INDONESIAN BAKSO MEATBALL PROPERTIES WITH POSTMORTEM MEAT TIME AND TAPIOCA STARCH CONCENTRATIONS

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Background

Food is an integral part of human society, providing nourishment and cultural enjoyment. Worldwide, more emphasis is being placed on convenient and traditional foods. Meatballs are a convenient meat product for preparation in the home or by commercial eating establishments. Meatballs and fishballs are especially popular in Asia. In Indonesia, meatballs known as bakso are made from prerigor meat or meat before completion of rigor mortis (Purnomo, 1990). The meat is ground and emulsified with salt, tapioca starch, and garlic. The batter is formed into small balls and cooked by steaming, boiling, or deep-frying, depending on the cuisine. Bakso is commonly served with boiled chicken stock or soup and distributed from pushcarts at street corners (Pandisurya, 1983), with consumer preference for tougher, but more elastic, bakso (Yuliati, 1999). Commercial production of bakso has been difficult for Indonesian meat processors because sufficient quantities of prerigor or early postmortem meat materials are not readily available. The use of raw chilled or frozen postrigor meat would provide for consistent supplies of adequate raw materials.

Objectives

The purpose of this research was to evaluate the properties of bakso after substitution of postrigor meat for early postmortem meat in bakso and to determine the appropriate level of tapioca starch for production of bakso with postrigor meat.

Materials and Methods

Local 2 to 4 year old Ongole crossbred grass-fed cattle were slaughtered at RPH Pegirian (Pegirian Slaughter House, Surabaya, East Java, Indonesia). Meat collection was approximately 3 hours in total for deboning of *Semimembranosus* and *Semitendinosus* muscles from carcasses and about 1 hour transportation to the PT. Eloda Mitra meat plant (Sidoarjo, East Java, Indonesia) in a refrigerated truck. The 160 kg of collected meat was chilled immediately after collection (10°C) and randomly assigned to early postmortem and postrigor groups of 80 kg. Early postmortem meat was ground for immediate usage for bakso. Postrigor meat was held chilled at 10°C for approximately 24 hours until processing into bakso. Early postmortem ground meat pH was 5.30-5.79, while the postrigor ground meat had pH of 5.06-5.59. Added ingredients were tapioca starch (National® 7, National Starch and Chemical, Singapore) at 5, 10, or 15% of total formulation, 0.6% sodium tripolyphosphate (STPP, $Na_5P_3O_{10}$, Albert & Wilson Phosphate Groups, Indonesia), 1.6% salt (NaCl) from local markets, 0.6% regular cane sugar obtained from local markets, and 0.8% monosodium glutamate (MSG, PT. Ajinomoto, Indonesia). The meat block was decreased proportionally to increased starch levels. Bakso was manufactured using the equipment, facilities, formulation, and processing procedures of PT. Eloda Mitra.

Ground meat was chopped in a bowl chopper (K.G. Wetter, Germany) for 20 minutes. Salt, STPP, and tapioca starch were added to the early postmortem or postrigor meat batches with crushed ice at 5% to maintain 15°C batter temperature. Batter was formed mechanically into 14 g balls with a meatball former (Chuang Zong Baller, Taiwan). The balls were boiled at 100°C for 20 minutes in an open boiler (PT. Mastrada, Indonesia) or until balls were floating in the boiling water. Cooked bakso balls were drained on perforated aluminum trays to remove excess water (outer surface appeared dry) before packing into limited-low-density polyethylene bags (25 x 160mm, 0.15 mm thick, Top Printing Indonesia Co., Indonesia) with 20 balls/bag for vacuum packaging (Henkelman H-800 Double Chamber, Netherlands) and frozen at -20°C. Each experiment was replicated 3 times.

Bakso balls were stored frozen at -20°C and thawed at room temperature (32°C) for 20 to 30 minutes before analyses. Moisture and fat were determined by methods 950.46 and 960.39 (AOAC, 1990), respectively, at Laboratorium Sentral Pangan (Central Food Lab, University of Brawijaya, Malang, East Java, Indonesia). Texture analysis was with a Lloyd Machine Model Universal Testing Instrument according to Hidayati (2002) and Yuliati (1999) at Pusat Antar Universitas Pangan dan Gizi (Center Inter-University Food and Nutrition, Gajah Mada University, Yogyakarta, Indonesia). The Lloyd Universal Testing machine was warmed up for 10 minutes before reading elasticity, gel strength, and shear force readings with an upper cycle limit of 4-mm, lower cycle limit of 3-mm, compression mode, and 60-mm/min test speed, 20-mm/min chart speed. Sample width was set to 10-mm, depth to 10-mm and gauge length to 10-mm. The bakso sample was a cube of 10 x 10 x 10-mm placed under the slice shear force probe for measurement of texture as minutes/gram for elasticity and newtons for gel strength (hardness) and shear force values. Samples for scanning electron microscope procedure were prepared according to Hidayati (2002) and Yuliati (1999) at UPT Mikroskopi Elektron (University of Airlangga, Surabaya, East Java, Indonesia). Bakso samples were sliced 2 to 3-mm thick with a razor blade, fixed with 2% glutaraldehyde in a phosphate buffer of 7.3 pH, and dried with critical point drying (Sumdri-780 Sample Drying, USA) for 72 hours before placing on a brass plate holder. Samples were coated with 24 carat gold with an ion sputter-fine coater (JEOL-GLE4X, JEOL Technic Co. Ltd., Japan) for 1.5 min, achieving an approximate thickness of 0.25-mm. The coated sample was observed under a scanning electron microscope unit (JEOL GSM-T100 Scanning Electron Microscope, JEOL Technic Co. Ltd., Japan) at 1500X magnification. Statistical analyses were performed by General Linear Model procedures for a completely randomized design (SAS, 1998), with main effects of postmortem condition, tapioca starch concentration, replication, and interactions, and least mean squares differences in analyses of variance at probability value of less than 0.05.

Results and Discussion

Replications in this experiment were different ($p<0.05$) for fat content and shear force, most likely due to animal source, but perhaps due to differences in homogenization of different batches. Moisture, fat, elasticity, and gel strength were not different ($p>0.05$) in bakso from postrigor meat or early postmortem meat. Shear force was higher ($p<0.05$) in bakso from early postmortem beef (21.4 N) than postrigor beef (20.6 N). The bakso met the Indonesian National Standards (70% moisture, less than 2% fat, Board of Nasional Standardization, 1995) with 72 to 75% moisture content and 0.2% fat. Moisture, fat, elasticity, and gel strength did not differ ($p>0.05$) with level of tapioca starch, but trends for increased texture with increased starch were observed. Shear force increased ($p<0.05$) with increased starch. SEM micrographs of bakso from early postmortem and postrigor meat with 5, 10, and 15% tapioca starch illustrated spongy three dimensional structures. The myofibrillar proteins appeared as interconnecting thin protein strands that formed a net-like matrix. The tapioca granules were observed as dense spherical granule aggregates, aw was also reported by Yuliati (1999) in canned bakso. The dense, aggregate, and non-swelled appearance of tapioca starch granules may be an effect of the high vacuum of the scanning electron microscope column (Hood et al., 1974). Micrographs of bakso from postrigor meat showed slightly less complex protein networking and pores appeared to have more large voids than in bakso from early postmortem meat. Bakso from postrigor meat had a spongy structure with less protein network development than bakso from early postmortem meat that appeared to have more extensive matrix development and more and smaller void spaces.

Sufficient proteins were extracted during comminution with 1.6% salt to result in stable batters (Barbut, 1995) and added phosphates reduce processing yield losses and stabilize emulsion structure (Eilert et al., 1996). Starch granule swelling and gelatinization contribute to emulsion stability, viscosity or elasticity, and prevention of syneresis during refrigeration, frozen storage, or thawing (Hood *et al*., 1974). Hidayati (2002) studied the effects of sodium tripolyphosphate and sodium alginate on the rheological properties of bakso and obtained elasticity ranging from 0.5183 to 0.540 min/gram while hardness (gel strength) of bakso ranged between 24.237 to 59.410N. The texture in those studies was relatively uniform, which was also observed with the present results. Sensory panelists indicated that tougher bakso with more elastic properties was more desirable (Yuliati, 1999).

Conclusions

Use of postrigor meat in bakso production gave only slightly different textural properties than early postmortem meat. Bakso with 15% starch had the highest elasticity, which is sought as a bakso rheological trait. Postrigor meat with inclusion of 15% tapioca starch could be used to produce bakso with sufficient textural traits for commercial mass production. This will allow improved raw material procurement and increased efficiencies for bakso processors.

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Table 1. Proximate analysis and rheological means of bakso from early postmortem and postrigor meat with 0, 5, and 15% starch.

Meat rigor Condition	Starch (%)	Moisture (%)	Fat (%)	Elasticity (min/g)	Gel strength (N)	Shear force (N)
Postrigor	5	72.78	0.18	0.439	34.269^{b}	18.505^{f}
Postrigor	10	74.80	0.20	0.503	36.335^{a}	21.401^{cd}
Postrigor	15	72.59	0.27	0.557	38.490^{a}	21.905^{b}
Early postmortem	5	74.45	0.22	0.535	34.901^{b}	19.720^{e}
Early postmortem	10	74.21	0.14	0.582	37.467^{a}	21.817^{bc}
Early postmortem	15	72.39	0.23	0.601	40.871^{a}	22.762^{a}
SEM		0.82nd	0.04nd	0.071nd	1.248	0.186

Data are means and standard errors of mean (SEM) of 3 replicated experiments. Means for a variable with different superscript letters are different ($p<0.05$); nd superscripts indicate no differences ($p>0.05$) among corresponding means.