greaser, M.L. and Jones, K.W. 1994. The meat we eat. Third Edition, Danville: Interstate Publisher Inc.

Serdaroglu, M. and Degirmencioglu, O. 2004. Effects of fat level (5%, 0%, 20%) and corn flour (0%, 2%, 4%) on some properties of Turkish type meatballs (koefte). Meat Science, 68: 291 – 296.

Sloan, A.E. 2003. What, when and where American eat: 2003. Food Technology, 57 (8): 48 – 50.

Smith, D.M. 1988. Meat proteins: functional properties in comminuted meat products. Food Technol., 42(4): 116 – 121.

Triatmojo, S. 1992. Pengaruh penggantian daging sapi dengan daging kerbau, ayam dan kelinci pada komposisi dan kualitas fisik bakso (Effects of beef substitution with buffalo, chicken and rabbit meat towards the composition and physical qualities of bakso). Buletin Peternakan UGM, 16: 63 – 70.

Triatmojo, S., Pertiwiningrum, A.W. and Indrayani, Y. 1995. Physical and organoleptic quality of beef meatballs filled with five different fillers. Special Edition Buletin Peternakan UGM, Yogyakarta.

Utami, H.D. 2004. Consumer behaviour and food processors response towards ethnic food in East java, Indonesia. Palmerston North: Massey University, Doctor of Philosophy Thesis.

Utami, H.D., Rauniyar, G., Bailey, W.C., Morris, S. and Purnomo, H. 2007. Marketing strategy as food processor response towards Malang meatballs. Journal of Food Products Marketing, 13 (4): 79—97.

Wibowo, S. 2000. Bakso ikan dan bakso daging (Fish meatballs and beef meatballs). Jakarta: Penebar Swadaya.

Widyastuti, E.S. 1999. Studi tentang penggunaan tapioca, pati kentang dan pati modifikasi dalam pembuatan bakso daging sapi (Study on the incorporation of tapioca starch, potato starch and modified starches in the production of beef bakso). Malang: Brawijaya University, Master Thesis.

Wurzburg, O.B.M.S. 1989. Modified starches: Properties and uses. Boca Raton, Florida: CRC Press, Inc.

Xiong, Y.L. and Brekke, C.J. 1991. Protein extractability and thermally induced gelation properties of myofibrils isolated from pre- and post-rigor chicken muscle. Journal of Food Science, 56(1): 210-215.

Yadav, A.R., Guha, M., Reddy,S.Y., Tharanathan, R.N. and Ramteke, R.S. 2007. Physical Properties of Acetylated and Enzyme-Modified Potato and Sweet Potato Flours. Journal of Food Science, 72 (5): E249-E253.

Yuliati, S. 1999. Pengaruh perebusan sebelum pengalengan dan lama simpan terhadap kualitas bakso dengan bahan pengisi tepung kentang modifikasi yang dikalengkan (Effects of boiling before canning and storage time towards modified potato starch substituted canned bakso). Malang: Brawijaya University, Bachelor Thesis.