Effects of incorporation of microwave: Dried corn silk (*Stigma maydis*) powder on the quality and stability of Beef Patties

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Abstract. Corn silk (*Stigma maydis*) is a waste product from corn cultivation and is known to contain high antioxidant activity and dietary fiber but is normally discarded due to lack of utilization. The study aimed to analyse microwave-drive corn silk powder (MDCSP) and incorporated in beef patties. The corn silk samples used in this study were obtained from a vendor situated in Juliana Market, Balintawak, Caloocan City. The identification and authenticity of the sample was confirmed at the UST Research Center for the Natural and Applied Sciences (RCNAS). All reagents used were of analytical (AR) grade. The reagents were acquired from the Laboratory Equipment and Supplies Office (LESO) of the University of Santo Tomas (UST), Chemline Scientific Corporation and Belman Laboratories. Glasswares and materials were acquired from LESO. All results were presented as mean (± SD) values in triplicates. The data were statistically treated using XLSTAT at P ≤ 0.05. The data were subjected to analysis of variance (ANOVA). If treatment effects were found significant (P ≤ 0.05), the differences between means were identified by Duncan’s Multiple Range Test. The result showed microwave drying corn silk for 4 minutes at 900 W was found most appropriate time and setting to achieve the desired moisture content of corn silk. Proximate analyses of MDCSP revealed that microwave – drying can retain its nutritional components. Physico-chemical analyses of MDCSP showed that slightly acidic pH and a low water activity. Particle sizes of MDCSP ranged from 3.69 – 39 µm.

1. Introduction
Corn is the third most important produced and consumed crop globally after rice and wheat [1]. In the Philippines, corn is a substitute staple food crop for rice and normally used in the food manufacturing, animal feeds and has significance in industrial uses [2]. Production of corn products yield high amount of waste like corn silk. Corn silk, stigma maydis, is a long, thread like strand from female corn flower and found inside the husk [3,4]. The stigmas are fine and soft yellowish to green or purple before pollination and subsequently, its color becomes light to dark brown [5]. Corn silk is a waste product from corn cultivation and normally discarded due to lack of utilization [6]. An average of 25% of the young corn ear’s fresh weight is comprised of silk [7]. Hence, approximately a young corn ear would generate almost 50,000 tons of silk in a year. Corn silk is a traditional medicine used in several countries to treat several diseases such as oedema, gout, cystitis and rheumatism. The corn silk have its
antihypertensive, antioxidant, anticancer, antidepressant, kaliuretic and neuroprotective properties as well as antimicrobial properties [1,6,8].

Despite the underutilization, corn silk contains phytochemical constituents such as flavonoids, terpenoids, alkaloids, tannins, and saponin. Also, corn silk contains protein, carbohydrate, vitamins, minerals (Ca, Mg, Cu, Zn, K &Mn), potassium salts, fixed and volatile oils, steroid compounds, plant acids and is highly rich in dietary fiber [3, 9,10]. The recommendations regarding the dietary fiber intake vary in different countries. In the Philippines, a daily intake of 20 - 25g dietary fiber is suggested, following the IOM and FAO/WHO recommendations [11]. Drying of corn silk by oven drying and sun drying and incorporating in meat systems and baked goods improved their cooking properties, antioxidant capacity and dietary fiber content [1,4]. However, microwave drying is known for its operational safety and nutrient retention capacity with minimal loss of heat-labile nutrients and antioxidants [12].

Meat products are comprehensively prone to lipid oxidation, as they normally contain high levels of fat and pro-oxidants such as salt [13]. Beef patty is one of the widely consumed processed meat products in several countries including Philippines. This wide popularity is due to beef patties being affordable and varying in taste [4]. However, beef patties possess high fat content [14]. Thus, susceptible to lipid oxidation which causes the production of off flavors and odors, loss of polyunsaturated fatty acid (PUFA), fat soluble vitamins and pigments, and lower consumer acceptability [15]. In additions, the storage at longer periods and processes such as grinding and cooking also reduce the stability against lipid oxidation due to structural degradation and the release of pro – oxidants [13]. In this study, corn silk was microwave – dried and incorporated in beef patties to determine the effect on their quality and stability.

2. Methodology

The corn silk samples used in this study were obtained from a vendor situated in Juliana Market, Balintawak, Caloocan City. The identification and authenticity of the sample was confirmed at the UST Research Center for the Natural and Applied Sciences (RCNAS). All reagents used were of analytical (AR) grade. The reagents were acquired from the Laboratory Equipment and Supplies Office (LESO) of the University of Santo Tomas (UST), Chemline Scientific Corporation and Belman Laboratories. Glassware’s and materials were acquired from LESO.

The corn silk threads were cleaned with distilled water until no foreign matter is present. The corn silk threads were then air-dried. The air-dried corn silk threads were sealed in zip lock and stored at a temperature of 0-4°C until further processing. The air-dried corn silk threads were equally divided into 3 lots and subjected to microwave drying using National Dimension 4 The Genius Microwave/Convection Oven at high power (900 W) at different durations (2, 4, and 6 minutes) to select most appropriate time of drying. Thirty (30) grams of corn silk threads were evenly placed on the turntable in the microwave cavity during treatment for even absorption of microwave energy. The microwave – dried corn silk threads were stored in amber jars at 0-4°C until further processing.

The pH of the sample was determined using the pH meter (sensION + pH 1). The equipment was calibrated using pH 4, 7, and 10 buffer solutions. The water activity of the corn silk powder was determined using a Novasina ms1 set-aw which used a resistive electrolytic technique. MDCSP (3 grams) was extracted, filtered, evaporated, and reconstituted with methanol. The extract was stored at 0-4°C until further analysis.

The total phenolic compounds in the extract was determined using Folin-Ciocalteau method. The phenolic content was compared to a gallic acid standard and was expressed as gallic acid equivalents (GAE) in mg/g of sample. The particle size of MDCSP was determined using a Scanning Electron Microscope (TM 3000 TableTop SEM, Hitachi) with magnifications of 100, 200, 500 and 2,500x. The SEM photograph was further analyzed using an open source image processing program (ImageJ) to measure the diameter. The beef patties were prepared according to the formulation with slight modifications. Four beef patty variations were prepared: control, 3%, 6%, and 9%. The finished beef patties were stored in a freezer at -18°C for further analysis.
Fresh beef chuck and fat were minced separately using a food processor (Philips HR7620) for 25 seconds. Back fat, salt, egg and potato starch were mixed one at a time with the processed beef chuck. A mixture which contains pepper, Worcestershire sauce, soy sauce, water, isolate soy protein and corn silk was made and added to the meat batter. The finished meat batters were weighed into 65-gram portions and placed in a polyethylene sheet. It was then formed into a circular glass molder to produce a uniform beef patty. The molded beef patties were packaged in polypropylene bags and sealed using a heat sealer. The raw beef patties were then frozen at −18°C. Beef patties were thawed in a refrigerator at 4°C before cooking. Beef patty samples were then cooked in a Dessini Double Grill Pan for 4 minutes in each side or until an internal temperature of 85 ± 1°C was achieved.

The cooking yield was determined by measuring the weight of the patties and calculating the weight differences before and after cooking. The moisture and fat retention values represented moisture and fat amount retained in the cooked product per 65 grams of raw sample. Ten (10) grams of sample was added and mixed with 90 ml of peptone solution (10-1). It was homogenized using a stomacher. Serial dilutions of up to 10-4 were prepared. One ml of the 10-2, 10-3, 10-4 dilution was taken to 3M petri films. Inoculated media were incubated at 37°C for 48 hours. Aerobic plate count of beef patties was determined using AOAC 990.12.

One ml of the 10-2, 10-3, 10-4 dilution was taken to 3M petri films. Inoculated media were incubated at 25°C for 3 to 5 days. Yeast and mold count of beef patties were determined using AOAC 997.02. The peroxide value (POV) is an important characteristic of lipid quality. The assessment of hydroperoxides provides an estimate of the overall oxidation status for lipids and lipid-containing foods especially in the primary phase of oxidation. The measurement of peroxide values was obtained during weeks 0, 1, 2, 3 and 4. All results were presented as mean (± SD) values in triplicates. The data were statistically treated using XLSTAT at P ≤ 0.05. The data were subjected to analysis of variance (ANOVA). If treatment effects were found significant (P ≤ 0.05), the differences between means were identified by Duncan’s Multiple Range Test.

3. Result and Discussion
Most appropriate drying time of corn silk was determined by which time obtained a moisture content equal to or lower than 10 to 11%. The oven-dried mature corn silks had a moisture content of 3.90 to 4.20% [7]. The corn silk threads subjected to microwave drying at high temperature setting for 6 minutes obtained the lowest moisture content.

Moreover, the moisture content acquired upon microwave drying for 4 minutes, which is 4.63%. Moreover, there was no significant (P ≤ 0.05) difference between the moisture content of corn silk dried in 4 minutes and 6 minutes. The microwave drying is known for its nutrient retention capacity with minimal loss of heat-labile nutrients like the dietary antioxidant and phenols [16]. The microwave drying of corn silk is found to be better than sun drying and shadow drying since microwave drying provided great convenience to consumers through shortened processing time than sun and shadow drying. Microwave power may also be expressed as Celsius heat units per minute (CHU/min) and equivalent to 28.43 CHU/min with 900W. Therefore, the microwave drying time of corn silk in high temperature setting was 4 minutes.

In Table 1, the moisture content and water activity of MDCSP indicated that a shelf-stable product, although proper packaging and storage conditions were still necessary to preserve its free-flowing property and prevent caking. This result showed that microwave drying yielded products with lower moisture content and water activity at a significantly shorter time.
Table 1. Proximate and physico-chemical analysis of MDCSP

| Parameters                        | Total       |
|----------------------------------|-------------|
| Proximate                        |             |
| Moisture content (%)             | 3.34 ± 0.17 |
| Fat (%)                          | 2.41 ± 0.13 |
| Protein (%)                      | 14.88 ± 0.35|
| Ash content (%)                  | 5.69 ± 1.10 |
| Carbohydrate Content (%)         | 13.23 ± 0.21|
| Total Dietary Fiber (%)          | 61.08 ± 0.00|
| Physico-chemical                 |             |
| Water activity (at 23.5 °C)      | 0.288 ± 0.00|
| pH                               | 6.35 ± 0.17 |

The slightly acidic pH of MDCSP as shown in Table 1 due to the organic acids such as phytic, oxalic and glutaric acid present in corn silk. The pH of corn silk was suitable to be utilized as an ingredient or additive in a wide range of food products, including beef patty. Meanwhile, the nutritional compositions of MDCSP, total crude protein obtained is 14.88. Besides, the crude fat obtained from MDCSP is 2.41. The result indicated that MDCSP was a poor source of lipids, which is in agreement with the general observation that plants are low lipid containing food.

The total dietary fiber obtained from MDCSP was higher than that of oven dried corn silk and indicated that microwave drying of corn silk was more efficient method compared oven drying due to more dietary fiber yield. In addition, since MDCSP is high in dietary fiber and suitable for use as fiber-enriching agent in various food products.

MDCSP was subjected to Scanning Electron Microscopy (SEM) to determine particle size. Based on SEM, the MDCSP particles was observed non-spherical and vary in sizes.

![Figure 1. Particle size observed under 500x magnification.](image)
The incorporation of 3% MDCSP resulted to a higher moisture content than the beef patties without the addition of MDCSP. However, there is no significant difference among the two ($P \leq 0.05$).

**Table 2.** Particle size of MDCSP

| MDCSP | Minimum Feret diameter (μm) |
|-------|-----------------------------|
|       |                            |
|       | 13.61                      |

The incorporation of 3% MDCSP resulted to a higher moisture content than the beef patties without the addition of MDCSP. However, there is no significant difference among the two ($P \leq 0.05$).

**Table 3.** Proximate analysis of beef patties.

| Parameters               | Control       | Raw Control | 3% MDCSP | Cooked Control | Cooked 3% MDCSP |
|--------------------------|---------------|-------------|----------|----------------|-----------------|
| Moisture Content (%)     | 59.78 ± 1.61ab| 61.56 ± 0.63a| 53.59 ± 1.36a| 52.86 ± 1.71a  |
| Fat Content (%)          | 10.39 ± 0.37a | 10.16 ± 0.30a| 21.92 ± 0.42a| 19.50 ± 0.29b  |
| Protein Content (%)      | 12.14 ± 0.08b | 13.82 ± 0.02a| 18.93 ± 0.05a| 18.51 ± 0.13a  |
| Ash Content (%)          | 1.45 ± 0.01b  | 1.79 ± 0.03a | 1.81 ± 0.02a | 1.73 ± 0.02a   |
| Carbohydrate Content (%) | 12.31 ± 0.07a | 4.67 ± 1.06a | 1.55 ± 0.03a | 5.72 ± 0.40b   |
| Total Dietary Fiber Content (%) | 4.86 ± 0.18b | 7.69 ± 0.23a | 1.44 ± 0.06b | 2.62 ± 0.04a   |

*Mean SD with different superscripts in a row (lowercase) differ significantly ($P \leq 0.05$)*

In additions, the cooked beef patty with 3% MDCSP had a lower moisture content compared to the control. The fat content of cooked beef patties incorporated with 3% MDCSP was lower than beef patties without MDCSP. The incorporation of 3% MDCSP resulted to a lower protein content in cooked beef patties compared to the cooked beef patties without MDCSP.

The addition of 3% MDCSP in the formulation of beef patties led to the increase in the total dietary fiber content of the product. The carbohydrate content of raw beef patties with 3% MDCSP had no significant difference than control beef patties. However, the carbohydrate content was significantly higher in beef patties with 3% MDCSP. Beef patties incorporated with 3% MDCSP had a higher dietary fiber content than the commercial frozen beef patty. The same trend was observed in the ash content of raw beef patties since ash content of raw beef patties also increased after the incorporation of 3% MDCSP.

Measuring the pH value of food products was important due to its influence on many quality characteristics such as shelf-life and colour. In Figure 2, pH of beef patties was measured from week 0 to week 4.
Figure 2. pH of beef patties from week 0 to week 4 packed in polypropylene plastic at -18°C.

Figure 2 showed the relationship between the pH value and storage period in both beef patty samples. During week 0 of storage, the pH value of both beef patties is equal. However, storing the beef patties at freezing temperature for 4 weeks resulted in an increasing trend. Furthermore, pH of the control beef patties obtained higher pH value than the beef patties incorporated with 3% MDCSP. During weeks 0 to 3 of storage period, no significant difference presented between control sample and beef patties with 3% MDCSP (P ≤ 0.05). However, during week 4 of storage period, beef patties with 3% MDCSP exhibited a significantly lower pH value compared to the control sample (P ≤ 0.05).

The gradual increase of the pH of beef patties with prolonged freezer storage was attributed to the accumulation of metabolites of bacterial action on meat and meat products. Moreover, meat proteins also exhibit deamination, which is the process of breaking down of amino acids.

Figure 3. Peroxide value of beef patties from week 0 to week 4 packed in polypropylene plastic at -18°C.

Based on Figure 3, the beef patty with 3% MDCSP had no significant difference from the control sample (P ≤ 0.05) in week 0. However, on the subsequent weeks of storage, beef patty with 3%
MDCSP exhibited a significantly lower peroxide value compared to the control sample (P ≤ 0.05). The POV of control beef patties from week 0 to week 1 and week 1 to week 2 had no significant difference from each other. In additions, POV of control beef patties from weeks 2 to 4 had significant differences due to faster increase in POV every week specifically during the 3rd week of storage period. More rapid increase was attributed to the faster rate of new hydroperoxides formation than degradation of hydroperoxides into secondary oxidation products. Furthermore, the decrease in the POV of control beef patties in the 4th week of its storage period indicates degradation of peroxides into secondary oxidation products which can be measured through TBARS analysis.

Beef patties with 3% MDCSP exhibited no significant differences throughout its storage period. This can be described to the gradual change in POV during the 4-week frozen storage period where closer POV values can be observed. The results show that incorporation of MDCSP in beef patties at 3% level was used as a natural antioxidant due to the reason that effectively inhibited lipid oxidation in long storage period, thus preserve its quality. This functional property of MDCSP in beef patty was described to the presence of phenolic compounds which are the most important phytochemicals and best indicator of antioxidant in corn silk [9,13]. The antioxidative potential of phenolic constituents is mainly due to their redox properties, which can play a significant function in adsorbing and neutralizing free radicals, quenching singlet oxygen, or decomposing peroxides [17].

4. Conclusion
In conclusions, microwave drying corn silk for 4 minutes at 900 W was found most appropriate time and setting to achieve the desired moisture content of corn silk. Proximate analyses of MDCSP revealed that microwave – drying can retain its nutritional components. Physico-chemical analyses of MDCSP showed that slightly acidic pH and a low water activity. Particle sizes of MDCSP ranged from 3.69 – 39 µm. The results showed that MDCSP had antioxidant activity and dependent on the particle size.

5. References
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