

Research Article

Physico-chemical characteristics of surimi gels made from washed and mechanically deboned Peking duck meat

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Abstract

Peking duck (*Anas platyrhynchos domesticus*) is the most popular duck breed in Asia which is raised for their meat. Nonetheless, duck meat is less utilized as further processed products due to its low functional properties including lower water holding capacity, emulsion stability, cooking yield and higher cooking loss. Washing processes of mechanically deboned/recovered meat have for a long time been applied to obtain better quality characteristics of meat, particularly in surimi and surimi-like materials production. The effects of washing processes on mechanically deboned Peking duck meat (MDPDM) after every washing cycle were investigated. MDPDM were washed up to three times with tap water and dewatered by centrifugation. Chemical composition and functional properties of MDPDM were analyzed by triplicate analysis of duplicate samples.

Washing processes removed the fat until 74.47%, reduced myoglobin content from 8.22 to 3.85 mg/g ($p < 0.05$), and increased pH from 6.48 to 7.10 and water holding capacity from 3.26 to 4.87 g water/g protein ($P < 0.05$). Colour and textural properties were evaluated on surimi gels. Gels were prepared from unwashed and washed meat after being blended with 3% NaCl and heated at 90°C for 10 minutes. Both colour and textural properties were improved significantly ($P < 0.05$). Gel strength increased from 1136.2 (unwashed meat) to 9477.7 *g.mm* after the third washing cycle. Texture profile of meat such as hardness and cohesiveness increased while its springiness decreased. It was therefore concluded that a washing cycle in triplicate was sufficient to improve the quality of MDPDM, thus it has potential to be developed as surimi-like material and utilized into further processed products.

Keywords: poultry, value addition, waste recovery, colour, texture, Malaysia.

Introduction

Duck meat production in the world has increased over the years. It had achieved 3.7 million tons per year in 2008, thus making duck meat as the most widely produced after chicken and turkey meat among the poultry. Beyond this increasing number of production, there is high demand for duck meat due to changing of seasonal character in consumption, making it acceptable as an all-year-round dish. It also has been helped by the availability of modern husbandry techniques that are able to supply great number of ducks [1, 2]. Duck meat is predominantly produced in Asian countries. Malaysia has become the third largest duck meat producer after China and France [3]. Peking duck (*Anas platyrhincos domesticus*) is the major breed for meat ducks in Asia [4, 5].

On the other hand, duck meat is less utilized as further processed meat products compared to chicken and turkey meat. Several studies have reported the susceptibility of duck meat and further processed products made from duck meat. Ali *et al.* [6] reported that duck meat had higher cooking loss, darker colour and more rapid decline of shear force during storage compared to chicken meat. Bhattacharya *et al.* [7] reported that sausages made from duck meat had lower cooking yield and emulsion stability. Biswas *et al.* [8] reported patties made from duck meat also had lower emulsion stability and cooking yield compared with chicken patties. This therefore indicates duck meat needs to be improved.

Washing treatment in surimi processing has successfully improved low value fish meat to become widely utilized raw materials and processed into various products. Surimi processing consists of removing undesired components by washing treatments and concentrating myofibrillar proteins by dewatering process. Myofibrillar proteins are closely related to functional and textural properties of meat [9, 10, 11].

Based on the successes with fish surimi, there has been further research in applying surimi processing techniques for non-fish meat such as beef, pork, mutton, sheep and chicken meat. These other types of meat have been known as surimi-like material which showed improvement in functional, textural and colour properties [12 - 20]. Surimi-like material has also been applied in further processed products such as nuggets and sausages [14, 21, 22]. However, research on the subject of surimi-like material from Peking duck meat has not been published. This research was conducted to study improvement effects of washing processes on mechanically deboned Peking duck meat.

Material and Methods

Materials

Mechanically deboned Peking duck meat was obtained from carcasses that were mechanically deboned at commercial processing plant (Fika Food Corporation Sdn. Bhd., Penang, Malaysia) using a deboning machine with pore size 0.9 mm (Meat Maker Deboner, Prince Industries Inc., USA) and kept as frozen meat block form. Tap water was used for leaching (washing processes).

Methods

Preparation of washed duck meat

Meat blocks were cut into smaller sizes and ground using meat grinder, then stirred with 3 portions of tap water (below 5°C) using a universal mixer for 5 minutes. Mixture was strained then centrifuged at 4000 rpm for 15 minutes and temperature was kept below 4°C using Union 5KR centrifuge (Hanil Science Industrial, Co., Ltd., Korea). Fat and supernatant were discarded from meat concentrate. Washing process cycles were continued for three times.

Gel preparation

Washed and unwashed minces were added with 3% salt and mixed using cutter mixer (Blixer®, Robot Coupe USA, Inc.) for one minute until they turned to meat batter. The batter was stuffed into plastic casing cylinders (diameter 2 cm, height 15 cm). Stuffed batter were incubated in water bath at 40°C for 30 minutes and heated at 90°C for 10 minutes. They were then immediately placed and cooled in ice to obtain core temperature of gels below 10°C.

Analysis

Chemical composition

Moisture, protein and fat contents were analyzed according to AOAC methods [23]. Moisture was determined by the air oven drying method at 110°C for 24 hours. Protein content was evaluated by the Kjeldahl method, while fat content was determined by the Soxhlet method.

pH measurement

pH was measured using digital pH meter (pH 211 microprocessor pH meter (Hanna Instrument®, USA). About 5 g of meat was mixed with 45 ml of distilled water using homogenizer (T25 digital ULTRA-TURRAX®, IKA®, Germany) and the pH was noted.

Water holding capacity

About 20 g of meat was mixed with 40 ml of distilled water using homogenizer (T25 digital ULTRA-TURRAX®, IKA®, Germany). 10 g of mixture was weighed into centrifugation tube then centrifuged at 2500 rpm for 5 min. Supernatant was discarded and precipitate was weighed. Water holding capacity was expressed as grams of water per grams of protein of the meat (g water/g protein).

Myoglobin content

Myoglobin content was analysed using the method of Jin, *et al.* [14], with slight modification. Two grams of sample were homogenized with 20 ml of 0.04 M phosphate buffer pH 6.8 at 13,500 rpm for 20 s. Then 10 g of homogenate was placed into centrifugation tube and centrifuged at 4000g for 30 min. The supernatant was filtered with Whatman No.1 filter paper and added with 0.2 ml of 1% (w/v) sodium dithionite. Myoglobin was measured using spectrophotometer at 555 nm, calculated from the millimolar extinction coefficient of 7.6 and a molecular weight of 16,111. Myoglobin content was recorded as mg/g sample.

Colour Analysis

Colour measurement was done to cooked surimi gel. Colour properties includes L* (lightness), a* (redness), and b* (yellowness) were measured using Minolta CM-3500d spectrophotometer. Whereas whiteness was calculated using this particular formula: $100 - [(100-L^*)^2 + a^{*2} + b^{*2}]^{1/2}$ (Park, 2005).

Gel strength, breaking force and deformation

Textural properties include breaking force, deformation and gel strength were measured using TA-XT plus (Stable Micro Systems, Ltd., UK). Cooked surimi gels were tempered at 20°C prior to measuring then cut 3 cm thick. Pieces of gel were placed upright on the platform. Gel was penetrated by spherical probe.

Texture Profile Analysis

Texture profile including hardness, chewiness, cohesiveness and springiness was measured using TA-HDi (Stable Micro Systems, Ltd., UK). Cooked surimi gels were tempered at 20°C prior to measuring then cut 3 cm thick. Pieces of gel were placed horizontally on the platform. Gel was forced by compression platen.

Results and Discussion

Chemical composition and functional properties of washed meat

Moisture, fat and protein

Chemical compositions are shown in Table 1. Washing processes reduced fat and increased moisture content after the third washing. Moisture content of unwashed minces was 64.96% and obviously increased after the third washing to become 79%. That moisture content is considered as second grade surimi, whereas first grade surimi normally has 77-78% moisture content [24]. Fat removal reached 74.47% and left 5.81% fat content. Duck meat has higher fat content than chicken, thus this washed duck meat did not result as low as 1-3% fat content of chicken surimi such as Ensoy *et al.* [25] and Jin *et al.* [14] found.

Furthermore, duck meat is rich in intramuscular fat which is about similar to red meat [26]. The methods used in this research did not achieve very low fat content such as mutton and sheep surimi-like material as reported by McCormick *et al.* [15] and Antonomanolaki *et al.* [12]. Among the reasons are their surimi was washed with a higher water ratio and longer stirring time during washing, e.g. 1 to 5 ratio and 10 minutes respectively. More water usage and washing time on surimi processing removed more undesirable components, but then resulted in more water waste [27, 28]. Protein was maintained until 84.19%, slightly reduced from 11.26% to 9.48%. Most of reduced proteins on surimi processing are sarcoplasmic which is water-soluble [29].

Table 1. Chemical composition of unwashed and washed meat.

Meat	Moisture (%)	Fat (%)	Protein (%)	Fat Removal (%)	Protein Recovery (%)
Unwashed	64.96 ±0.20	22.76 ±0.13	11.26 ±0.14	ND	ND
After third washing	79.00 ±0.04	5.81 ±0.48	9.48 ±0.21	74.47	84.19

- Values are expressed as mean ± standard deviation
- ND means not determined

pH and WHC

Washing treatment escalated pH value on every washing step. pH increased significantly from 6.48 on unwashed meat to 6.84, 7.02 and 7.10 after first, second and third washing respectively. This pH increment was confirmed by a previous report on chicken surimi [16]. Existing amounts of lactic acid on unwashed meat led to pH declining, otherwise washing processes reduced lactic acid and affected pH increment [14]. Unwashed duck meat had low WHC with ratio 3.26 grams water per gram protein. WHC increased to 3.56, 4.62 and 4.87 gram water per gram protein after first, second and third washing respectively. WHC was increased along with pH value after meat washing processes [14].

Myoglobin and colour properties

Myoglobin content of meat, lightness and whiteness of cooked surimi gels are shown in Table 2. Myoglobin is a part of the sarcoplasmic proteins which is undesirable in surimi. Myoglobin content was reduced significantly after first washing from 8.22 to 3.85 mg/g ($p < 0.05$) and gradually decreased after second and third washing, from 2.88 to 2.42 mg/g ($p < 0.05$). The amount of myoglobin also affects the colour properties of surimi. As a result of lower myoglobin content on washed meat, it achieved higher lightness and whiteness significantly ($p < 0.05$), from only 60.86 to 74.49 and 56.44 to 65.68 respectively. Antonomanolaki *et al.* [12] correlated

lighter colour of surimi as result of higher moisture content. Similar results were confirmed by Nowsad *et al.* [16] and Ensoy *et al.* [25].

Table 2. Myoglobin, pH and WHC of unwashed and washed meat.

Meat	pH	WHC (g water/g protein)	Myoglobin (mg/g)	Lightness	Whiteness
Unwashed	6.48 ^a ± 0.04	3.26 ^a ± 0.04	8.22 ^d ± 0.01	60.86 ^a ± 0.60	56.44 ^a ± 0.02
1 st washing	6.84 ^b ± 0.00	3.56 ^a ± 0.07	3.85 ^c ± 0.32	63.38 ^b ± 0.01	58.51 ^b ± 0.61
2 nd washing	7.02 ^c ± 0.00	4.62 ^b ± 0.12	2.88 ^b ± 0.07	66.64 ^b ± 0.18	62.46 ^c ± 0.12
3 rd washing	7.10 ^d ± 0.01	4.87 ^c ± 0.03	2.42 ^a ± 0.04	74.49 ^d ± 0.71	65.68 ^d ± 0.83

- Values are expressed as mean ± standard deviation
- Means with different superscripts within the same column are significantly different (p<0.05)

Textural properties of cooked gels

Gel strength, breaking force and deformation

Gel strength, breaking force and deformation of cooked surimi gels are shown in Table 3. Unwashed meat had lowest gel strength, breaking force and deformation. Every washing step resulted significant improvement in breaking force (p<0.05). Third washing resulted with breaking force seven times higher than unwashed meat, from 135.60 g to 945.58 g. Gel deformation also increased significantly after first and second washing, but tended to slightly decrease after third washing. Gel strength is a main parameter to determine surimi quality in industry. Increase of gel strength is closely related to an increasing amount of concentrated myofibrillar proteins and a decrease in sarcoplasmic proteins [25]. As a result of gel breaking force multiplied by deformation, gel strength obviously and significantly increased (p<0.05) after third washing, from 1136.2 g.mm to 9477.7 g.mm. Nowsad *et al.* [16] reported similar increases in gel strength and breaking force of gels from washed spent hen and broiler compared with unwashed meat.

Table 3. Gel strength, breaking force and deformation of cooked gels from unwashed and washed meat.

Meat	Breaking force (g)	Deformation (mm)	Gel Strength (g.mm)
Unwashed	135.60 ^a ± 7.96	8.51 ^a ± 0.27	1136.2 ^a ± 28.96
1 st washing	209.07 ^b ± 5.52	9.10 ^b ± 0.25	1896.1 ^b ± 17.00
2 nd washing	574.18 ^c ± 11.28	10.80 ^c ± 0.28	6246.6 ^c ± 221.26
3 rd washing	945.58 ^d ± 0.40	10.01 ^{bc} ± 0.14	9477.7 ^d ± 99.26

- Values are expressed as mean ± standard deviation
- Means with different superscripts within the same column are significantly different (p<0.05)

Texture profile analysis

Texture profile analysis (TPA) of cooked surimi gels are shown in Table 4. This TPA showed an increase in hardness gradually and significantly, from 2313 g to 9224.15 g (p<0.05). First and second washing did not result in significant changes on chewiness, springiness and cohesiveness. Then third washing achieved highest chewiness and cohesiveness beside lowest springiness. Chewiness increased obviously from 222.86 g to 949.20 g (p<0.05). Cohesiveness increased from 0.141 to 0.249 (p<0.05), whereas springiness decreased from 0.686 to 0.410 (p<0.05). Yang and Froning [20] reported an increase in hardness and chewiness of gels from washed mechanically deboned chicken meat compared with unwashed meat. Besides myofibrillar proteins, the textural properties are influenced by salt addition and heating temperature during gel preparation. Park *et al.* [17] reported 3% salt addition achieved the highest hardness of gel and water binding activity. Uresti *et al.* [30] reported surimi gels which were set at 40°C and

continued with heating at 90°C had highest intensity of myosin. Myosin is part of myofibrillar proteins that are responsible for gelling capacity of the muscle system.

Table 4. Texture profile analysis of cooked gels from unwashed and washed meat.

Meat	Hardness (g)	Chewiness (g)	Springiness	Cohesiveness
Unwashed	2313 ^a ±8.77	222.86 ^a ±18.76	0.686 ^c ±0.01	0.141 ^a ±0.01
1 st washing	6633.70 ^b ±78.91	744.08 ^b ±46.87	0.568 ^b ±0.03	0.198 ^b ±0.00
2 nd washing	7234.80 ^c ±166.88	717.60 ^b ±18.00	0.526 ^b ±0.00	0.189 ^b ±0.00
3 rd washing	9224.15 ^d ±216.44	949.20 ^d ±88.44	0.410 ^a ±0.04	0.249 ^c ±0.00

- Values are expressed as mean ± standard deviation
- Means with different superscripts within the same column are significantly different (p<0.05)

Conclusion

Three washing cycles is sufficient to make surimi-like material from mechanically deboned Peking duck meat with improved quality. Meat undergoing a third washing resulted in the highest moisture, lightness, whiteness, water holding capacity, pH, gel strength, hardness and chewiness, besides lowest in fat and myoglobin content. As well as developing surimi-like material from mechanically deboned Peking duck meat as a raw material, further research may be conducted to develop it into ready to eat products.

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