Sains Malaysiana 40(2)(2011): 155–161

# Cornsilk Improves Nutrient Content and Physical Characteristics of Beef Patties

(Sutera Jagung Memperbaiki Kandungan Nutrien dan Ciri-Ciri Fizikal Burger Daging)

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ABSTRACT

*The nutrient composition, cooking characteristics and sensory properties of beef patties incorporated with various level of cornsilk were studied. The beef patties were formulated with either 2, 4 or 6% of cornsilk. Protein content increased in line with the cornsilk level in both raw and cooked beef patties. Both raw and cooked patties incorporated with 6% cornsilk recorded the highest protein concentration at 17.2 and 23.3%, respectively. Both raw and cooked patties containing 6% cornsilk recorded the lowest concentration of fat at 12.4 and 11.4%, respectively. All cooked patty samples recorded moisture content ranging from 40.42-42.98%. Beef patty formulated with 6% cornsilk recorded the highest cooking yield at 80.13% compared to other treatments. The addition of cornsilk did not change the sensory properties and consumer acceptability of cornsilk-based beef patties. Cornsilk fibre was effective in improving cooking yield, moisture and fat retention and enhancing texture of beef patties.*

*Keywords: Beef patty; chemical composition; cornsilk; sensory evaluation*

ABSTRAK

*Kajian komposisi zat makanan, ciri memasak dan penilaian deria terhadap burger daging lembu yang ditambah dengan kandungan sutera jagung yang berbeza telah dikaji. Burger daging diformulasikan dengan 2, 4 atau 6% sutera jagung. Kandungan protein meningkat selari dengan peningkatan kandungan sutera jagung dalam burger mentah dan yang digoreng. Kedua-dua burger mentah dan goreng yang mengandungi 6% sutera jagung masing-masing merekodkan kandungan protein sebanyak 17.2 and 23.3%. Kedua-dua burger mentah dan goreng yang mengandungi 6% sutera jagung masing-masing merekodkan kandungan lemak yang rendah iaitu 12.4 and 11.4%. Semua sampel burger merekodkan kandungan lembapan antara 40.42-42.98%. Burger daging yang diformulasikan dengan 6% sutera jagung merekodkan hasil memasak yang tinggi iaitu 80.13% berbanding perlakuan lain. Penambahan sutera jagung tidak mengubah ciri-ciri sensori dan penerimaan pengguna terhadap burger daging berasaskan sutera jagung. Serat dietari sutera jagung berkesan dalam mengekalkan hasil memasak, lembapan dan lemak serta memperbaiki tekstur burger daging.*

*Kata kunci: Burger daging; komposisi kimia; penilaian deria; sutera jagung*

## INTRODUCTION

Beef patties are amongst the most popularly consumed processed meat products in Malaysia and other parts of the world. Some of the reasons for such wide popularity are their affordable cost, availability in different tastes and longer shelf life. Extensive studies have been conducted to the use of various types of fat replacer and plant dietary fibre in processed meat products in improving dietary fibre and lowering fat content. The utilization of tapioca starch, oat fibre (Desmond et al. 1998; Dongowski et al. 2003; El-Magoli et al. 1996; Inglett et al. 2005; Yilmaz & Daglioglu 2003), cereal and fruit fibres (García et al. 2002; Hecker et al. 1998; Mansour & Khalil 1999), whey protein (El-Magoli et al. 1996), palm based fat (Babji et al. 2001) on the physical, chemical and sensory properties of low-fat beef patties has been studied previously.

Presently, consumers are very concern about their diet and the food they eat. With the demand for nutritious and healthy food products, processed meat producers have to focus their creation toward processed meats that are lean, low fat and high in protein content. Health concerns about fat utilization and changes in consumer's preferences have led to comprehensive research on low-fat foods (Kumar & Sharma 2004; Yang et al. 2007). The high contents of saturated fats and cholesterol have been a major problem, resulting in meat products becoming the subject of scrutiny by nutritional, medical, and consumer groups. The American Heart Association (AHA 2004) and other health groups have recommended a decrease in the consumption of animal fats. Decrease in calories from fat, from 40% to 30% and in saturated fat intake from 18% to 10%, have also been recommended (Carrol 1998).

Reduction of fat in processed ground meat products presents a number of difficulties in terms of appearance, flavor and texture. Manufacturers have introduced several modifications in an attempt to offset the detrimental effects of reducing the fat level. These modifications include the use of non-meat ingredients that could help to convey desirable texture and, more important, enhance water-holding capacity (Ako 1998). In this regard, carbohydrates and fibre have been successful in improving cooking yield, reducing formulation cost and enhancing texture (Jimenez Colmenero 1996; Keeton 1994).

The utilization of palm fats in meat products was first investigated as alternatives to animal fats in beef burgers and chicken nuggets (Babji et al. 2001). Babji et al. (2001) also found that there were no significant differences in cooking losses, texture, juiciness, oiliness and overall acceptance between the burgers prepared with palm fats and with beef fat. Meanwhile, Shiota et al. (1995) reported that beef patties containing Bungo beef received the highest scores with 20% palm oil and palm mid-fraction.

Cornsilk (*Zea mays* L.) also known as *Maydis stigma* refers to the collection of stigmas of the maize female flowers. The cornsilk threads are normally discarded during the processing of baby corn as a vegetable. Statistical information on baby corn production is limited because many producing countries either do not report baby corn production or include it within the sweet corn category.

Traditionally, infusion of cornsilks had been used as a therapeutic remedy. These ailments include inflammation of the urinary bladder and prostate and treatment for irritation of the urinary system. To date, numerous commercially viable traditional products prepared from cornsilk are available (El-Ghorab et al. 2007). Cornsilk contain various chemicals, including proteins, vitamins, alkaloids, tannins and mineral salts, carbohydrates, steroids, and flavonoids as well as other volatile chemicals (Kwag et al. 1999).

The pharmaceutical and biological activities of cornsilk constituents are well reported in the literatures. These include antibiotic activity of glycoside maysin (Maksimovic & Kovacevic 2003), attractant activity toward corn earworm (Guevara et al. 2000), purification and characterization of anticoagulant (Sang-Kyu & Hye-Seon 2004). Other than these reported activities, some local species are consumed as tea, powdered as food additive and flavorings agents in several regions of the world (Koedam 1986; Yesilada & Ezer 1989). However, the utilization of consilk in any meat product is never been studied.

Thus, this study investigated the cooking characteristics and sensory properties of beef patties formulated with added cornsilk.

## MATERIALS AND METHODS

### PREPARATION OF CORNSILK

Fresh young *Zea mays* were harvested from Pantai Cahaya Bulan, a coastal district area of Kota Bharu, in the state of Kelantan, Malaysia. Upon arrival in the Nutrition laboratory of the School of Health Sciences, Universiti Sains Malaysia, the hairs of the young corns or cornsilks were detached from the fruit stalks, cleaned and washed with distilled water. The fresh cornsilks collected were then oven dried at 50°C until brownish threads were obtained. The brownish dried cornsilks were ground into powder form and kept in screw cap bottle at 4°C before further analyses.

### BEEF BURGER FORMULATION

The beef patties were prepared following the formulations described by Wan Rosli et al. (2006) with slight modifications. Four beef patty formulations were compared. Each of them contains either 0% (control), 2, 4 and 6% of dried cornsilk. The percentages of other ingredients are unchanged compared to the control sample, whereas the percentage of potato starch decreases with the increase of cornsilk fibre content. The dried cornsilk fibres were incorporated into the beef burgers using the formulations described in Table 1. The finished beef patties were stored in a freezer at -18°C while waiting for further analysis. Cornsilk was prepared in Nutrition Laboratory of the School of Health Sciences, Universiti Sains Malaysia Health Campus. Beef cut of hind quarter was purchased from local wet market. Other dry materials were purchased from local suppliers.

### PROCESSING

Beef cut of hind quarter beef was manually cut using a band saw (JG-210) and minced through a 4 mm-diameter grinder plate. The minced beef was stored at –18°C until processing time. Isolated soy protein was blended with water and shortening at a ratio of 1:5:5 using a Hobart mixer (N-50 Canada). The emulsion prepared (called pre-emulsion) was kept in a chiller (2-5°C) until ready for use. Salt was added to the frozen minced beef and mixing was carried out using a Hobart mixer for 3 min. Water mixed with spices, potato starch and cornsilk powder were added and mixed for another 2 min. The pre-emulsion was then added and mixing continued for another 2 min. The finished meat batters were then weighed into 70 g portions, and then manually stamped to produce a uniform beef patty. The raw beef patties were then frozen at –18°C.

### COOKING PROCEDURE

Beef patties were thawed at 4°C for 12 h. Beef patty samples were then cooked in a pan-fried electric skillet (Model KX-11K1, Sharp Corporation, Japan) for 7-8 minutes until an internal temperature of 72 ± 1°C was achieved.

### COOKING YIELD

Cooking yield of beef patties was determined by measuring the weight of six patties for each treatment/batch and

TABLE 1. Beef burger formulated with different level of cornsilk powder

| Ingredients (%) | Cornsilk powder level (%) | | | |
|---|---|---|---|---|
| | Control (0) | 2 | 4 | 6 |
| Beef (hind quarter) | 54.0 | 54.0 | 54.0 | 54.0 |
| Fat | 9.0 | 9.0 | 9.0 | 9.0 |
| Water | 26.0 | 26.0 | 26.0 | 26.0 |
| Potato starch | 6.0 | 4.0 | 2.0 | 0.0 |
| Dried cornsilk (%) | 0.0 | 2.0 | 4.0 | 6.0 |
| Isolated soy protein | 3.0 | 3.0 | 3.0 | 3.0 |
| Salt | 1.0 | 1.0 | 1.0 | 1.0 |
| Spices and seasoning | 1.0 | 1.0 | 1.0 | 1.0 |
| Total | 100 | 100 | 100 | 100 |

calculating weight differences for patties before and after cooking, as follows (El-Magoli et al. 1996):

$$\text{Cooking yield (\%)} = \frac{(\text{cooked weight} \times 100)}{\text{Raw weight}}.$$

### MOISTURE AND FAT RETENTION (%)

The moisture and fat retention values represent the amount of moisture and fat retained in the cooked product per 100 g of raw sample, These values were calculated according to the following equations (El-Magoli et al. 1996):

$$\text{Moisture retention (\%)} = \frac{(\text{percent yield} \times \%\ \text{moisture in cooked patties})}{100},$$

$$\text{Fat retention (\%)} = \frac{(\text{cooked weight} \times \text{percent fat in cooked beefpatties})}{(\text{raw weight} \times \text{percent fat in raw beef patties})} \times 100.$$

### DIAMETER REDUCTION (%)

Change in beef patties' diameter was determined using the following equation:

$$\text{Diameter reduction (\%)} = \frac{\text{raw beef patties diameter} - \text{cooked beef patties diameter}}{\text{raw beef patties diameter}} \times 100.$$

### SENSORY EVALUATION

Sensory evaluations were carried out by 60 untrained consumers consisting of students and staff of the School of Health Sciences, Universiti Sains Malaysia Health Campus. They evaluated samples for colour, texture, juiciness, beef flavour, cornsilk flavour and overall acceptance on a 7 point scale (0 = dislike extremely and 7 = like extremely). Significance was established at $P \leq 0.05$ unless otherwise indicated.

### STATISTICAL ANALYSIS

Data obtained were tested for significance using ANOVA and Duncan Multiple Range Test with SAS version 6.12 (SAS 1989). All measurements were carried out in triplicate (n = 3).

## RESULTS AND DISCUSSION

The chemical analyses of raw beef patties formulated with ground cornsilk are shown in Table 2. Generally, protein concentration was increased proportionally with the level of cornsilk powder used in raw beef patty formulation. Beef patty formulated with 6% cornsilk significantly ($P<0.05$) recorded the highest protein concentration (17.17%) followed by patty with 2% cornsilk (15.80%). On the other hand, the concentration of fat was inversely proportional to the cornsilk level in raw beef patty. Beef patty incorporated with 6% cornsilk significantly ($P<0.05$) recorded the lowest concentration of fat. However, the fat content of raw beef patty incorporated with 2 and 4% cornsilk were not significant with control. The highest protein and the lowest fat percentage detected in beef patty formulated with 6% cornsilk powder may be due to the moderate amount of protein (12.96%) existing originally in dried cornsilk used in this study (Wan Rosli et al. 2008). The percentage of ash in all raw beef patties ranged from 2.09 -2.37%. There was also no difference in moisture content between all raw patties. All raw patty samples recorded moisture content ranging from 55.37-55.86%. These values were comparable with our previous result (Wan Rosli et al. 2007).

Table 3 shows chemical composition of the beef patty formulated with cornsilk powder. The concentration of protein was increased proportionally with the level of cornsilk powder used in cooked beef patty. Similar to raw patties, cooked patties formulated with 6% cornsilk significantly ($P<0.05$) recorded the highest protein concentration (23.67%) followed by patty with 2% cornsilk (20.00%). The same trends of fat content in raw patties were recorded in cooked patties. Beef patty formulated with 6% cornsilk significantly ($P<0.05$) recorded the lowest content of fat (11.39%). However, the fat content of raw beef patty incorporated with 2 and 4% cornsilk were not significant ($P<0.05$) with control.

TABLE 2. Nutrient Analyses Of Raw Beef Patty Incorporated With Cornsilk Powder

| Treatment | Concentration (Percent) | | | |
|---|---|---|---|---|
| | Protein | Fat | Ash | Moisture |
| Control | 15.66 + 0.77 [ab] | 13.84 ± 0.58 [a] | 2.19 ± 0.01 [b] | 55.86 ± 0.27 [a] |
| 2% | 15.80 + 0.22 [b] | 13.75 ± 0.21 [a] | 2.12 ± 0.04 [c] | 55.66 ± 0.18 [a] |
| 4% | 16.56 + 0.48 [ab] | 13.04 ± 0.51 [ab] | 2.09 ± 0.02 [c] | 55.45 ± 0.25 [a] |
| 6% | 17.17 + 1.03 [a] | 12.40 ± 0.74 [b] | 2.37 ± 0.01 [a] | 55.37 ± 0.27 [a] |

[a-b] Mean values within the same column bearing different superscripts differ significantly (P<0.05)

TABLE 3. Nutrient analyses of cooked beef patty incorporated with cornsilk powder

| Treatment | Concentration (Percent) | | | |
|---|---|---|---|---|
| | Protein | Fat | Ash | Moisture |
| Control | 19.53 + 0.41 [c] | 13.18 ± 1.11 [a] | 2.75 ± 0.03 [b] | 42.98 ± 1.21 [a] |
| 2% | 20.00 + 0.48 [c] | 12.81 ± 0.91 [a] | 2.83 ± 0.11 [c] | 42.97 ± 1.78 [a] |
| 4% | 21.29 + 0.13 [b] | 11.88 ± 0.28 [ab] | 2.89 ± 0.13 [c] | 42.70 ± 1.59 [a] |
| 6% | 23.26 + 0.26 [a] | 11.39 ± 0.39 [b] | 3.45 ± 0.42 [a] | 40.42 ± 1.01 [a] |

[a-b] Mean values within the same column bearing different superscripts differ significantly (P<0.05)

The percentage of ash in all cooked beef patties were ranging from 2.75 -3.45% with patty contained 6% cornsilk recorded the higher percentage of ash. There was also no difference in moisture content between all raw patties. All cooked patty samples recorded moisture content ranging from 40.42-42.98%.

Physical characteristics of cooked beef patties are presented in Table 4. Compared to the control sample, beef patties formulated with cornsilk powder showed an increase (P<0.05) in cooking yield. In fact, the high cooking loss was from the control patty. This could be attributed to the high loss of moisture and fat during cooking. Cooking yield was significantly ($p > 0.05$) higher in beef patty incorporated with cornsilk. Patty formulated with 6% cornsilk powder recorded the highest cooking yield (80.13%) compared to other treatments. This is probably due to the ability of cornsilk hydrocolloidal fibre to create a tridimensional matrix, holding not only water, but also fat added to the formula, avoiding losses of fat and water during cooking (Warner & Inglett 1997). In control burgers, fat was more easily removed during cooking, probably due a low density meat protein matrix, along with a high fat unstability. This is in agreement with previous research (Suman and Sharma 2003) who studied the effect of grind size and levels on the physico-chemical and sensory characteristics of low-fat ground buffalo meat patties.

The results of moisture retention of beef patties formulated with cornsilk powder were similar with the trend of cooking yield. The moisture retention was proportionally increased with the increment of fibre content in burger formulations. The higher the amount of cornsilk powder, the lower the loss of moisture during cooking.

Control beef patty shows more moisture and fat loss (P<0.05) after cooking as compared to cornsilk-added beef patty. Control beef patty recorded 58.76% moisture retention and 70.69% fat retention while cornsilk-added beef patty recorded moisture and fat retention ranging from 60.17-62.49% and 72.61-73.68%, respectively. Dietary fibres increased cooking yield because of their high ability to keep moisture and fat in the matrix. This finding is supported by the previous work of (Aleson-Carbonell et al. 2005) on the incorporation of lemon albedo fibres in beef patty formulation. Similar findings were documented by Mansour and Khalil (1997) and Turhan et al. (2005), who have utilized wheat fibres; hazelnut pellicles, respectively in beef patty formulations.

Diameter retention was also increased with the level of cornsilk powder in patty formulations. Even though this cooking trait values were higher in beef patty containing cornsilk but they were not significantly different (P > 0.05) with control. These findings were similar to the study done by (Pinero et al. 2008) who reported that there were no significant in diameter reduction of low-fat patty containing oat's soluble fibre and control. The retention of the size and shape of cornsilk-added beef patty during cooking could be due to the binding and stabilizing property of cornsilk fibre, which held the meat particle together and resisted changes in the shape of the product.

In this study, the percent of cooking yield during cooking was comparatively higher than other study. For example, Sheard et al. (1998) reported that cooking loss of grilled and fried beef patties contained 9-30% of fat were ranging from 22 – 36%. Pinero et al. (2008) reported the cooking loss of 25 and 29%, respectively in beef patties incorporated with oat fibres. This present study only used

TABLE 4. Cooking characteristics of cooked beef patty incorporated with cornsilk powder

| Cornsilk powder level | Moisture retention (%) | Fat Retention (%) | Diameter Retention (%) | Cooking Yield (%) |
|---|---|---|---|---|
| Control (0%) | 58.76 ± 1.44 [c] | 70.69 ± 1.76 [b] | 7.63 ± 0.16 [a] | 76.37 + 1.86 [c] |
| 2% | 60.17 ± 1.35 [bc] | 72.61 ± 1.23 [ab] | 7.77 ± 0.16 [a] | 77.95 + 1.40 [bc] |
| 4% | 62.17 ± 1.11 [ab] | 72.42 ± 0.30 [ab] | 7.76 ± 0.23 [a] | 79.51+ 0.53 [ab] |
| 6% | 62.49 ± 0.84 [a] | 73.68 ± 1.06 [a] | 7.77 ± 0.21 [a] | 80.13 + 1.15 [a] |

[a-b] Mean values within the same row bearing different superscripts differ significantly (P<0.05)

15% fat in patty formulation and the cooking loss was less than 20% as compared to Sheard et al. (1998). From this result, it can be suggested that cooking loss increased proportionally with fat content in patty formulation. As the fat content increases, the mean free distance between fat cells decreases, raising the likelihood of fat coalescing and then leaking from the products. Thus, high fat products tend to lose large amounts of fat during cooking whilst low fat meat products lose relatively little fat (Tornberg et al. 1989).

Manufacturers have introduced several modifications in an attempt to offset the detrimental effects of reducing the fat level. In this regard, carbohydrates and fibre have been successful in improving cooking yield, reducing formulation cost and enhancing texture (Jimenez Colmenero 1996).

Table 5 shows the sensory evaluation scores for beef patties incorporated with cornsilk. All cooked beef patties incorporated with 4 and 6% cornsilk powder were not significantly different (P>0.05) compared to control beef patty for all attributes. Beef patty containing cornsilk were found to be significantly (P<0.05) flavourful than the control which could be attributed to the increased amount of cornsilk used in the formulation. Consumers were unable to differentiate colour and juiciness of beef patties made from different levels of cornsilk. These findings are contradictory with those of Pinero et al. (2008) who found that beef patties containing oat's fibre were found to be significantly (P>0.05) juicier than the control, which could be attributed to the increased moisture retention of the product during cooking. The score for beef patties containing 4 and 6% of cornsilk were comparable to control (P>0.05) for all sensory attributes. All sensory attributes from these treatments were not significant different (P>0.05) with control. This is similar to the report by Besbes et al. (2008) who found that there was no negative effect of wheat fibre concentrate addition, up to 1.5%, on flavour and texture of beef burgers.

## CONCLUSIONS

Incorporation of cornsilk powder resulted in increasing protein, cooking yield, moisture and fat retention but decreasing fat content. Beef patties with 6% corn silk-added showed the highest cooking yield, moisture and fat retention. This could be attributed to the high retention of moisture and fat during cooking. Consumers were not able to differentiate colour, juiciness and overall attributes between burgers containing different level of dried cornsilk and control. In summary, the addition of cornsilk resulted in an increase in the nutritional composition, water and fat holding capacity while maintaining the sensory quality of beef patties so they are as acceptable to consumers as normal beef patties. This incorporation could permit a reduction of the formulation cost without affecting sensory descriptors of the product to which the consumer is familiarized.

TABLE 5. Sensory attributes of cooked beef patties as influenced by the addition of cornsilk (N= 60)

| Sensory attribute | Cornsilk Content (%) | | | |
|---|---|---|---|---|
| | 0 | 2 | 4 | 6 |
| Colour | 4.98 ± 0.94 [a] | 4.86 ± 1.03 [a] | 4.58 ± 1.16 [a] | 4.36 ± 1.19 [a] |
| Texture | 5.04 ± 1.09 [a] | 4.72 ± 1.14 [a] | 4.62 ± 1.08 [a] | 4.74 ± 1.10 [a] |
| Juiciness | 4.92 ± 1.10 [a] | 4.76 ± 1.03 [a] | 4.50 ± 1.06 [a] | 4.62 ± 1.07 [a] |
| Beef flavour | 5.02 ± 1.07 [a] | 4.72 ± 1.16 [a] | 4.86± 1.04 [a] | 4.78 ± 1.06 [a] |
| Cornsilk flavour | 4.04 ± 1.04 [a] | 3.86 ± 1.04 [a] | 4.36 ± 1.05 [a] | 4.48 ± 1.04 [a] |
| Overall acceptance | 5.10 ± 1.07 [a] | 4.94 ± 1.00 [a] | 4.96 ± 1.10 [a] | 4.96 ± 1.09 [a] |

[a-b] Mean values within the same row bearing different superscripts differ significantly (P<0.05)

AKNOWLEDGEMENT

The authors appreciate the funding from Universiti Sains Malaysia short term grant 304/PPSK/6131549, Farid Che Ghazali, Rosliza, Mohd Zaki Selamat, Saiful Haizad, Nik Fakurudin, Norazita, Roziyani and other staffs of School of Health Sciences who participated in sensory evaluation of cornsilk based products. The authors thank Mohd Sabri for his assistance towards the research and findings of this paper.

REFERENCES

AHA. 2004. American Heart Association. *Heart and stroke encyclopedia. Dietary guidelines for healthy American adults*. Cholesterol. Fat. http://www.americanheart.org.

Ako, C. 1998. Fat replacers. *Food Technology* 52: 47-53.

Aleson-Carbonell, L., Fernandez-Lopez, J., Perez-Alvarez, J.A. & Kuri, V. 2005. Characteristics of beef burger as influenced by various type of lemon albedo. *Innov. Food Sci. Emer. Technol* 6: 247-255.

Babji, A.S., Alina, A.R., Mohd Suria Affandi, Y. & Wan Sulaiman, W.I. 2001. Palm oil: A healthy fat substitute?. *Meat International* 11(2): 26-27.

Besbes, S., Attia, H., Deroanne, C., Makni, S. & Blecker, C. 2008. Partial replacement of meat by pea fiber and wheat fiber: Effect on the chemical composition, cooking characteristics and sensory properties of beef burgers. *Journal of Food Quality* 31: 480-489.

Carrol, O.P. 1998. Trimming the fat. *The World of Ingredient* 18: 11-14.

Desmond, E., Troy, D. & Buckley, D. 1998. Comparative studies of nonmeat adjuncts used in the manufacture of low-fat beef burgers. *Journal of Muscle Foods* 9(3): 221-241.

Dongowski, G., Drzikova, B., Senge, B., Blochwitz, R., Gebhardt, E. & Habel, A. 2003. Rheological behaviour of β-glucan preparations from oat products. *Food Chemistry* 93: 279-291.

El-Ghorab, A., El-Massry, K.F. & Shibamoto, K. 2007. Chemical composition of the volatile extract and antioxidant activities of the volatile and nonvolatile extracts of Egyptian corn silk (*Zea mays* L.). *Journal Agriculture Food Chemistry* 55 (22): 9124-9127.

El-Magoli, S., Laroia, S. & Hansen, P. 1996. Flavor and texture characteristics of low fat ground beef patties formulated with whey protein concentrate. *Meat Science* 42(2): 179-193.

García, M., Dominguez, R., Galvez, M., Casas, C. & Selgas, M. 2002. Utilization of cereal and fruit fibres in low fat dry fermented sausages. *Meat Science* 60(3): 227-236.

Guevara, P., Perez-Amador, M.C., Zuniga, B. & Snook, M. 2000. Flavones in corn silks and resistance to insect attacks. *Phyton* 69: 151-156.

Hecker, K., Marg, M., Newman, R. & Newman, W. 1998. Barley β-glucan is effective as a hypocholesterolaemic ingredient in foods. *Journal of the Science of Food and Agriculture* 77: 179-183.

Inglett, G., Peterson, S., Carriere, C. & Maneepun, S. 2005. Rheological, textural and sensory properties of Asian noodles containing on oat cereal hydrocolloid. *Food Chemistry* 90(1&2): 1-8.

Jimenez Colmenero, F. 1996. Technologies for developing low-fat meat products. *Trends in Food Science and Technology* 7: 41-48.

Keeton, J.T. 1994. Low-fat meats products technological problems with processing. *Meat Science* 36: 261-276.

Koedam, A. 1986. Volatile oil composition of Greek mountain tea (*Sideritis spp*.). *Journal of the Science of Food and Agriculture* 36: 681-684.

Kumar, M. & Sharma, B. 2004. The storage stability and textural, physico-chemical and sensory quality of low-fat ground pork patties with carrageenan as fat replacer. *International Journal of Food Science and Technology* 39: 31-42.

Kwag, J.J., Lee, J.G., Jang, H.J. & Kim, O.C. 1999. Volatile components of corn silk (*Zea mays* L.). *Han'guk Sikp'um Yongyang Hakhoechi* 12(4): 375-379.

Maksimovic, Z.A. & Kovacevic, N. 2003. Preliminary assay on the antioxidative activity of *Maydis stigma* extracts. *Fitoterapia* 74: 144-147.

Mansour, E. & Khalil, A. 1999. Characteristics of low-fat beef burgers as influenced by various types of wheat fibres. *Journal of the Science of Food and Agriculture* 79: 493-498.

Mansour, E.H. & Khalil, A.H. 1997. Characteristics of low fat beef burgers as influenced by various types of wheat fibers. *Food Research International* 30: 199-205

Pinero, M.P., Parra, K., Huerta-Leidenz, N., Moreno, A.A., Ferrer, M., Araujo, S. & Barboza, Y. 2008. Effect of oat's soluble fibre (β-glucan) as a fat replacer on physical, chemical, microbiological and sensory properties of low-fat beef patties. *Meat Science* 80: 675-680.

Sang-Kyu, C. & Hye-Seon, C. 2004. Purification and characterization of an anticoagulant from corn silk. *Han'guk Sikp'um Yongyang Kwahak Hoechi* 33(8): 1262-1267.

SAS. 1989. SAS User's Guide: Statistics. Version 6.12, SAS Institute Inc., Cary, NC.

Sheard, P.R., Nute, G.R. & Chappell, A.G. 1998. The effect of cooking on the chemical composition of meat products with special reference to fat loss. *Meat Science* 49(2): 175-191.

Shiota, K., Kawahara, S., Tajima, A., Ogata, T.K. & Ito, T. 1995. Sensory evaluation of beef patties and sausages containing lipids with various component fatty acids. *Meat Science* 40: 363-371.

Suman, S. & Sharma, B. 2003. Effect of grind size and levels on the physico-chemical and sensory characteristics of low-fat ground buffalo meat patties. *Meat Science* 65: 973-976.

Shiota, K., Kawahara, S., Tajima, A., Ogata, T., Kawano, T. & Ito T. 1995. Sensory evaluation of beef patties and sausages containing lipids with various component fatty acids. Meat Science 40(3): 363-371.

Tornberg, E., Olsson, A. & Persson, K. 1989. A comparison in fat holding between hamburgers and emulsion sausages. *Proceedings of the 35th International Congress of Meat Science and Technology, Copenhagen, Denmark*: 752-759.

Turhan, S., Sagir, I. & Ustin, N.S. 2005. Utilization of hazelnut pellicle in low-fat beef burgers. *Meat Science* 71: 312-316.

Wan Rosli, W.I., Jesmine, K., Nurhanan, A.R., Mohsin, S.S.J. & Farid, C.G. 2008. Aqueous, alcoholic treated and proximate analysis of *Maydis stigma* (*Zea mays* hairs). *Annals of Microscopy* 8: 66-72.

Wan Rosli, W.I., Babji, A.S. & Aminah, A. 2007. Lipid profile, apparent digestibility and protein efficiency ratio of Sprague Dawley rats fed with red palm fat diets. *ASEAN Food Journal* 14(3): 153-160.

Wan Rosli, W.I., Babji, A.S., Aminah, A., Foo, S.P. & Abd Malik, O. 2006. Vitamin E contents of processed meats blended with palm oils. *Journal of Food Lipids* 13: 186-198.

Warner, K. & Inglett, G. 1997. Flavor and texture characteristics of foods containing Z-trim corn and oat fibers as fat and flour replace. *Cereal Food World* 42(10): 821-825.

Yang, H., Choi, S., Jeon, J., Park, G. & Joo, S. 2007. Textural and sensory properties of low fat pork sausages with added hydrated oatmeal and tofu as texture-modifying agents. *Meat Science* 75(2): 283-289.

Yesilada, E. & Ezer, N. 1989. The antiinflammatory activity of some sideritis species growing in Turkey. *International Journal of Crude Drug Research* 27: 38-40.

Yilmaz, I. & Daglioglu, O. 2003. The effect of replacing fat with oat bran on fatty acid composition and physicochemical properties of meatballs. *Meat Science* 65(2): 819-823.

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Received: 29 December 2009
Accepted: 20 May 2010