Agriculture and Natural Resources 52 (2018) 382–387

Contents lists available at ScienceDirect

Agriculture and Natural Resources

journal homepage: http://www.journals.elsevier.com/agriculture-and-natural-resources/

Original Article

Hoary basil seed mucilage as fat replacer and its effect on quality characteristics of chicken meat model

Ekkarach Saengphol,[a] Tantawan Pirak[a, b, *]

[a] Department of Product Development, Faculty of Agro-Industry, Kasetsart University, Bangkok 10900, Thailand
[b] Product Innovation Research Unit (PIRUN), Department of Product Development, Faculty of Agro-Industry, Kasetsart University, Bangkok 10900, Thailand

ARTICLE INFO

Article history:
Received 23 September 2017
Accepted 7 June 2018
Available online 21 June 2018

Keywords:
Sensory perception
Chicken meat source
Pork back fat
Hoary basil seed mucilage
Fat replacer

ABSTRACT

The effect of chicken breast meat source and main ingredients (salt, pork back fat (BF) and hoary basil mucilage (HBM)) on sensory perception and quality characteristic of meat products was investigated. Three different meat sources were selected and assigned as Brand A, B and C. Brand C had highest protein content (26.38%) and extracted salt soluble protein content (7.54%), which indicated the nutritional and quality of meat. This sample was used for investigating the effect of salt (1% and 2%) and BF to HBM ratio (100:0 to 0:100) on meat product model properties. The significant effect of these factors was detected ($p < 0.05$). The model with 2% salt without HBM possessed the gels with superior texture and sensory properties; however, HBM was able to substitute as BF replacer at 80% (2% salt) without any change of sensory perception from 100% BF model.

Copyright © 2018, Kasetsart University. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Introduction

Meat is considered as a good source of protein due to its nutritional properties and appreciated taste and flavor (Soares et al., 2014). The highest consumption of meat is reported as chicken meat due to its nutritional value and religious reason. It consisted of high protein content with low fat content, and also contained minerals and a small proportion of carbohydrates (Shah et al.,2014). In addition, chicken meat has less total fat, saturated fat and cholesterol than beef and pork (Tahergorabi et al., 2011). Hence, chicken meat and their products occupy a prominent position in the human diet because of their high quality protein content, essential amino acids and excellent source of vitamin B complexes, minerals and other nutrients (Cui et al., 2009; Hygreeva et al., 2014). The internal properties of meat, such as pH, protein content, extractable salt soluble protein content, directly affected the production system and quality of the resulted product. These properties depended on breed, weight, diet, sex, age and source (Díaz et al., 2005). In Thailand, there are various types of market both in urban and rural area; for example flea market, open market, minimart, supermarket and hypermarket. These markets sell various types of meat at different price and quality. Hence, the effect of meat source on meat quality and safety is very interesting in order to select the proper meat for further processing. Salt (NaCl) is considered as the most important ingredient in meat products, being constantly studied due to its contribution to the sensory attributes of meat flavor and texture. During the process of meat products, the most important step is to extract the salt soluble protein from the meat with NaCl. The sticky rigid meat batter was received. Moreover, it improves the water retention properties of the meat as a consequence of an increase in myofibrillar proteins solubility (Puolanne et al., 2001; Volpato et al., 2008).

The second most important ingredient in meat product is fat. Fat contributes the texture, flavor, juiciness, tenderness, and also palatability of the products. Due to the fact that pork back fat (BF) used in meat products contained the large amount of saturated fatty acid, several studies have been making great efforts to develop meat products with reduced fat contents. The BF substitution with the other ingredients directly affected the overall qualities of meat product; hence the amount of fat replacer was limited. The results of Abiola and Adegbaju (2001) indicated that up to 66% BF can be replaced with rind in pork sausage without the adverse effect on processing yield. Furthermore, the replacement of oatmeal and tofu in low fat sausage was also studied. BF was replaced with 25% hydrated oatmeal or 25% tofu without the change of acceptability (Yang et al., 2007). Moreover, Mora-Gallego et al. (2014) reported that sunflower oil (3%) suited for using asBF substitution in

* Corresponding author. Department of Product Development, Faculty of Agro-Industry, Kasetsart University, Bangkok 10900, Thailand.
E-mail address: fagitwk@ku.ac.th (T. Pirak).

https://doi.org/10.1016/j.anres.2018.06.001
2452-316X/Copyright © 2018, Kasetsart University. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

fermented sausages, conferring desirable sensory properties similar to sausages with 100% BF.

Hydrocolloid is one of the prominent fat replacer in meat products, confirmed by previous reports. Mucilage is one of important hydrocolloids in food formulation. It is usually used as gelling, thickening and stabilizing agents, that able to improve stability and textural properties of many food products (Hosseini-Parvar et al., 2010; Karazhiyan et al., 2011). Khazaei et al. (2014) reported that hoary basil mucilage (HBM) are mainly composed of two major fractions of glucomannan (43%), with the ratio of glucose to mannose 10:2, and (1 → 4)-linked xylan (24.29%) and a minor fraction of glucan (2.31%). HBM is a novel hydrocolloid which is recently interested to use in food products. It has a great potential to be used as thickening, stabilizing ingredient and fat replacer in the food systems (Rafe et al., 2012) such as processed cheese (Hosseini-Parvar et al., 2015) and low fat ice cream (Javidi et al., 2016). The previous research show that the optimal HBM quantity could be substitute fat in food products and did not affected on characteristics of food system. However, there has been limited information published on the application of HBM in meat products.

The objective of this study was to substitute of BF with HBM and to evaluate the effect of chicken breast meat source, salt concentration and BF reduction on sensory perception and other important properties of chicken meat model.

Materials and methods

Chicken breast meat selection and quality characteristics

Material

There are 3 different meat markets in Thailand— meat from local market, meat from supermarket and meat from premium supermarket. These meats were different in manufacturing and storing process condition. Fresh chicken breast meats (skinless, trim and clean) were collected from different retailed cuts and randomly selected in the same production lot to ensure the quality consistency.

Brand A is the retailed cuts purchased from local market. Chicken were raised in opened-system farm. Whole chicken breast was cut by trader without temperature control. Meat was stored in refrigerator and put on ice tray for sale in open market at the price around 70 baht/kg.

Brand B is the retailed pack purchased from supermarket. Chicken breast meat was obtained from the contracted slaughter houses and repacked in plastic tray with shrink film on top at the supermarket. The meats were stored at temperature ≤4 °C, with the control of meat hygiene and temperature. The price is around 200 baht/kg.

Brand C is the retailed pack from premium supermarket. The chicken was raised in closed-system farm and manufacturing at the meat slaughter houses that certified quality standard including Q Mark, GMP, HACCP, ISO 9001:2008 and ISO 14001:2004. They claimed that the meat was protected against pathogens and parasites that may be caused by natural factors. The meat also contained no antibiotic residues, no growth promoter, no insecticides and no harmful pathogens. Chicken breast meat was packed in plastic tray, add water absorbent, tightly sealed with plastic film and stored at ≤4 °C. The price is 215 baht/kg.

After purchased, chicken samples were stored at −18 °C for further use. The frozen samples were thawed in refrigerator (4 °C) for 12 h before determination of quality characteristics.

Proximate composition and pH value

The proximate composition was determined using the method of Association of Official Analytical Chemists (2000).5 g of ground cooked chicken breast meat were added in 45 ml of distilled water and homogenize for measuring pH values (Petrou et al., 2012).

Salt soluble protein extraction

The samples were extracted with 5% NaCl using the buffer to meat ratio of 2:1. They were blended for 60 s and stored at 4 °C for 24 h. Then, the samples were centrifuged (10,000 rpm, 4 °C) for 30 min according to the method of Barbut et al. (2005) and kept the upper supernatant (salt soluble protein, SSP) at 4 °C for assay. SSP was compared with standard protein concentration on Biuret's method (Copeland, 1994).

Color measurement and cooking loss

The surface color of samples (rawand cooked) was assessed using a Spectrophotometer (D_{65} light source, 10° standard observer; Model CM-3500d; Minolta Camera Company; Osaka; Japan) and expressed in terms of L*, a*, and b* scores (Kirmaci and Singh, 2012). Color evaluation was conducted in duplicate. Cooking loss was determined for 5 individual samples and calculated based on the weight differences before and after cooking (Choi et al., 2014) as following Eq. (1):

$$\text{Cooking loss } (\%) = \left(\frac{W_r - W_c}{W_r}\right) \times 100 \quad (1)$$

where: W_r = weight of raw meat (g)

W_c = weight of cooked meat (g)

Microbiological analysis

A sample of 10 g was randomly picked, homogenized and diluted for microbial analysis (total plate count and yeast mold) using the pour plate technique (Kok and Park, 2007). The results were expressed as log numbers of colony forming units per gram of sample (log cfu/g). The samples were analyzed at day 1 after production. The analysis was carried out in duplicate.

Sensory evaluation of chicken breast meat

Sensory evaluation was performed to the panelists in the sensory room of the Kasetsart University Sensory and Consumer Research Center (KUSCR), Department of Product Development, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand.

Each sample was evaluated in term of color, aroma, flavor, tenderness, juiciness and overall liking by 30 semitrained panelists using 9-point hedonic scaling test. The scores, ranging from 1 to 9, were as follows: 1—disliked very much; 2—disliked; 3—moderately disliked; 4—slightly disliked; 5—indifferent; 6—liked slightly; 7—liked moderately; 8—liked; and 9—liked very much.

Chicken breast meats were steam until a center temperature of 75 °C in a steam pot (boiled water at 95 °C), cooled to 25 °C, cut into small dice (1.0 cm^3), coded with a randomly selected 3-digit number and served to the panelists randomly. They tasted the sample one by one and were instructed to clean their mouth between each sample with water.

Hoary basil seed selection, production and characteristics of HBM

Hoary Basil seed from Raitip brand (Thai cereal world Co. Ltd., Bangkok, Thailand) was used. They were removed of dusts and chaffs. The cleaned seeds were kept in plastic bags, sealed to prevent quality changes and stored in cooled-dried place.

Hoary Basil seeds were soaked and swelled in distilled water (1:30) at 4 °C for 30 min. Then, the swollen seeds were drained and blended with Waring blender (8011BU, Waring, Germany) at

10,000 rpm for 20 s. Separation of mucilage from seeds was performed by squeezing through muslin cloth and stored at 4 °C. The process and condition for soaking was selected from preliminary study and the properties of HBM was mainly composed of water (98%) and it possessed pH at 5.57. It had light gray color (L* at 51.76, a* at 0.64 and b* at 3.39). The extractable yield was 76.66%. HBM had the good water and oil binding ability (21.50 and 31.23 g/g sample, respectively). This result implied that HBM is the potential hydrocolloids that able to corporate in meat batter with the promising improvement of water binding and texture. This sample was extracted in bulk and used in meat product model as BF replacer.

Chicken meat model and quality characteristics

In an experiment, two factors including substitution of BF with HBM at different ratio (100:0, 80:20, 60:40, 40:60, 20:80 or 0:100) and salt concentration at 1% and 2% of total weight was studied.

Chicken meat model processing

Chicken breast meat use in this study was selected from previous procedure. Lean meat was cleaned, cut into small dice size and then frozen. BF was minced twice (minced through a 3 mm grinding plate) in a meat mincer and store at −18 °C until use.

Meat model consisted of 365 g of ground meat, 135 g of BF:HBM and different salt content upon formulation. Frozen meat was blended on low speed in a bowl chopper with half salt content and 50 g of ice water for 2 min to allow sufficient protein extraction. Fat, remaining salt and an additional 50 g of ice were added, blade speed was increased to high, and chopped continued for 3 min. Batter was removed from the bowl chopper, stuffed into 2.0 cm collagen casings, cooked until internal temperature of 75 °C, cooled down in an ice bath, vacuum packed and stored at 4 °C for further analysis.

The pH value and color measurement

The pH measurement was same as the method used in chicken breast sample and color was objectively measured at the center of cooked sample slices (2.0 cm thickness) using a method similar to chicken breast meat measurement.

The color of meat models were determined as the surface color based on the method described in the previous section with some modification in sample preparation. The meat models were cut into the 2 cm length and measured for 6 times per sample.

Water holding capacity (WHC)

For WHC analysis, the centrifugation method (10,000 rpm for 15 min at 4 °C) was used (Pramualkijja et al., 2016). The WHC was expressed as a percentage of the initial water content of the sample and was calculated using the following Eq. (2):

$$\text{WHC}\ (\%) = \left(\frac{W_s - W_w}{W_s}\right) \times 100 \qquad (2)$$

where: W_s = weight of initial sample (g)

W_w = weight of water loss (g)

Texture analysis

TPA was performed using a texture analyzer (Stable Micro System, TA. XT Plus, UK) equipped with a 2 kg load cell. Prior to testing, the cooked model were steam until a center temperature of75 °C in steam pot (boiled water at 95 °C), cooled to 25 °C and sliced into 2.0 cm thickness. The samples were subjected to compression testing using a cylindrical probe (36 mm in diameter). The probe compressed the sample to 50% of its original height twice at a speed of 2.0 mm/s. From the resulting force/deformation curves, the textural parameters were calculated (Chen et al., 2007).

Sensory evaluation of chicken meat model

A sensory evaluation was performed using 30 semitrained panelists who evaluated their attribute of the product in terms of appearance, aroma, tenderness, juiciness and overall liking by 9-point hedonic scaling test using the method as described in the previous section.

Each sample, were presented to the panelists in the sensory room of the Kasetsart University Sensory and Consumer Research Center (KUSCR), Department of Product Development, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand.

The samples were previously reheated until a center temperature of 75 °C in a steam pot (boiled water at 95 °C). The samples were then cut into approximately 2.0 cm thickness with cylindrical shape of 2 cm diameter (total weight around 10 g) and transferred to encoded plastic box that were covered with aluminium foil to ensure minimum loss of heat and volatile aromatics. The plastics box were kept in a steam pot at 75 °C to maintain the temperature of the samples within the range of 65–70 °C.

Two pieces per treatment were provided for every panelist in plastic and lidded containers that were coded with a randomly selected 3-digit number. The samples were served randomly in tray one by one and water was served in order to be used between the tastings to remove the aftertaste.

Statistical analysis

The experiment were studied with two replicates ($n = 2$). In each replicate, at least three measurements were performed for all determinations. The differences between each samples was analyzed using statistical software (SPSSversion 12.0, SPSS, Thailand) package with an ANOVA. When the significant effect was found ($p < 0.05$), the Duncan New's Multiple Rank test was used to compare the mean values. The data are reported as mean values ± standard deviation (SD).

Results and discussion

Effect of different source on characteristics of chicken breast meat

Proximate composition and chemical properties of chicken breast meat

The protein content of chicken breast meat Brand C was significantly different from that of the other samples (Table 1). It was a certified-safe meat, which lowest fat content and highest protein content. However, ash content of chicken meat Brand C did not significantly different from chicken breast meat Brand A and B. The different source did not affect moisture and carbohydrate content of the collected meat ($p > 0.05$). These results correlated with the report of Díaz et al. (2005) that composition can be influenced by individual factors such as diet, breed, age/weight and level of fat.

The highest salt soluble protein (7.54%) and extractable yield (27.50%) were found in chicken breast meat Brand C (Table 1). The pH value of the three chicken breast meats were in between 5.87 and 6.00 within the range of pH values in previous reports (5.81–6.12) (Zheng et al., 1999; Qiao et al., 2002). The chicken breast meat Brand C had pH value greater than Brand A and B ($p < 0.05$). The correlation between pH value and cooking loss were similar to the results of Barbut et al. (2005). They also found that chicken meat (pH = 6) had lowest cooking loss than when comparing with other chicken meats (pH value below or upper 6). They explained that chicken meat with pH at 6 had appropriate quality.

Table 1
Properties of chicken breast meat from different sources.

Properties			Brand A	Brand B	Brand C
Chemical properties					
Chemical composition (%wb)	Moisture ^{ns}		66.48 ± 1.10	65.13 ± 1.40	65.25 ± 1.68
	Protein		25.08 ± 0.90^{b}	24.42 ± 0.48^{c}	26.38 ± 0.89^{a}
	Carbohydrate ^{ns}		4.42 ± 1.89	6.21 ± 1.02	4.35 ± 2.24
	Fat		2.99 ± 0.10^{b}	3.13 ± 0.22^{a}	2.94 ± 0.14^{b}
	Ash		1.03 ± 0.06^{b}	1.12 ± 0.06^{a}	1.09 ± 0.03^{ab}
pH value			5.87 ± 0.00^{c}	5.94 ± 0.00^{b}	6.00 ± 0.00^{a}
SSP	Yield (%)		12.02 ± 1.60^{b}	11.30 ± 2.73^{b}	27.50 ± 3.45^{a}
	Protein (mg BSA/gDW)		5.38 ± 0.24^{c}	6.53 ± 0.84^{b}	7.54 ± 0.19^{a}
Physical properties					
Color	Raw meat	L*	61.72 ± 0.72^{a}	57.50 ± 2.13^{b}	56.92 ± 1.94^{b}
		a*	5.19 ± 0.85^{b}	7.98 ± 0.97^{a}	5.23 ± 1.09^{b}
		b*	13.92 ± 1.21^{b}	17.81 ± 1.61^{a}	14.36 ± 2.77^{b}
	Cooked meat	L*	76.22 ± 1.04^{b}	78.49 ± 1.73^{a}	78.24 ± 1.40^{a}
		a*	2.01 ± 0.57^{b}	3.05 ± 0.35^{a}	2.49 ± 0.36^{ab}
		b* ^{ns}	17.40 ± 2.50	18.04 ± 0.53	17.62 ± 1.93
Cooking loss (%)			5.70 ± 2.40^{ab}	17.91 ± 2.75^{a}	14.21 ± 1.70^{b}
Microorganism properties					
Total Plate Count (cfu/g)			1.46×10^{3}	2.13×10^{3}	1.31×10^{3}
Yeast/Mold (cfu/g)			2.92×10^{2}	2.78×10^{2}	2.68×10^{2}

$^{a-c}$Mean within the same row with different letters are significantly different ($p < 0.05$) while ^{ns} mean within the same row aren't significantly different ($p > 0.05$).

Color value and microorganism analysis

The color of post-cooked chicken breast meat was white gray. The meat source significantly ($p < 0.05$) affected color of the obtained chicken meat due to its internal property. L* and b* of pre-cooked meats were lower than post-cooked meats while a* was found in the opposite way. Chicken breast meat Brand C had lowest total bacterial count (1.31×10^{3} cfu/g) and yeast/mold (2.68×10^{2} cfu/g), when compare to Brand A and B due to chicken breast meat Brand C was better storage condition than others.

Sensory evaluation of chicken breast meat

For sensory evaluation, the samples were not significantly ($p > 0.05$) on color, aroma, tenderness and overall liking, except flavor and juiciness. Chicken Brand A was the lowest score on attribute of flavor and juiciness due to this sample was not control temperature storage on shelf. It affected loss water of chicken breast meat between period storage.

Chicken breast meat Brand C was good taste and acceptable (Table 2). These results implied that chicken breast meat Brand C possessed high quality with good functional properties. Hence, chicken breast meat Brand C was the appropriate sample to study in next experiment.

Effect of salt concentration and BF:HBM ratio on characteristics of chicken meat model

Physicochemical properties of meat product model

Effect of salt concentration and BF to HBM ratio were detected. These factors affected color and pH value ($p < 0.05$) of the produced model. The high salt concentration could be protected the change of color. When increasing temperature, the lightness of batter with 1% and 2% salt increased. However, the color change of batter with 2% salt concentration was lower than batter with 1% salt (Table 3). Moreover, a* value of pre-cooked and post-cooked batter was decreased when temperature increased similar to b*. This might occurred because of the degradation of meat pigment—myoglobin, when heated. In addition, the increase of BF level resulted in increasing of L* and decreasing of water holding capacity as well as the addition of HBM. Some studies have been reported the significant increase of L* values with increasing fat level, such as in Greek traditional sausages (Papadima and Bloukas, 1999) and Sucuk, a Turkish traditional fermented sausage (Soyer et al., 2005).

Table 2
Sensory evaluation of chicken breast meat from different sources.

Attributes	Brand A	Brand B	Brand C
Color^{ns}	6.73 ± 1.30	7.15 ± 1.04	6.83 ± 1.96
Aroma ^{ns}	6.03 ± 1.62	6.32 ± 1.61	6.17 ± 1.43
Flavor	5.90 ± 2.02^{b}	6.88 ± 0.94^{a}	6.35 ± 1.40^{ab}
Toughness ^{ns}	6.55 ± 1.85	6.65 ± 1.30	6.63 ± 1.46
Juiciness	5.98 ± 2.00^{b}	6.63 ± 1.18^{a}	6.27 ± 1.39^{ab}
Overall liking ^{ns}	6.13 ± 1.85	6.65 ± 1.19	6.37 ± 1.50

$^{a-b}$Mean within the same row with different letters are significantly different ($p < 0.05$) while ^{ns} mean within the same row aren't significantly different ($p > 0.05$).

When increasing of salt concentration, the pH value was decreased. The interaction between salt concentration and pH value were clearly shown especially at high salt concentration (Table 3). Furthermore, water holding capacity was depended on pH of meat. WHC of meat product model was decreased when BF was replaced by HBM due to high water content of mucilage (Fig. 1A). WHC of the cooked model was improved when increasing the salt concentration to 2%. Moreover, a report suggested that the effect of BF reduction had a greater impact on these properties than the elevated salt concentration (Mora-Gallego et al., 2016). The fat reduction together with the increase in the NaCl concentration at a certain level is a novel strategy for generating a low fat product. The addition of a fat replacer like HBM can be done at the limited quantity with the high salt concentration (2%).

The effects of pH and salt content on WHC were also observed by Puolanne et al. (2001). They reported that the binding of chloride ions decreased with increasing pH. In the other hand, the binding of sodium ions increased when salt was added. As a result, the maximum in water-holding was reached gel of meat or myosin at pH = 6. When adding salt over maximum level, the changes of texture and properties of products were resulted (Hosseini-Parvar et al., 2010; Rafe et al., 2012). Hence, HBM can be used at the limited quantity.

Texture of meat product model

The hardness of model with 1% or 2% salt and with or without HBM was shown in Fig. 1B. At 2% salt concentration, the chicken model had high textural property in term of hardness than 1% salt concentration. The substitution of BF with HBM affected texture of chicken meat product model ($p < 0.05$).

Table 3
pH value and color of chicken meat model with 1% or 2% salt and 0%–100% HBM.

Salt concentration (%)	Fat to HBM ratio	pH value		Color		
		Pre-cooked	Post-cooked	L*	a*	b*
1.0	100:0	6.20 ± 0.02^{b}	6.30 ± 0.03^{ab}	77.52 ± 0.97^{abcd}	0.59 ± 0.16^{bc}	14.33 ± 0.32^{ab}
1.0	80:20	6.11 ± 0.01^{c}	6.06 ± 0.08^{d}	78.27 ± 0.79^{abc}	0.71 ± 0.32^{b}	14.26 ± 0.33^{ab}
1.0	60:40	6.30 ± 0.09^{a}	6.15 ± 0.04^{cd}	77.21 ± 0.78^{bcd}	0.75 ± 0.19^{b}	14.49 ± 0.81^{ab}
1.0	40:60	6.34 ± 0.10^{a}	6.23 ± 0.03^{bc}	78.67 ± 0.38^{a}	0.88 ± 0.24^{b}	14.81 ± 0.32^{a}
1.0	20:80	6.30 ± 0.08^{a}	6.25 ± 0.03^{bc}	78.47 ± 0.94^{ab}	0.69 ± 0.21^{b}	14.45 ± 0.22^{ab}
1.0	0:100	6.29 ± 0.13^{a}	6.39 ± 0.24^{a}	77.16 ± 0.83^{bcd}	0.15 ± 0.32^{cd}	14.61 ± 0.31^{a}
2.0	100:0	6.06 ± 0.04^{cd}	6.17 ± 0.06^{cd}	74.30 ± 0.54^{f}	2.08 ± 0.21^{a}	12.31 ± 0.43^{c}
2.0	80:20	6.09 ± 0.03^{cd}	6.14 ± 0.03^{cd}	75.18 ± 0.67^{f}	2.13 ± 0.18^{a}	12.85 ± 0.32^{c}
2.0	60:40	6.12 ± 0.04^{bc}	6.16 ± 0.01^{cd}	75.55 ± 0.65^{ef}	0.78 ± 0.21^{b}	14.21 ± 0.67^{ab}
2.0	40:60	6.06 ± 0.04^{cd}	6.14 ± 0.02^{cd}	76.61 ± 0.43^{de}	0.66 ± 0.37^{b}	14.50 ± 0.73^{ab}
2.0	20:80	5.94 ± 0.03^{e}	6.16 ± 0.04^{cd}	76.90 ± 0.54^{d}	0.03 ± 0.11^{d}	14.11 ± 0.54^{ab}
2.0	0:100	6.02 ± 0.04^{de}	6.21 ± 0.05^{bc}	76.96 ± 0.54^{cd}	0.40 ± 0.21^{c}	13.83 ± 0.21^{b}

[a-f]Mean within the same column with different letters are significantly different ($p < 0.05$).

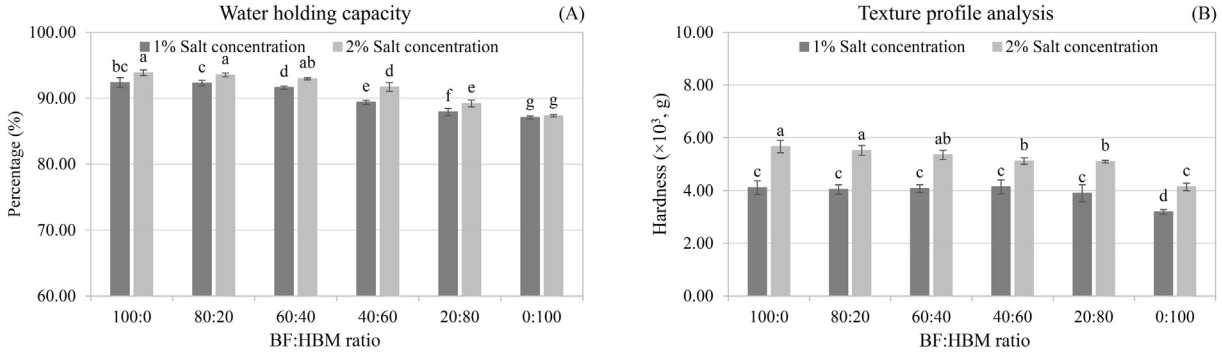


Fig. 1. Chicken meat model with HBM at different substitution level; (A) = Water holding capacity (WHC), (B) = Hardness where means with different letters are significantly different ($p < 0.05$).

Model with 2% salt and BF to HBM ratio at 100:0 possessed the highest hardness, while the lowest hardness were found in treatment with 1% salt and BF to HBM ratio at same BF:HBM ratio. The model with high salt concentration had the better texture since salt can improve binding and water-holding properties of meat products by extracting salt soluble protein. Chloride ions tend to penetrate into the intra-fluids around myofilaments causing them to swell and the sodium ions form a ion "cloud"' around the filaments This results in concentration differences which lead to an increased osmotic pressure within the myofibrils which causes the filament lattice to swell (Puolanne et al., 2001). The improvement of water holding capacity and gel formation was resulted. Moreover the addition of salt from 1 to 2% affected the amount of myofibrillar protein, which is the major protein contributed the meat batter texture water holding capacity. The higher salt concentration, the more extractable protein was received.

BF reduction of the chicken meat model with HBM were significantly different from the control, having a soft texture. The increase in the water content in the model tended to affect the heat set gelation of protein during forming the emulsion batter and hence resulted in batter with a high water content and a soft texture after boiling. Moreover, the reduction of fat resulted in a significant decrease in hardness of the resulting frankfurters, similar to the other reports (Crehan et al., 2000).

Sensory properties of chicken meat product model

The result in Table 4 indicated that the liking scores of treatments with different salt concentration and BF to HBM ratio was

Table 4
Sensory evaluation of chicken meat model with 1% or 2% salt and 0%–100% HBM.

Salt concentration (%)	Fat to HBM ratio	Attributes				
		Appearance	Aroma^{ns}	Toughness	Juiciness	Overall liking
1.0	100:0	6.50 ± 1.14^{abc}	5.67 ± 1.32	5.97 ± 1.13^{bcde}	6.00 ± 1.05^{bcd}	5.90 ± 0.99^{bc}
1.0	80:20	6.57 ± 1.22^{abc}	5.73 ± 1.60	6.50 ± 1.31^{ab}	6.73 ± 1.23^{a}	6.37 ± 1.38^{ab}
1.0	60:40	7.03 ± 0.72^{a}	5.77 ± 1.61	6.17 ± 1.26^{abcde}	6.33 ± 1.42^{abc}	6.13 ± 1.28^{abc}
1.0	40:60	6.37 ± 1.10^{bcd}	5.67 ± 1.49	5.50 ± 1.48^{e}	5.53 ± 1.28^{d}	5.57 ± 1.33^{c}
1.0	20:80	6.70 ± 0.99^{abc}	5.60 ± 1.52	5.73 ± 1.23^{de}	6.00 ± 1.11^{bcd}	5.93 ± 1.11^{bc}
1.0	0:100	6.43 ± 1.07^{abc}	5.70 ± 1.60	5.97 ± 1.13^{bcde}	5.80 ± 1.21^{cd}	5.83 ± 1.23^{bc}
2.0	100:0	6.97 ± 0.93^{ab}	5.97 ± 1.50	6.87 ± 0.97^{a}	6.77 ± 1.10^{a}	6.70 ± 1.18^{a}
2.0	80:20	6.73 ± 1.14^{abc}	5.63 ± 1.88	6.47 ± 1.07^{abc}	6.73 ± 1.05^{a}	6.40 ± 1.00^{ab}
2.0	60:40	6.53 ± 1.11^{abc}	6.07 ± 1.55	6.50 ± 1.07^{ab}	6.50 ± 1.20^{ab}	6.40 ± 1.13^{ab}
2.0	40:60	6.70 ± 1.06^{abc}	5.87 ± 1.48	6.37 ± 0.93^{abcd}	6.37 ± 1.16^{abc}	6.20 ± 1.00^{abc}
2.0	20:80	6.30 ± 1.18^{cd}	6.13 ± 1.36	6.27 ± 1.41^{abcd}	6.53 ± 1.20^{ab}	6.33 ± 1.18^{ab}
2.0	0:100	5.80 ± 1.37^{d}	5.33 ± 1.83	5.77 ± 1.28^{cde}	6.50 ± 1.11^{ab}	5.83 ± 1.53^{bc}

[a-e]Mean within the same column with different letters are significantly different ($p < 0.05$) while ^{ns} mean within the same column aren't significantly different ($p > 0.05$).

significantly different ($p < 0.05$). Appearance, tenderness, juiciness and overall liking of the model were significantly different. The addition of mucilage into chicken meat product model (2% salt) did not significantly affect the overall liking score ($p < 0.05$). The significant change was detected in treatment with 100% mucilage. The treatment with substitution ratio of BF to HBM at 20:80 with 2% salt had the highest liking score and the property of this treatment was similar to that of the control. The changes in all sensory characteristics could not be detected by the consumers. These results are congruent with the findings of other researchers (Kim et al., 2011). Hence, HBM could be used as BF replacer in meat model at 80% BF substitution.

Conclusion

Sensory perception plays an important role in meat product acceptance. There are many factors affected sensory perception of meat products such as meat source, formulation and ingredients. The understanding of those factors will enhance the potential to create the new, novel functional meat products suited for the target consumer. These results are useful for meat industry, and can be applied into various meat products. Hoary Basil mucilage can be used as pork back fat replacer up to 80% in chicken meat batter with 2% salt. The sensory perception of this treatment was similar to that of the control and this chicken meat model was accepted by consumer.

Conflict of interest

The authors declare that there is no conflict of interest statement.

Acknowledgements

The authors are grateful to the financial support from Graduated School of Kasetsart University, Bangkhen campus, Bangkok, Thailand.

References

Abiola, S.S., Adegbaju, S.W., 2001. Effect of substituting pork back fat with rind on quality characteristics of pork sausage. Meat Sci. 58, 409–412. https://doi.org/10.1016/S0309-1740(01)00043-2.

Association of Official Analytical Chemists, 2000. Official Methods of Analysis of AOAC, International, seventeenth ed. AOAC International, Washington, DC, USA.

Barbut, S., Zhang, L., Marcone, M., 2005. Effects of pale, normal, and dark chicken breast meat on microstructure, extractable proteins, and cooking of marinated fillets. Poultry Sci. 84, 797–802. https://doi.org/10.1093/ps/84.5.797.

Chen, H.H., Xu, S.Y., Wang, Z., 2007. Interaction between flaxseed gum and meat protein. J. Food Eng. 80, 1051–1059. https://doi.org/10.1016/j.jfoodeng.2006.08.017.

Choi, Y.S., Kim, H.W., Hwang, K.E., Song, D.H., Choi, J.H., Lee, M.A., Chung, H.J., Kim, C.J., 2014. Physicochemical properties and sensory characteristics of reduced-fat frankfurters with pork back fat replaced by dietary fiber extracted from *makgeolli* lees. Meat Sci. 96, 892–900. https://doi.org/10.1016/j.meatsci.2013.08.033.

Copeland, R.A., 1994. Methods for Protein Analysis: a Practical Guide to Laboratory Protocols, first ed. Chapman and Hall, London, England.

Crehan, C.M., Hughes, E., Troy, D.J., Buckley, D.J., 2000. Effects of fat level and maltodextrin on the functional properties of frankfurter formulated with 5, 12 and 30% fat. Meat Sci. 55, 463–469. https://doi.org/10.1016/S0309-1740(00)00006-1.

Cui, C., Zhou, X., Zhao, M., Yang, B., 2009. Effect of thermal treatment on the enzymatic hydrolysis of chicken proteins. Innovat. Food Sci. Emerg. Technol. 10, 37–41. https://doi.org/10.1016/j.ifset.2008.09.003.

Díaz, M.T., Álvarez, I., Fuente, J.D.A., Sañudo, C., Campo, M.M., Oliver, M.A., Font iFurnols, M., Montossi, F., San Julián, R., Nute, G.R., Cañeque, V., 2005. Fatty acid composition of meat from typical lamb production systems of Spain, United Kingdom, Germany and Uruguay. Meat Sci. 71, 256–263. https://doi.org/10.1016/j.meatsci.2005.03.020.

Hosseini-Parvar, S.H., Matia-Merino, L., Goh, K.K.T., Razavi, S.M.A., Mortazavi, S.A., 2010. Steady shear flow behavior of gum extracted from *Ocimumbasilicum*L. seed: effect of concentration and temperature. J. Food Eng. 101, 236–243. https://doi.org/10.1016/j.jfoodeng.2010.06.025.

Hosseini-Parvar, S.H., Matia-Merino, L., Golding, M., 2015. Effect of basil seed gum (BSG) on textural, rheological and microstructural properties of model processed cheese. Food Hydrocolloids 43, 557–567. https://doi.org/10.1016/j.foodhyd.2014.07.015.

Hygreeva, D., Pandey, M.C., Radhakrishna, K., 2014. Potential applications of plant based derivatives as fat replacers, antioxidants and antimicrobials in fresh and processed meat products. Meat Sci. 98, 47–57. https://doi.org/10.1016/j.meatsci.2014.04.006.

Javidi, F., Razavi, S.M.A., Behrouzian, F., Alghooneh, A., 2016. The influence of basil seed gum, guar gum and their blend on the rheological, physical and sensory properties of low fat ice cream. Food Hydrocolloids 52, 625–633. https://doi.org/10.1016/j.foodhyd.2015.08.006.

Karazhiyan, H., Razavi, S.M.A., Phillips, G.O., 2011. Extraction Optimization of a hydrocolloid extract from cress seed (*Lepidiumsativum*) using response surface methodology. Food Hydrocolloids 25, 915–920. https://doi.org/10.1016/j.foodhyd.2010.08.022.

Khazaei, N., Esmaiili, M., Djomeh, Z.E., Ghasemlou, M., Jouki, M., 2014. Characterization of new biodegradable edible film made from basil seed (*Ocimumbasilicum* L.) gum. Carbohydr. Polym. 102, 199–206. https://doi.org/10.1016/j.carbpol.2013.10.062.

Kim, I.S., Jin, S.K., Mandal, P.K., Kang, S.N., 2011. Quality of low fat pork sausages with tomato powder as color and functional additive during refrigerated storage. J. Food Sci. Technol. 48, 591–597. https://doi.org/10.1007/s13197-010-0182-2.

Kirmaci, B., Singh, R.K., 2012. Quality of chicken breast meat cooked in a pilot-scale radio frequency oven. Innovat. Food Sci. Emerg. Technol. 14, 77–84. https://doi.org/10.1016/j.ifset.2012.01.003.

Kok, T.N., Park, J.W., 2007. Extending shelf life of set fish ball. J. Food Qual. 30, 1–27. https://doi.org/10.1111/j.1745-4557.2007.00103.x.

Mora-Gallego, H., Serra, X., Guardia, M.A., Arnau, J., 2014. Effect of reducing and replacing pork fat on the physicochemical, instrumental and sensory characteristics throughout storage time of small caliber non-acid fermented sausages with reduced sodium content. Meat Sci. 97, 62–68. https://doi.org/10.1016/j.meatsci.2014.01.003.

Mora-Gallego, H., Guàrdia, M.D., Serra, X., Gou, P., Arnau, J., 2016. Sensory characterisation and consumer acceptability of potassium chloride and sunflower oil addition in small- caliber non-acid fermented sausages with a reduced content of sodium chloride and fat. Meat Sci. 112, 9–15. https://doi.org/10.1016/j.meatsci.2015.10.008.

Papadima, S.N., Bloukas, J.G., 1999. Effect of fat level and storage conditions on quality characteristics of traditional Greek sausages. Meat Sci. 51, 103–113. https://doi.org/10.1016/S0309-1740(98)00103-X.

Petrou, S., Tsiraki, M., Giatrakou, V., Savvaidis, I.N., 2012. Chitosan dipping or oregano oil treatments, singly or combined on modified atmosphere packaged chicken breast meat. Int. J. Food Microbiol. 156, 264–271. https://doi.org/10.1016/j.ijfoodmicro.2012.04.002.

Pramualkijja, T., Pirak, T., Kerdsup, P., 2016. Effect of salt, rice bran oil and malva nut gum on chemical, physical and physico-chemical properties of beef salt-soluble protein and its application in low fat salami. Food Hydrocolloids 53, 303–310. https://doi.org/10.1016/j.foodhyd.2015.03.004.

Puolanne, E.J., Ruusunen, M.H., Vainionpaa, J.I., 2001. Combined effects of NaCl and raw meat pH on water-holding in cooked sausage with and without added phosphate. Meat Sci. 58, 1–7. https://doi.org/10.1016/S0309-1740(00)00123-6.

Qiao, M., Fletcher, D.L., Smith, D.P., Northcutt, J.K., 2002. Effects of raw broiler breastmeat color variation on marination and cooked meat quality. Poultry Sci. 81, 276–280. https://doi.org/10.1093/ps/81.2.276.

Rafe, A., Razavi, S.M.A., Khan, S., 2012. Rheological and structural properties of β-lactoglobulin and basil seed gum mixture: effect of heating rate. Food Res. Int. 49, 32–38. https://doi.org/10.1016/j.foodres.2012.07.017.

Shah, M.A., Bosco, S.J.D., Mir, S.A., 2014. Plant extracts as natural antioxidants in meat and meat products. Meat Sci. 98, 21–33. https://doi.org/10.1016/j.meatsci.2014.03.020.

Soares, S., Amaral, J.S., Oliveira, M.B.P.P., Mafra, I., 2014. Quantitative detection of soybean in meat products by a Taq Man real-time PCR assay. Meat Sci. 98, 41–46. https://doi.org/10.1016/j.meatsci.2014.04.002.

Soyer, A., Ertas, A.H., Üzümcüoglu, Ü., 2005. Effect of processing conditions on the quality of naturally fermented Turkish sausages (sucuks). Meat Sci. 69, 135–141. https://doi.org/10.1016/j.meatsci.2004.06.015.

Tahergorabi, R., Beamer, S.K., Matak, K.E., Jaczynski, J., 2011. Effect of isoelectric solubilization/precipitation and titanium dioxide on whitening and texture of proteins recovered from dark chicken-meat processing by-products. LWT - Food Sci. Technol 44, 896–903. https://doi.org/10.1016/j.lwt.2010.10.018.

Volpato, G., Michielin, E.M.Z., Ferreira, S.R.S., Petrus, J.C.C., 2008. Optimization of the chicken breast cooking process. J. Food Eng. 84, 576–581. https://doi.org/10.1016/j.jfoodeng.2007.06.022.

Yang, H.-S., Choi, S.-G., Jeon, J.-T., Park, G.-B., Joo, S.-T., 2007. Textural and sensory properties of low fat pork sausages with added hydrated oat meal and tofu as texture-modifying agents. Meat Sci. 75, 283–289. https://doi.org/10.1016/j.meatsci.2006.07.013.

Zheng, M., Toledo, R., Wicker, L., 1999. Effect of phosphate and pectin on quality and shelf-life of marinated chicken breast. J. Food Qual. 22, 553–564. https://doi.org/10.1111/j.1745-4557.1999.tb00186.x.