Functional Characteristics of Spent Duck Meat for Use in Emulsion-Type Meat Products

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Abstract. Spent ducks produce nutritive meat; however the meat possesses undesirable characteristics such as strong odor and tough. Hence, appropriate yet simple processing technologies need to be developed in order to maximize the use of duck meat. The experiment was conducted to evaluate functional characteristics of spent duck meat as raw material for the production of emulsion-type meat products, such as nugget and sausage. Chilled carcasses of 96 spent ducks were deboned manually, then mixed thoroughly and ground using a 5 mm diameter grinding plate. The ground meat was divided into 4 batches (group) of treatments; one batch was treated with iced tap water (M1), one batch with 0.1% NaCl solution (M2), one batch with 0.5% NaHCO3 solution (M3), and one batch was left *as is* as control (M4). Variables measured were water holding capacity (WHC), pH, emulsion capacity and stability of the meat; and firmness and tenderness of the meat gel. Results showed that M1 meat has significantly higher WHC (less percentage of free water) than control (M4), whereas M2 and M3 meat has similar WHC to control. Processing caused the ground duck meat to have significantly higher pH than control. The highest meat pH was observed in M3, followed by M2, M1 and control. Processing duck meat with iced tap water, NaCl or NaHCO3 produced significantly more tender meat gel compared to untreated meat (as is). Tenderness of meat gel of M3 was the most tender followed by M2 and M1. Similar results for meat gel firmness were observed. No significant differences were observed in term of emulsion capacity (expressed as ml oil/gr protein and ml oil/gr fresh meat), emulsion stability (expressed as ml oil and total liquid released per 100 gr emulsion), and cooking recovery (%). The study reported in this paper offers simple processing technologies to improve functional characteristics of spent duck meat to be use as raw material for the production of emulsion type meat products.

Key Words: spent duck meat, processing, functional characteristics, emulsion type meat product

Introduction

Duck population significantly increased from 32. 5 million in 2004 to 36.9 millions in 2008 with highest population in the province of Central and West Java. Duck meat production increased from 22.200 tonnes (2004) to 45.200 tonnes (2008) (Directorate General of Livestock Services, 2008). Ducks, particularly Muscovy ducks, yield approximately 74% carcasses under intensive management system (Etuk et al., 2006; Wawro et al., 2004). However, Peking ducks have lower dressing percentages, which is 72% for males and 71% for females (Solomon et al., 2006). In addition to carcass characteristics, duck meat characteristics are also influenced by genotype (Chartrin et al., 2006). Duck meat is a good source of polyunsaturated fatty acids, particularly those with 20 and 22 carbon atoms. The major fatty acids in liver and in the meat of breast and leg were C-16:0 (18–22%), C-18:0 (12–22%), C-18:1 (17–34%), C-18:2 (13–23%) and C-20:4 (8–19%) (Cobos et al., 2000).

The best slaughter age of ducks was found between 7 and 8 weeks because within this range, the meat content of carcass was the highest and meat to fat ratio proved the most favourable. As the age increased, the tenderness decreased by the flavour and stringiness increased (Baéza et al., 2000). However, considerably high amount and nutritive meat can be obtained from older ducks, particularly spent layer ducks. The general characteristics of spent duck meat are tough, dark in color and strong in odor, which are objectionable to most consumers. Thus, grounding and comminuting of spent duck meat and process it into emulsion-type products are reliable options to maximize its utilization. Emulsion-type meat products can be defined as fine paste as a mixture composed essentially of lean meat, 'fat' and water, whose homogeneity is such that the grain of the added constituents is no longer visible to the naked eye, for example Mortadella, frankfurters and liver pâté (Linden and Lorient, 1999). Sausages from spent duck meat has considerably higher fat content than those made from broiler meat but still nutritionally sound and acceptable to consumers (Debashis et al., 2007). Duck sausages can be consumed up to 14 days when stored at chilling temperature (4±1°C) (Biswas et al., 2006).

The growing population of layer ducks will result in more spent duck meat production. Understanding of the functional characteristics of spent duck meat is required before appropriate processing technologies can be applied to produce emulsion-type meat products from spent duck meat. Therefore, this experiment was aimed to determine the functional characteristics of spent duct meat for use in the emulsion-type meat products.

Materials and Methods

Preparation of material and experimental design

A total of 48 heads of spent egg-type (layer) Peking ducks were purchased and slaughtered for this experiment. Carcasses were deboned manually after being chilled for 12 hours. Boneless meat was mixed thoroughly and ground using a grinding machine a 5 mm diameter grinding plate. Grinding was done 3 times. Ground meat was divided into 4 treatment groups, which were M1: meat treated/washed with iced water, M2: meat treated with 0.1% NaCl solution, M3: meat treated with 0.5% NaHCO3 solution, and M4 meat *as is* as control. Three steps of washing were conducted and the meat was squeezed using a clean linen cloth after each washing. The objective of washing ground meat was to remove meat pigment and other water soluble materials in order to improve meat protein functionality when used in a food system. Functional characteristics of the ground and washed meat were the object of this experiment. Treatments were arranged in a completely randomized design (CRD) with 5 replicates for each treatment.

Measurement procedures

Water Holding Capacity

Water-holding capacity (WHC) was estimated by determining expressible juice using a modification of the filter paper press method. A meat sample weighing 300 mg was placed on a 11 cm diameter filter paper between plexiglass plates and pressed in a Carver press at 500 psi for 3 min. The outline area of the expressible juice and the meat film was traced, and the two areas were determined using a compensating polar planimeter. Free water, as a percentage, was calculated as 100-(total wet area-meat film area)×water/square inch filter_paper divided by total moisture (mg) of original sample (sample wt in (mg)×% moisture)

Tenderness

Products (meat gels) were prepared following the procedures described by Babji and Lee (1994). Samples were sheared using a Warnes Bratzler Shear Machine and the force required to cut each sample (lb/inch^2) was recorded and converted into gr/cm^2.

Firmness

Firmness of the products, as for tenderness, was determined using a Penetrometer. One centimeter thick samples were placed under the needle of the penetrometer machine and its chuck was released for 10 s. The length of penetration of the chuck into the sample (mm) was recorded.

Acidity

Acidity (pH) of the ground spent duck meat was determined by blending 10 gr sample with 100 ml distilled water in a Waring blender for 10 s. pH of the slurry was measured using a Sargent Welch pH meter model RB 1000.

Emulsion capacity

Emulsion capacity of duck meat was determined using the procedures described by Qiao *et. al.* (2001). In brief, a 10-g ground meat sample was blended with 75 mL cold 1 *M* NaCl solution at high speed for 1 min. An 8-g aliquot of the homogenate was transferred to another blender jar with 45 mL, cold, 1 *M* NaCl solution and was mixed for an additional 10 s at low speed. Corn oil was first added in a 50-mL aliquot. The blender was run at high speed, and additional oil was added at 1.0 mL/s until the solution changed phases as evidenced by a viscosity change, a darkening color, and an audible change in motor speed. The total amount of oil used was recorded and was used to express emulsification capacity (EC) as the amount of oil (mL) needed to effect the phase change.

Emulsion stability

Modified procedures described by Townsend *et. a.l* (1968) were employed to determine emulsion stability. In brief, emulsion was prepared by mixing 70 gr sample, 30 gr fat, 15 ml cold water and 2 gr salt in an Omni mixer. The emulsion was weighed and transferred into a plastic bottle with cap and placed in a shaker waterbath with 48.8^{o}C initial temperature. The temperature was raised intermittently until the internal temperature of the mixture reached 68.8^{o}C in about one hour. Fat and water released during cooking were transferred into graduated tubes and centrifuged. The amount of fat and water were determined and expressed as ml or gr per 100 gr emulsion. Cooking recovery was calculated as cooked and drained weight divided by initial weight multiplied by 100.

Statistical analysis

Variability between treatments was tested using analysis of variance (ANOVA) employing Generalized Linear Model procedures of SAS software with 5% level of significance. The *post hoc* test used was Honestly Significance Test (HST).

Results and Discussion

Table 1 shows that treatments significantly affected the pH of ground spent duck meat ($P<0.05$). The use of iced water, NaCl and $NaHCO_3$ to remove meat pigments significantly increased meat pH, hence M4 has the lowest pH. As expected, $NaHCO_3$ treated meat has the highest pH. In term of WHC, M1 meat has significantly higher WHC (less percentage of free water) than control (M4), whereas M2 and M3 meat has similar WHC to control. Table 1 also shows that gel produced from washed meat was significantly more tender and less firm than control. Treating ground duck meat with iced tap water, NaCl or NaHCO3 produced significantly more tender meat gel compared to untreated meat (as is). Meat gel of M3 was the most tender followed by M2 and M1. Similar results for meat gel firmness were observed.

In general, no significant differences were observed in term of emulsion capacity (expressed as ml oil/gr protein and ml oil/gr fresh meat), emulsion stability (expressed as ml oil and total liquid released per 100 gr emulsion), and cooking recovery (%). The general average of oil than can be emulsified was 709 ml/gram of protein.

Results shows that several characteristics of ground spent duck meat were changed after washing the meat with iced water, NaCl or $NaHCO_3$ solution. Washing resulted in loss of sarcoplasmic protein and other water-soluble material. Babji and Kee (1994) reported 10.23 and 13.05% sarcoplasmic protein (% total protein) after repeated washing of broiler and spent hen meat. As a result, the myofibrillar protein proportion increased and this condition was expected. This type of protein plays important roles in the preparation of emulsion-type meat products, such as meatballs, sausages and patties. In addition, washing also changed the proteins, amino acid, vitamin, mineral and cholesterol contents of beef and pork (Park et al., 1996).

Tabel 1. Water holding capacity, tenderness, firmness and pH of ground spent duck meat$^{*)}$

Treatments	WHC	pH	Tenderness (gr/cm^2)	Firmness (mm penetrometer scale)
M1 (Iced water)	24.8^c	6.8^b	88.56^b	6.8^b
M2 (NaCl 1%)	51.8^a	7.2^c	51.05^c	9.3^c
M3 (NaHCO3 0.5%)	29.7^{bc}	7.9^d	4.4^d	12.8^d
M4 (Control)	43.6^{ab}	6.2^a	170.8^a	3.3^a

$^{*)}$ WHC and pH were measured in uncooked ground meat, whereas tenderness and firmness were measured in cooked products (meat gels). Means in the same column with different superscript differ significantly ($P<0.05$)

Table 2. Emulsion capacity and stability, and cooking recovery of emulsion-type products made from duck meat*)

Treatment	Ml oil/gr protein	Ml oil/gr fresh tissue	Oil released (ml)	Water released (ml)	Cooking recovery (%)
M1 (Iced Water)	691.0	135.8	8.7	6.8[ab]	83.6
M2 (NaCl 1%)	739.8	146.9	9.0	5.6[b]	83.6
M3 (NaHCO3 0.5%)	771.2	135.4	10.5	7.2[ab]	81.5
M4 (Control)	634.1	139.1	9.9	9.4[a]	81.2

*) Emulsion capacity is expressed and ml oil/gr protein and ml oil/gr fresh tissue, whereas emulsion stability is expressed as oil and water released after cooking.

Higher pH in washed meat can be attributed to the removal of lactic acid. Lactic acid in the meat is the product of post mortem an-aerobic glycolysis. pH of meat contributes to both color and functional properties (Qiao et al., 2001). Under normal condition, pH of duck meat ranged from 5.7-5.8 (Wawro et al., 2004). The fact that salt-washed ground duck meat possessed highest WHC can be attributed to the presence of NaCl which able to improve water retention in the meat system.

A lower amount of force required to shear through the meat gel indicate more tender meat gel. Except for control, sarcoplasmic proteins of spent duck were removed during washing while miofibrillar proteins were practically remain because of its insolubility in water. This resulted in the increase of the ratio of myofibrillar to sarcoplasmic protein. This finding was similar to the observation of Babji and Kee (1994) in spent hen meat. Addition of sarcoplasmic proteins into meat emulsion increase the strength of gel prepared from water-washed pork (Yuji et al., 2004). On the other hand, addition of cereal flours and fat reduced the hardness of duck meat sausages (Yang et al., 2009).

Grounding spent duck meat produces a fine paste as a mixture composed essentially of lean meat, 'fat' and water and the grain is no longer visible to the naked eye. Meat protein has been considered as having good emulsifying properties. Two types of test are currently in use in the meat industry for measuring the effectiveness of an emulsifying agent: emulsifying capacity and stability under heat. Washing treatments were expected to improve protein functionality as an emulsifier. However, results of the present experiment showed that washing ground duck meat was not able to improve emulsion capacity and stability although washed meat tended to have higher emulsion capacity. It seemed that the increase of myofibrilar protein proportion was not sufficient to significantly improve emulsion capacity. The capacity for emulsification is directly linked to the quantity of soluble proteins (Linden and Lorient, 1999). Debashis et al. (2007) reported that compare to sausages prepared from broiler meat, sausages made from duck meat have showed significantly lower moisture content, emulsion stability and cooking yield.

Emulsion capacity is an important characteristic of meat for used in the preparation of meat products such as sausages and nuggets Emulsion capacity of myofibril proteins is 160 cm^3 fat for 100 mg proteins and that of sarcoplasmic proteins is close to 30cm^3 oil for 100 mg soluble proteins. This difference in behaviour can be explained by the linear shape of the protein of the sarcomere, which are more suited than the other category to form stable pseudomembranes in the course of emulsification (Linden and Lorient, 1999). Emulsion capacity and stability are also dependent to type of meat (Ömer and Eükrü, 2008).

Cooking recovery is an important factor in the processing of meat products, and good cooking recovery depends on the stability of meat emulsion. Cooking recovery observed in the present study is similar to those reported by Yang and Froning (1992) in mechanically deboned chicken meat. Cooking recovery can be improved by adding vegetable oil and rice bran fiber in low-fat meat emulsion (Zorba and Kurt, 2006).

Conclusions

Preparation procedures significantly influence the functional characteristics of spent duck meat. Functional characteristics of spent duck meat can be improved by grinding followed by three steps washing treatment with NaHCO3 solution 0.5%. The products can be used to prepare meat-based food products requiring meat protein as emulsifier, such as sausages and nugget.

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