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The Influence of the Types of Smoke Powder and Storage Duration on Sensory Quality of Balinese Beef and Buffalo Meatballs

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***Abstract*—**This study aims to examine the sensory quality of meatballs made from Balinese beef and buffalo meat after the addition of smoke powder prior to storage at the temperatures of 2-5°C for 7 days. This study used meat from *Longissimus dorsi* muscle of male Balinese cattle aged 3 years and of male buffalo aged 5 years as the main raw materials, and smoke powder as a binder and preservative in making meatballs. The study was based on completely randomized design (CRD) of factorial pattern of 2 x 3 x 2 where factors 1, 2 and 3 included the types of meat (cattle and buffalo), types of smoke powder (oven dried, freeze dried and spray dried) with a level of 2% of the weight of the meat (w/w), and storage duration (0 and 7 days) with three replications, respectively. The parameters measured were the meatball sensory quality (scores of tenderness, firmness, chewing residue, and intensity of flavor). The results of this study show that each type of meat has produced different sensory characteristics. The meatballs made from buffalo meat have higher tenderness and elasticity scores than the Balinese beef. Meanwhile, the buffalo meatballs have a lower residue mastication score than the Balinese beef. Each type of smoke powders has produced a relatively similar sensory quality of meatballs. It can be concluded that the smoke powder of 2% of the weight of the meat (w/w) could maintain the sensory quality of the meatballs for 7 days of storage.

***Keywords*—**Balinese beef meatballs, buffalo meatballs, sensory quality, smoke powder.

I. Introduction

MEATBALLS are processed meat that can be made from several types of livestock, e.g. cattle, buffalos, pigs, chicken, or fish. This type of food is highly popular in Indonesia and some of Asian countries, including China, Thailand, or Malaysia. The quality standards of meatballs pointed out by the consumers should be solid, dense, soft and slightly chewy with a distinctive flavor of meat. These qualities are solely determined by the amount of meat inside the dough and its quality in which tender meat will produce better quality of meatballs than tough meat. Thus, pre-rigor meat, signified by its high capacity to hold water (water holding capacity), will produce meatballs with higher quality and yields compared to those of post-rigor meat. As [1] uses the pre-rigor meat to increase the level of yields and sausage meat texture.

A decrease in post-rigor meat functional properties, particularly in its ability to bind with protein water, is a natural process resulted from the formation of acidic conditions within the flesh, and as a result of changes of muscle glycogen into lactic acid [2]. To improve the water-binding ability of meat (water holding capacity), the addition of additional non-meat materials can be applied, e.g. phosphate [3]-[5], salt (NaCl) [5] and liquid smoke [6].

The addition of smoke powder into the post-rigor meat is expected to be able to maintain or improve the functional properties of the same meat as in the addition in liquid form. Therefore, the issue of time limitation in processing pre-rigor meat can be solved. The use of 10% liquid smoke concentration at the level of 1-2% of the meat weight (w/w) can increase the water holding capacity of *Longissimus dorsi* muscle of Balinese cattle [7], improve the quality of meatballs where the cooking loss decreases, tenderness, elasticity, and preference level increases [8], [9]. The addition of 1% liquid smoke on meatball production of three different muscle types and rigor phases produces high quality meatballs which are signified by the same shear force, elasticity, and sensory quality on the three different muscles and rigor phases [6]. The addition of liquid smoke to catfish sausage to maintain the oxidation stability had been carried out by [10].

The utilization of liquid smoke as a natural and environmentally friendly preservative in the form of smoke powder on beef meatballs has never been conducted.

This study presents the results of researches that had been conducted on Balinese beef and Buffalo meatballs which were added with smoke powder, oven drying, frozen dried, sprayed dried at the level of 2% of the weight of the meat with storage time of 7 days, thus aiming to examine the sensory quality of the meatballs.

II. Material and Method

This study used two types of fresh post-rigor meat, i.e. 3-year-old Balinese male cattle and 5-year-old buffalo of *Longissimus dorsi* muscle as the main raw materials of making meatballs, smoke powder with a 10 % concentration produced by oven drying, by freeze drying and by spray drying as the binders and preservatives, and other additives including salt and tapioca powder [6].

The smoke powder is the result of draining liquid smoke concentrations of 10% through the drying oven (70^0C – 22 hours), a dry frozen (-27^0C-22 hours), and dry spray (120^0C – 30 minutes/100 ml) [11]

Smoke powder was added to the meatball dough during the milling and mixing process of meat and other ingredients in

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meatball production. After the process was performed, it was put to storage at the temperatures of 2^0-5^0C for 7 days. The parameters measured in the sensory test included tenderness, elasticity, mastication residue and flavor intensity.

The sensory test involved 15 panelists who had previously undergone training and assessed the sensory quality of meatballs based on the scale converted into an assessment score, ranging from 1–6, indicating that 1 is very tough, very non-chewy, very much residue mastication, very low flavor intensity and 6 is very soft, very chewy, very little residue mastication and very high flavor intensity [6]-[8].

The research design was a complete random design (CRD) with the factorial pattern of 2 x 3 x 2 (the first factor: the type of meatballs (beef and buffalo); the second factor: types of powder (oven drying, freeze drying, and spray drying); the third factor: storage time (0 and 7 days). Each treatment was repeated 3 times.

The data were processed by using analysis of variance and continued by LSD test when there is a significant difference as proposed by [12] by using SPSS (SPSS 16.0, SPSS Ltd., West Street Working, Surrey, UK).

III. Results and Discussion

A. Meatball Sensory Characteristics

1. Tenderness Scores

The average values of meatball tenderness scores assessed by the panelists are based on the types of meat, powder, and storage time with the smoke powder level of 2% as seen in Table I.

Analysis of variance shows that the types of meat and storage time have a highly significant effect ($P < 0.01$) and a significant effect ($P < 0.05$) on the tenderness score of beef meatball respectively; however, types of smoke powder do not have a significant effect on the score.

TABLE I
AVERAGE TENDERNESS SCORES OF SMOKE MEATBALL

Treatments	Type of powder	Storage Duration (days)		Average
		0	7	
Balinese beef	Oven	3.07	3.67	3.37
	Freeze drying	3.67	3.17	3.42
	Spray	3.53	3.10	3.32
	Average	3.42	3.31	**3.37**[a]
Buffalo	Oven	4.77	4.10	4.43
	Freeze drying	4.83	4.43	4.63
	Spray	4.83	4.83	4.83
	Average	4.81	4.46	**4.63**[b]
Average type of Smoke powder	Oven	3.92	3.88	3.90
	Freeze drying	4.25	3.80	4.03
	Spray	4.18	3.97	4.08
Average Storage		**4.12**[b]	**3.88**[a]	4.00

Description: Numbers with different superscripts in the same column stated a highly significant difference ($P < 0.01$) and a significance effect on the same row

Assessment Scores: 1-6 (1, very tough, …. 4, rather soft, ... 6, very soft)

Buffalo meatballs obtain a significantly higher tenderness score than that of Balinese beef (4.63 vs. 3.37). Thus, the homogeneous milling process both in the production process of buffalo and Balinese beef meatballs and with the addition of 2% of smoke powder shows that the age of cattle is not significantly influential in the tenderness assessment. As the meat used in the study was taken from the 5-year-old buffalo, the Balinese meat of the 3-year-old cattle should obtain better scores for its tenderness than the buffalo meat. Meat tenderness is largely determined by the contraction level of muscular tissues and substances as well as connective tissue solubility i.e. collagen [2]. When the age increases, the prominent role of connective tissues also increases to produce tougher meat. Nevertheless, the technology of powder milling and addition of smoke powder result in a higher tenderness score of buffalo meatballs than that of Balinese beef meatballs. Furthermore, in this case, the possibility of loosening the myofibrils bond working mechanism happens far more intense on buffalo meat than on beef as raw material in the meatball production. Consequently, it causes the buffalo meatballs to have a higher tenderness score.

The duration of storage resulted in the tenderness score of smoke powder meatballs by 2% in 7 days storage, better than 0-day storage, but the tenderness scores declined by 5.83%. This can be explained through the phenomenon of maturation (aging) in which it occurs in the cold temperature storage of 2-5^0 C as a result of endogenous proteolysis enzyme activity, particularly the cathepsin. And, it is also possibly triggered by the smoke powder activity which has the capacity to loosen the myofibril fibers bonding, so that it becomes more tender during storage [7].

2. Meatball Elasticity Scores

The elasticity score of meatballs based on the types of meat, smoke powder, and storage time on the level of smoke powder by 2% can be seen in Table II.

TABLE II
AVERAGE ELASTICITY SCORES OF SMOKE MEATBALL

Treatments	Type of powder	Storage Duration (days)		Average
		0	7	
Balinese beef	Oven	3.00	3.60	3.30
	Freeze drying	3.07	3.73	3.40
	Spray	3.43	2.90	3.17
	Average	3.17	3.41	**3.29**[a]
Buffalo	Oven	4.33	4.20	4.27
	Freeze drying	3.93	3.67	3.80
	Spray	3.57	4.17	3.87
	Average	3.94	4.01	**3.98**[b]
Average type of Smoke powder	Oven	3.67	3.90	3.78
	Freeze drying	3.50	3.70	3.60
	Spray	3.50	3.53	3.52
Average Storage		3.56	3.71	3.63

Description: Numbers with different superscripts in the same column stated a highly significant difference ($P < 0.01$).

Assessment Scores: 1-6 (1. very not chewy, ... 4, slightly chewy, ... 6, very chewy)

Analysis of variance shows types of meat ($P < 0.01$) are highly significant, while the types of powder and storage duration are not significantly influential in the elasticity scores of meatballs.

The types of meat producing meatballs are significantly influential in the different elasticity scores ($P < 0.01$) in which the elasticity score of buffalo meatballs is 20.97% higher than

that of beef meatballs. This indicates that the addition of smoke powder at the level of 2% enable the fresh buffalo meat to maintain its elasticity level in which the buffalo used in this study was older than the Balinese cattle at time of the meatball production. Chewy, dense and solid meatballs are signified by high quality meatballs which can be produced from the addition of smoke powder by 2% as it was performed in this study on buffalo meatballs.

Even though the types of powder obtain similar elasticity scores of meatballs, there is a tendency that the elasticity score of meatballs in oven dried is slightly better than that of the freeze dried ones; and the score of meatballs produced by freeze dried is slightly better than that of the spray dried. Subsequently, it indicates that the addition of smoke powder in meatball production resulted in the same elasticity as scored by the panelists who conducted the assessments on the three types of powder. Therefore, further researches can consider choosing one of the powder types.

The duration of storage resulted in similar elasticity scores of meatballs despite the slightly higher elasticity score on 7 days storage.

3. Mastication Residue Scores

In Table III, the average value of mastication residual score of meatballs based on the types of meat, powders and storage time can be identified.

TABLE III
AVERAGE MASTICATION RESIDUE SCORES OF SMOKE MEATBALL

Treatments	Type of powder	Storage Duration (days)		Average
		0	7	
Balinese beef	Oven	3.53	2.90	3.22
	Freeze drying	2.63	3.27	2.95
	Spray	3.07	3.27	3.17
	Average	3.08	3.14	**3.11**[a]
Buffalo	Oven	4.50	3.83	4.17
	Freeze drying	4.03	4.07	4.05
	Spray	3.93	4.50	4.22
	Average	4.16	4.13	**4.14**[b]
Average type of Smoke powder	Oven	4.02	3.37	3.69
	Freeze drying	3.33	3.67	3.50
	Spray	3.50	3.88	3.69
Average Storage		3.62	3.64	3.63

Description: Numbers with different superscripts in the same column stated a highly significant difference (P <0.01).
Assessment Scores: 1-6 (very much – very little)

The analysis of variance shows that the types of meat are highly significantly influential (P <0.01), while the types of powder and storage duration do not significantly affect mastication residue scores of meatballs.

Mastication residue score of buffalo meatballs is lower by 33.12% than that of Balinese beef meatballs and this indicates that the mastication residue of buffalo meatballs is less than that of the beef meatballs. Thus, tender beef or meatballs commonly produce less mastication residues as stated in the high scale of the mastication residue score. In this case, the higher score of mastication residue of buffalo meatballs by 4.14 if compared to Balinese beef meatballs 3.11 explains that buffalo meatballs produce a little amount of mastication residue which is commonly resulted from highly tender beef or meatballs. This is in line with what had been discussed on the panelists' assessment towards the tenderness levels in which buffalo meatballs are more tender than Balinese meatballs (See at Meatball Tenderness Score).

In regards to the types of powder, the score of the mastication residue of meatballs is nearly the same, although there is a tendency that the scores of the mastication residue of meatballs using oven drying powder and spray drying powder are lower than the score of mastication residue using freeze drying powder. Consequently, due to the fact that similar capacity of all three types of smoke powder added in the meatball production produces similar mastication residue, it is recommended to choose one of the three smoke powder types for further or advanced research.

The duration of storage time produces similar scores for the mastication residue despite the fact that there is a tendency the score of the mastication residue for 7-day storage is lower than that of 0-day storage. This can be explained by the improvement on beef or meatball tenderness during storage due to the proteolysis enzyme activity and capacity of the smoke powder to stimulate the tenderness.

4. Meatball Flavor Intensity Scores

Meatball flavor intensity scores based on the types of meat, powders and storage time can be seen in Table IV.

TABLE IV
AVERAGE FLAVOR INTENSITY SCORES OF SMOKE MEATBALL

Treatments	Type of powder	Storage Duration (days)		Average
		0	7	
Balinese beef	Oven	3.17	3.43	3.30
	Freeze drying	3.93	3.70	3.82
	Spray	3.60	3.37	3.48
	Average	3.57	3.50	3.53
Buffalo	Oven	3.53	3.73	3.63
	Freeze drying	3.33	3.33	3.33
	Spray	3.33	3.90	3.62
	Average	3.40	3.66	3.53
Average type of Smoke powder	Oven	3.35	3.58	3.47
	Freeze drying	3.63	3.52	3.58
	Spray	3.47	3.63	3.55
Average Storage		3.48	3.58	3.53

Assessment Scores: 1-6 (1, very low flavor intensity... 4, high flavor intensity ... 6, very high flavor intensity)

Analysis of variance shows that the different types of meat, powder, and storage are not significantly influential on the score of the meatball flavor intensity added 2% of smoke powder.

The types of meat produce the same scores in the meatball flavor intensity by 3.53 (moderate) on a scale of 1-6, indicating that the panelists had an equal assessment on flavor (taste) produced by beef and buffalo meatballs, and the flavor criteria are generally assessed by smelling and tasting.

The types of smoke powder produce meatball flavor intensity scores ranging between 3.47 to 3.55, where freeze-drying smoke powder gives slightly better flavor intensity than the other two types of smoke powder.

Even though smoke powder meatball flavor intensity of 2% has s slightly better score for 7-day storage, statistically, the score is not significantly different from the flavor intensity score on 0-day storage. This can be explained by the improvement of meat flavor during cold storage of 2^0 - 5^0C as the result of endogenous proteolysis enzymes activity (maturation phenomena) [2].

IV. Conclusion

1. The types of meatballs produce higher scores of the sensory characteristics of tenderness and elasticity of buffalo meatballs than those of the Balinese beef meatballs. Meanwhile, the mastication residual score of buffalo meatballs is lower than that of Balinese beef meatballs.
2. The types of powder produce similar scores of meatball sensory characteristics.
3. The storage duration of 7-day results in lower tenderness scores, while the elasticity, mastication residue and flavor intensity scores are more or less the same.
4. Sensory quality of buffalo meatballs is better than that of Balinese beef.

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