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Chemical and Phytochemical Characteristics of Local Corn Silk Powder of Three Different Varieties

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***Abstract*— Corn silk is a part of the corn plant that is still considered to be waste from corn processing; however, corn silk is actually known to have the potential to be developed as functional food ingredients and/or nutraceuticals. The potential applications of corn silk are closely related to its chemical composition and the action mechanisms of its bioactive compounds, which have beneficial effects on human health, such as flavonoids and phenolics. This study aimed to investigate the chemical and phytochemical characteristics of local corn silk powder of three different varieties, i.e. Bisma, Arjuna, and Srikandi Putih. Phytochemical and proximate analyses were conducted on each sample of corn silk powder. The total phenolic content was examined using the Folin-Ciocalteau method, while the beta sitosterol was analysed by gas chromatography and the antioxidant activity of the extract was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. The results show that all samples had different amounts for their moisture, ash, protein, fat and carbohydrate contents from the proximate analyses. The Bisma variety of corn silk powder reveals the highest fat and protein contents, which are 0.30%±0.02 and 17.70 ±0.47, respectively. Furthermore, the highest total phenolics, total flavonoids, beta-sitosterol contents and antioxidant activity for the corn silk powder are also demonstrated by Bisma; i.e. 8262.93±178.59 µg gallic acid equivalent (GAE)/g for total phenolics, 236.03±8.37 µg gallic acid equivalent (GAE)/g for total flavonoids, 1343.93±78.44ppm for beta-sitosterol and 73%±1.09 for antioxidant activity. Thus, it may be suggested that among the three local varieties of corn silk, a corn silk powder from the Bisma variety could be developed as a source of bioactive compounds and nutrients to convert corn silk from being waste into value-added corn products.**

***Keywords*— local corn silk powder; chemical; phytochemical; characteristics.**

I. INTRODUCTION

Corn is one of the plants most widely grown as cereal throughout the world, and ranks third after wheat and rice [1]. Maize production in Indonesia amounted to 19.01 million tonnes (in 2014), and increased to 20.67 million tonnes (in 2015) [2]. Production amounted to 8.73% and the estimated percentage of corn silk is about 10%. This amount is quite large and it could potentially be used as a raw material for the food industry. Corn and its parts are used in a variety of foods, agriculture (feed stuffs) and applications in health [3];[4]. Immature corn (harvested after 60 days) contains protein (25.60 %), dietary fibre (30.40 %), fat (3.67 %), ash (3.74 %) and the total content of sugar is 10.1 g/100g [5]. Immature maize contains 5.4 mg/100g of ascorbic acid, amino acid (0.1 g/g of methionine, 2.8 g/g isoleucine and 0.7 g/g leucine) and some minerals Ca, Mg and P (95 m/100g, 345 mg/100g and 898.6 mg/100g, respectively). One part of the corn is corn silk [6].

Corn silk is a set stigma hair that is soft and smooth, and looks like a thread or yellowish hair. Corn silk comes from the female flowers of the corn crop. At first, the hair colour of the corn is usually light green, and then will turn red, yellow, or brown depending on the variety. The function of the corn silk is to capture pollen for pollination. Corn silk hair length can reach 30 cm or more. Until now, corn silk has not been used by the community to the fullest extent possible, but is known to have the potential to be developed into a functional food, which is expected to reduce the risk factors for hypercholesterolemia. Corn silk contains secondary metabolites such as flavonoids, saponins, tannins, phlobatannin, phenols, alcohols, terpenoids, glycosides, proteins, carbohydrates, fibre, B vitamins, vitamin C, vitamin K, Zn, Be, Ca, Mg, and P, and steroids such as stigmasterol, alkaloids, saponins, tannins, anthocyanins, protokatekin, vanillic acid, derivatives hasperidin, and quercetin [7];[8];[9], maysin, β-carotene, beta-sitosterol, geraniol, hordenin, limonene, menthol and viteskin [10]. Corn silk contains water (9.65 %), protein (17.60 %), fat (12.29 %), ash (3.91 %), and crude fibre (40.00 %) [11]. In addition, corn silk is a source of bioactive compounds, especially flavonoids [12]. The nutrient content and functional characteristics corn silk possesses means it has the potential to be used as a functional food ingredient [8].The studies that have led to the use of corn silk for health benefits have been widely published, the conditions, among others, that corn silk may provide a benefit for are hypercholesterolemia [13];[14];[15];[16], hyperthyroidism [17], renal conditions [18];[19], hypertension, tumours, hypoglycaemia, hepatitis, cystitis, gout, kidney stones, diabetes, nephritis and prostate [20].

Corn silk is known to contain mainly flavonoids and phenolic-rich, high-antioxidant compounds in different amounts and proportions depending on the variety of maize [21];[22];[23];[24]. The variety and growing conditions affect the antioxidant components due to the different responses of plants to the environment [25]. There is a very significant difference in the total phenolic content, and the total flavonoid, anthocyanin and antioxidant activity in corn silk in Thailand [26]. The content for phenols, flavonoids, anthocyanins and antioxidant activity varying among the varieties in Thailand was reported by [23], while in Malaysia it was reported by [27] that both immature and mature corn silk is considered to be a source of nutrition and has a good antioxidant capacity. Immature corn silk has a higher content of polyphenols and flavonoids ($p<0.05$) than the mature corn silk [27]. The corn varieties that exist in Indonesian are very diverse both in terms of location and provides a variety of different hair lengths. So far, the studies on corn silk are dominated by studies on the utilization of corn silk for health purposes. Through the three local varieties of corn silk (Bisma, Arjuna and Srikandi Putih) there is potential that has not been disclosed, including, among others, the chemical and phytochemical characteristics. Increasing the value added from corn silk can be done by processing the corn silk into powder.

Processing corn silk into powder can cause changes in the chemical characteristics of corn silk powder. The magnitude of this change depends on the drying method used to optimize the drying process and maintain the quality of the dried product. Drying is one important aspect in food processing and is a common technique used in food preservation to produce [28];[29]. The drying method most commonly used in the food industry is the conventional oven-drying method using hot air [30], which works by evaporating water from the material [28].

II. Material and Method

A. Materials

Local varieties of corn silk were used in this study (Bisma, Arjuna and Srikandi Putih) that were ±80–90 days of age, each of which has different characteristics, and were obtained from Lawangan, Lempuyang Village, Candiroto District, Temanggung Regency.

The chemicals that were used to test the proximate obtained in the Laboratory of Chemistry and Food Biochemistry, Faculty of Agricultural Technology, Semarang University and to test the phytochemicals include acetate buffer 0.1 M (pH 5.5) (a mixture of Na-acetate and acetic acid), methanol DPPH 3 mM methanol, 95 % ethanol, distilled water, reagent Folin-Ciocalteau gallic acid, and Na_2CO_3 5 %. All of reagents used were in analytical grade.

B. Equipment

The equipment used for proximate test purposes include a Sanyo drying oven OvenMov-112 (to analyse the moisture content), Kjeldahl (to analyse the protein content), Soxhlet and thimble (for the fat content analysis), a furnace (for the ash content analysis), and equipment glasses. Essential equipment to analyse the total phenols, total flavonoids, beta-sitosterol and analyse the antioxidant activity were the UV- VIS Spectronic 20, a centrifuge, a vortex, beakers, test tubes, cuvettes, Mohr pipettes and a gas chromatograph of brand Shimadzu QP 5000 (GCMS).

C. Sample Preparation

Fresh corn silk, as much as 3g, was washed with distilled water, dried in an oven at 60°C for 24h [31] until the final moisture content was 10–11%, ground into a powder using a grinder, vacuum packed and stored at below -20°C until the analysis was performed.

D. Analysis

Proximate analysis was conducted on water con tent and ash using the drying (oven) method [32], on the protein content using the Micro-Kjeldahl method [32], on the fat content using Soxhlet extractor [32], on the ratio of carbohydrates using carbohydrate by difference [32], and on the phytochemicals of corn silk to determine total phenols [33], flavonoids [22], beta-sitosterol [34] and antioxidant activity [33].

E. The Experimental Design

The experimental design used was the complete random design (CRD) for one factor (Bisma, Arjuna and Srikandi Putih) with six replications. Data is expressed as mean ± standard deviation (SD). The acquired data was statistically analysed using analysis of variance (ANOVA) with a significance level of 95%, and analysed to determine if there is influence between continued treatments using the *Duncan multiple range test (DMRT)* at the 5% level.

III. Result and Discussion

A. Analysis of Raw Materials

The analysis conducted on the raw materials included water, protein, ash and carbohydrate content, as well as the phytochemicals, as shown in Table 1.

Overall, the values of water, ash, protein, fat, carbohydrates and phytochemicals in the fresh corn silk varied as detailed in Table 1. The Bisma variety of fresh corn silk shows the highest levels of protein (0.45 %) and fat (22.29 %). For the Bisma variety, the content of total phenols, total flavonoids, beta sitosterol and antioxidant activity are 9346.22 µg/g, 301.59 µg/g, 178.37 ppm and 83.57%, respectively, with this giving the highest level of antioxidant activity. These differences are allegedly due to differences in the variety, growing conditions, the level of maturity at harvest and storage conditions after harvest, which can affect the components of a material.

TABLE I.
THE RESULTS OF THE PROXIMATE ANALIYSIS OF THREE LOCAL CORN SILK

Components	**Local Varieties**		
	Bisma	**Arjuna**	**Srikandi Putih**
Water (% db)	67.11± 1.38^{b}	71.80± 1.22^{c}	62.54± 2.01^{a}
Abu (% db)	3.69± 0.10^{c}	2.91± 0.88^{a}	3.48± 0.12^{b}
Fat (% db)	0.45± 0.04^{c}	0.25± 0.03^{a}	0.34± 0.04^{b}
Protein (% db)	22.29± 1.01^{c}	15.38± 1.05^{a}	18.90± 1.34^{b}
Carbohydrates (% db)	6.47± 2.43^{c}	9.68± 1.87^{b}	14.75± 3.25^{a}
Total phenols (µg GAE/g)	9346.22± 4037.11^{c}	8088.05± 160.19^{b}	4813± 286.52^{a}
Total flavonoids (µg GAE/g)	301.59± 9.87^{c}	240.94± 13.50^{b}	194.73± 14.81^{a}
Beta-sitosterol (ppm)	1783.37± 57.70^{c}	1327.95± 54.80^{b}	963.86± 198.39^{a}
Antioxidant Activity (%)	83.57± 1.36^{c}	65.49± 2.59^{b}	53.03± 2.50^{a}

db: *dry* base. The figures followed by different superscript letters in the same line are significantly different (p<0,05)

B. Colour and Length of the Corn Silk

An analysis was performed of the colour of the three varieties of corn silk, which included visual observation and observation using spectrophotometer equipment. The visual observation reveals that the colours and lengths of the corn silk are different. Each variety is shown in Figure 1.

Bisma Arjuna Srikandi Putih

Fig 1. Three varieties of corn silk

Figure 1 illustrates that, visually, the Bisma variety tends to have a dark brown hair colour, while the Arjuna variety has a brown-and-white colour and the Srikandi Putih variety is a light brown colour. The observation on the degree of colour with a parameter variation value for brightness L has a value ranging between 8.42%-17.80%, this confirms the corn silk has different levels of colour intensity. The Bisma variety has a dark brown colour. The hair colour density level in corn is believed to influence the content of phenolic compounds and flavonoids in corn silk. Flavonoids and their derivatives are compounds that can provide colour to the corn silk; furthermore, it is well known that phenolics are rich in antioxidants, but the highest amounts and proportions differ depending on the variety of maize [21];[22];[23];[24]. For Bisma the corn silk length is 14–27 cm, for Arjuna it is 13–23 cm and for Srikandi Putih the corn silk length 10–21cm. Differences in colour and length corn silk are thought to be caused by differences in genetics and environment.

C. Proximate Content

Table 2 shows that the three varieties of corn silk tested have different levels of the chemical components. The moisture, ash, protein, fat and carbohydrate content are significantly different ($p<0.05$) among the three varieties of corn silk. The Bisma variety has the highest levels of protein (17.70%±0.47) and fat (0.30%±0.02). Plants that have different genetic characteristics will have different adaptations to the environment. This will also lead to differences in the rate and metabolic products are created. Therefore, the factors that are suspected to contribute to the differences in the chemical composition of the corn silk are genetic traits, different varieties, growing conditions, the level of maturity at harvest time, storage conditions after harvest and the production process. The chemical composition of corn silk varies depending on the variety and growing conditions that affect the antioxidant components due to the different responses of plants to the environment [25]. Variations in composition are influenced by several factors, such as differences in varieties, the climate where it grows, soil fertility, the care of the plant and the treatment method [35]. The chemical composition of corn grain, such as proteins, lipids and starches, is more influenced by genetic traits [36]. Plants that have different genetic characteristics will have different adaptations to the environment. This will lead also to differences in the rate and the metabolic products that are created. Factors that allegedly contribute to the differences in the chemical composition of the corn starch are genetic traits. There are differences in the genes across the varieties, each of which has a diverse character. The environment plays a role in the context of the actual appearance of the characteristics contained in the gene. The appearance of a gene is still unstable because they are influenced by environmental factors, so often similar plants are found with different characteristics. Each variety shows growth, and the results vary as a result of genetic and environmental influences, of which the genetic influence is the influence of the descendants of the strain properties, while the influence of the environment is the effect caused by the habitat and environmental conditions [37].

The three local varieties of corn silk powder (Bisma, Arjuna and Srikandi Putih) are dried at 60°C for 24h [31] and have a water content ranging from 8.1–14.7%. This is in contrast to what is reported [27], which is that the corn silk at different stages of maturity, dried at 55°C for 48 hours, has a water content of 3.90%, a fat content of 0.66%, a protein content of 8.95%, an ash content of 5.51%, a level of carbohydrate of 29.74% and has an amount of 51.24% of crude fibre. The water content of the three local varieties of corn silk powder is higher than for pare pericarp seed (5–13.4%) at the different stages of maturity, which were dried at 40°C for 24h [38], and higher than for the powdered mango bark [39]. The differences are due to the accumulation of hydrocarbons at a stage of maturity that affect lipid composition [27]. The protein content at the different maturity levels is probably influenced by the function and biosynthesis of amino acids that occur during the development process. The protein content of the local varieties of corn silk powder is higher than for some vegetables (2–4%) [40], and for under-utilized crops such as mango skin (3.6%) and legumes [41]. Amino acids are actively metabolized in the immature cob in the early stages of hair emergence to regulate the growth of seedlings [42]. This is different to what is reported by [43], which is that powdered corn silk has a water content of 9.06g/100g, a fat content of 0.91g/100g, an ash content of 4.60%, a protein content of 17.94g/100g and a carbohydrate content of 51.37g/100g.

TABLE II.
THE RESULTS OF THE PROXIMATE ANALYSIS OF THREE LOCAL CORN SILK POWDERS

Components	Local Varieties		
	Bisma	**Arjuna**	**Srikandi Putih**
Water (% db)	1158± 0.42^{b}	14.66± 0.46^{c}	8.09± 0.35^{a}
Abu (% db)	3.29± 0.14^{b}	2.66± 0.30^{a}	3.33± 0.12^{c}
fat (% db)	0.30± 0.02^{c}	0.13± 0.01^{a}	0.21 ± 0.03^{b}
Protein (% db)	17.70± 0.47^{c}	12.89± 0.79^{a}	14.87± 0.28^{b}
Carbohydrates (% db)	67.13± 0.72^{a}	69.54± 0.85^{b}	73.53± 0.39^{c}

db: *dry* base. The figures followed by different superscript letters in the same line are significantly different (p<0,05)

D. *Phytochemical Content of Corn Silk Powder*

1) *Total Phenols*

Table 3 reveals that there are differences in the total phenolic content of corn silk powder across the three varieties of local corn silk tested (p<0.05). The highest total phenol content is contained in the Bisma variety of corn silk powder, with an amount of 8262.93±178.59 µg gallic acid equivalent (GAE)/g and this is significantly different to the corn silk powder from the Bisma and Arjuna varieties. While the corn silk powder for the Srikandi Putih variety has the lowest levels of total phenols with an amount of 3367.10±210.69 µg gallic acid equivalent (GAE)/g.

Table 3 and Figure 2 show that the three local varieties of corn silk powder contain phenolic components that are different from what was found by previous researchers. The total phenol content for fresh corn silk is highest for the Bisma variety, which is 9346.22 µg gallic acid equivalent (GAE)/g. Once powdered, the total phenol content of corn silk is 8262.93±178.59 µg gallic acid equivalent (GAE)/g.

The corn silk was dried using different methods (*microwave*, *sun* and *shadow*) with the total phenol content for each being 1.20 mg/g, 0.85 mg/g and 1.33 mg/g, respectively [44]. Drying in the sun makes food lose vitamins when compared to drying using *sun and shadow*. The differences between the phenol content of the extract derived from fresh and dry samples are due to the drying process [45]. A phenolic compound is easily oxidized and sensitive to heat treatment, so that using the process of drying in the sun can reduce the total content of phenolic compounds. The optimum temperature used for drying to obtain the maximum level of total phenols was 60°C. If the drying done at a higher temperature than 60°C after 4 minutes, then the phenols will be damaged and the levels tend to decline [46]. There is a relationship between the temperature and the total content of phenolic compounds, with the phenolic compounds' content decreasing with an increasing temperature [47]. This is due to the decomposition of the phenolic compounds. The content of phenolic compounds is very sensitive, unstable and highly susceptible to degradation [48]. The main things causing degradation are the temperature, oxygen level and light. Heating with an increased drying temperature will cause damage to most of the phenolic compounds [49]. The processing method also affects the level of total phenols. There will be a decrease in phenolic acids with increasing temperature [50].

TABLE III.
PHYTOCHEMICAL ANALYSIS OF THREE LOCAL CORN SILK POWDERS

Components	Local Varieties		
	Bisma	**Arjuna**	**Srikandi Putih**
Total phenols (µg GAE/g)	8262.93± 178.59^{c}	6331.15± 185.08^{b}	3367.10± 210.69^{a}
Total flavonoids (µg GAE/g)	236.03± 8.37^{c}	178.33± 7.95^{b}	136.36± 12.83^{a}
Beta-sitosterol (ppm)	1343.93± 7.44^{c}	1047± 41.40^{b}	818.54± 28.60^{a}
Antioxidant activity (%)	73± 1.09^{c}	57.42 ± 2^{b}	44.19 ± 1.95^{a}

db: *dry* base. The figures followed by different superscript letters in the same line are significantly different (p<0,05)

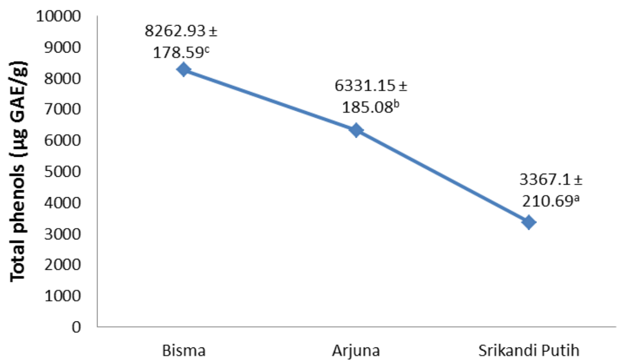

Fig 2. Total phenols for corn silk powder

2) *Total Flavonoids*

Table 3 and Figure 3 identify that there are differences in the total flavonoid contents of the local corn silk powder varieties in the third test ($p<0.05$). The highest content of total flavonoids is found in the Bisma variety of corn silk powder with an amount of 236.03 mg±8.37µg gallic acid equivalent (GAE)/g, which is significantly different to the values for the corn silk powder of the Arjuna and Srikandi Putih varieties. Whereas, the corn silk powder for the Srikandi Putih variety has the lowest level of total flavonoids with an amount of 178.33±7.95µg gallic acid equivalent (GAE)/g. The difference is believed to be because the different varieties of corn silk contain different levels of flavonoid compounds, depending on agronomic factors, varieties and processes. Flavonoid compounds are not resistant to heat and are easily oxidized at high temperatures [51]. Flavonoids will be degraded at temperatures above 100°C. Flavonoids are sensitive to heat because of the hydroxyl group and ketones, as well as unsaturated double bonds [52].

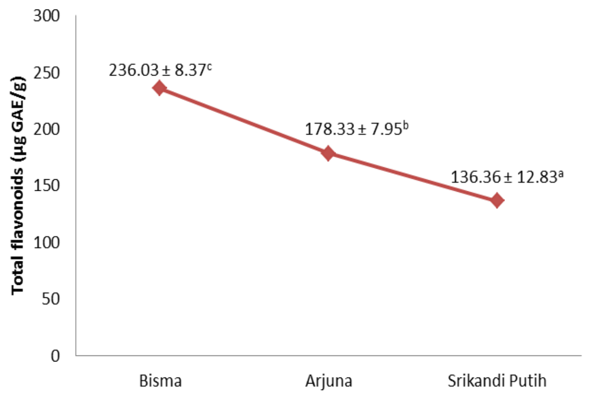

Fig 3. Total flavonoids for corn silk powder

3) *Beta-Sitosterol*

Table 3 shows that there are differences in the beta-sitosterol content of the three local varieties of corn silk powder tested ($p<0.05$). The Bisma variety corn silk powder has the highest level of beta-sitosterol with an amount of 1343.93±78.44 ppm and the lowest value obtained is for the Srikandi Putih variety of corn silk powder, which is 818.54±28.60 ppm.

The Bisma variety corn silk powder has the highest level of beta-sitosterol because the total phenol content was also the highest among the samples tested (Figure 4). This is consistent with what is proposed by [53], which is that the antioxidant activity of corn silk is associated with the total phenolic content. The content varies depending on the total phenolic content of the corn varieties used in the study.

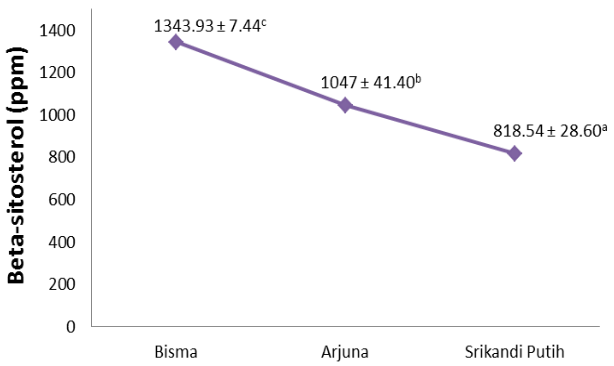

Fig 4. Beta-sitosterol for corn silk powder

4) *Antioxidant Activity*

The antioxidant activity for the three local varieties of corn silk powder measures their ability to counteract scavenging using DPPH free radicals. The results of the study is given in Figure 5.

Table 3 and Figure 5 show that the antioxidant activity for the corn silk powder obtained from the three local varieties was primarily tested for its ability to counteract free radicals, and that highest value is for the Bisma variety corn silk powder, which is equal to 73%±1.09. The activity differs significantly to the other samples ($p<0.05$). The second highest antioxidant activity was obtained from the Arjuna variety corn silk powder, with an amount of 57.42%±1.99. The lowest antioxidant activity was obtained from the Srikandi Putih variety of corn silk powder, with an amount of 44.19%±1.95.

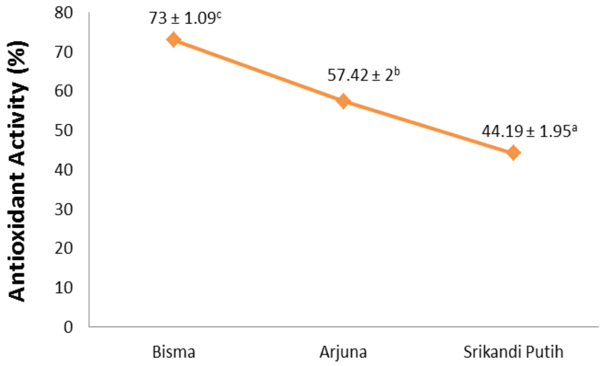

Fig 5. Antioxidant activity for corn silk powder

Temperature is one of the most important factors affecting antioxidant activity. The drying processes at higher temperatures, such as roasting, cause damage to the active substance contained in a food [54]. The high antioxidant activity for corn silk powder is affected by the levels of total phenols and flavonoids. The antioxidant activity increases with increasing levels of total phenols and flavonoids, which are bioactive compounds that act as antioxidants [55]. There are differences in the antioxidant capacity of the oven and microwaves (OM) drying method, due to the fact that in the oven method the heating occurs through a temperature gradient, while heating in the OM method occurs through a direct interaction between materials and microwaves, so that the energy transfer takes place more rapidly and the product quality is better [56];[57];[29]. This is evidenced in the research done by [58], where using the OM method with a power of 200 watts for 2 minutes has an antioxidant capacity of 499.55 mol/10g, this result is higher than from using the methods of roasting, boiling, steaming and frying. Similar results were also obtained in potatoes cooked using the OM method, which have a higher antioxidant capacity compared to cooking with boiling, frying and baking [59]. The antioxidant activity is directly proportional to the total phenol content; the higher the content of phenols in a material, the higher the antioxidant activity [53]. A strong correlation is demonstrated in a variety of studies between the values for the of total phenol content and antioxidant activity. There is a 93% correlation between the total phenol content and antioxidant activity in corn silk hair [60]. This is also supported by other studies that show the correlation between the total phenol content and antioxidant activity of plant leaves is 99% [61]. Phenolic compounds, such as flavonoids, are able to inhibit free radicals through the capture of the radical (radical scavenging) by donating an electron to the unpaired electrons in free radicals so the number of free radicals is reduced [62]. Contributing phenolic compounds as an antioxidant, because it can bind oxygen, so oxygen is not available for oxidation processes as well as phenolic compounds, can bind to the metal that is capable of catalysing the oxidation reaction [63]. However, prolonged exposure to oxygen will oxidize phenolic compounds, which can decrease antioxidant activity due to a decrease in total phenol content.

IV. Conclusions

Corn silk powder of three different local varieties have differences in the amounts for their moisture, ash, protein, fat and carbohydrate content. The Bisma variety has the highest fat and protein contents of corn silk powder, which is shown by values of 0.30%±0.02 and 17.70%±0.47, respectively. Furthermore, the highest total phenol content, total flavonoid content, beta-sitosterol contents and antioxidant activity of the corn silk powder are also attributed to the Bisma variety; i.e. 8262.93±178.59 μg gallic acid equivalent (GAE)/g for total phenol content, 236.03±8.37μg gallic acid equivalent (GAE)/g for total flavonoid content, 1343.93±78.44 ppm for beta-sitosterol content and 73%±1.09 for antioxidant activity. Thus, it may be suggested that among three local varieties of corn silk, a corn silk powder from the Bisma variety could be developed as a source of bioactive compounds and nutrients to convert corn silk from waste into value-added corn products.

References

[1] K. Ramessar, M. Sabalza, T. Capell, and P. Christou. "Maize plants: an ideal production platform for effective and safe molecular pharming", Plant Sci., vol. 174, pp. 409–419. 2008.

[2] Badan Pusat Statistik. (2013) Luas panen, produksi dan produktivitas jagung di DIY tahun 2007–2011. [Online] Available: http://www.bps.go.id

[3] N. Voca, B. Varg, T. Kricka, D. Curic, V. Jurisic, and A. Matin. "Progress in ethanol production from corn kernel by applying cooking pre-treatment", Bioresour. Technol., vol. 100, pp. 2712–2718. 2009.

[4] S. Naqvi, K. Ramessar, G. Farre, M. Sabulza, B. Miralpeix, R. M. Twyman, T. Capel, C. Zhu, and P. Christou. "High-value products from transgenic maize", Biotechnol. Adv., vol. 29, pp. 40–53. 2011.

[5] W. I. W. Rosli and C. J. Anis. "The potential of Zea mays ears and its extracts as an alternative food nutritive ingredients", APCBEE Procedia, vol. 2, pp. 141–147. 2012.

[6] S. Hooda and A. Kawatra. "Nutritional evaluation of baby corn (Zea mays)", Nutr. Food Sci., vol. 43, pp. 9–9. 2013.

[7] M. A. Ebrahimzadeh, F. Pourmorad, and A. R. Bekhradnia. "Iron chelating activity, phenol and flavonoid content of some medicinal plants from Iran", African Journal of Biotechnology, vol. 7, no. 18, pp. 3188–3192. 2008.

[8] J. Guo, T. Liu, L. Han, and Y. Liu. "The effect of corn silk on glycaemic metabolism", Journal of Nutrition and Metabolism Biomed Central, vol. 6, p. 47. 2009.

[9] M. A. Sholihah, A. R. Nurhanan, and W. I. W. Rosli. "Phytochemicals screening and total phenolic content of Malaysian Zea mays hair extracts", International Food Research Journal, vol. 19, no. 4, pp. 1533–1538. 2012.

[10] A. Rahmayani. Telaah Kandungan Kimia Rambut Jagung (Zea mays L). Bogor: Institut Pertanian Bogor. 2007.

[11] C. Wang, T. Zhang, J. Liu, S. Lu, C. Zhang, E. Wang, Z. Wang, Y. Zhang, and J. Liu. "Subchronic toxicity study of corn silk with rats", Journal of Ethnopharmacology, vol. 137 pp. 36–43. 2011.

[12] S. C. Ren, Z. L. Liu, and X. L. Ding. "Isolation and identification of two novel flavone glycosides from corn silk (Stigma maydis)", J. Med. Plants Res., vol. 3, no. 12, pp. 1009–1015. 2009.

[13] P. Barter. "HDL cholesterol, very low levels of LDL cholesterol and cardiovascular event", The New England Journal of Medicine, vol. 357, no. 13, pp. 1301–1310. 2007.

[14] Dachriyanus, D. O. Katrin, O. Rika, E. Olvi, Suhatri, and M. Husni. Uji efek a-mangostin terhadap kadar kolesterol total, trigliserida, kolesterol HDL dan kolesterol LDL darah mencit putih jantan serta penentuan Lethal Dosis 50 (LD50). Jurnal Sains dan Teknologi Farmasi, vol. 12, no. 2, pp. 64–7. 2007.

[15] D. Utariningsih. Dekok Rambut Jagung (Zea mays) Efektif dalam Menurunkan Kadar Kolesterol Tikus Putih (Rattus norvegicus). Malang: Universitas Muhammadiyah Malang. 2007.

[16] R. Yosmar, H. Arifin, and R. Mustika. "Pengaruh ektrak etanol rambut jagung (Zea mays L) terhadap kadar kolesterol mencit putih jantan hiperkolesterol", in Prosiding Seminar Nasional dan Workshop. Perkembangan Terkini Sains Farmasi dan Klinik IV Tahun 2014. 2014.

[17] T. Bhaigyabati, J. Ramya, and K. Usha. "Effect of methanolic extract of sweet corn silk on experimentally induced hyperthyroidsm in Swiss albino rats", IRJP, vol. 3, no. 3. 2012.

[18] N. M. H. Sukmawati. Pengaruh ekstrak Rambut Jagung (Maydis stigma) Terhadap Histologi Ginjal dan Ekspresi Gen pada Tikus Yang Diinduksi Gentamisin dan Piroksikam. Bandung: ITB. 2008.

[19] Nessa, A. Helmi, and H. Muchtar. "Efek Diuretik dan Daya Larut Batu Ginjal dari Ekstrak Etanol Rambut Jagung (Zea mays L)", in Prosiding Seminar Nasional Perkembangan Terkini Sains Farmasi dan Klinik III. Sumatera Utara: Fakultas Farmasi Universitas Andalas. 2013.

[20] Q. L. Hu and Z. Deng. "Protective effects of flavonoids from corn silk on oxidative stress induced by exhaustive exercise in mice", African Journal of Biotechnology, vol. 10, pp. 3163–3167. 2011.

[21] A. R. Nurhanan, W. I. W. Rosli, and S. S. J. Mohsin. "Total polyphenol content and free radical scavenging activity of corn silk (Zea mays hairs)", Sain Malysiana, vol. 40, no. 2, pp. 155–161. 2012.

[22] J. Liu, C. Wang, Z. Wang, C. Zhang, S. Lu, and J. Liu. "The antioxidant and free-radical scavenging activities of extract and fractions from corn silk (Zea mays L) and related flavone glycosides", Food Chemistry, vol. 126, pp. 261–269. 2011.

[23] E. Sarepoua, Tangwangchai, B. Suriharn, and J. Lertrat. "Relationships between phytochemicals and antioxidant activity in corn silk", International Food Research Journal, vol. 20, no. 5, pp. 2073–2079. 2013.

[24] F. H. Ramadani, D. Intannia, and M. Ni'mah. "Profil penurunan kadar glukosa darah ekstrak air rambut jagung (Zea mays L) tua dan muda pada mencit dan jantan galur balb-c", Jurnal Pharmascience, vol. 3, no. 1, pp. 37–44. 2016.

[25] S. Butsat, Siriamornpun, and Sirithon. "Antioxidant capacities and phenolic compounds of the husk, bran and endosperm of Thai rice", Journal Food Chemistry, vol. 119, pp. 606–613. 2010.

[26] E. Sarepoua, Tangwangchai, B. Suriharn, and J. Lertrat. "Influence of variety and harvest maturity on phytochemical content in corn silk", Food Chemistry Journal, vol. 169, pp. 424–429. 2015.

[27] A. R. Nurhanan and W. I. W. Rosli. "Nutritional compositions and antioxidative capacity of the silk obtained from immature and mature corn", Journal of King Saud University-Science, vol. 26, pp. 119–127. 2014.

[28] V. Sachin, Jangram, C. L. Low, and A. S. Mujumdar. Drying of Food, Vegetables, and Fruit. Volume 1. ISBN: 978-0806759-1. 2010.

[29] R. F. Mechlouch, W. Elfalleh, M. Ziadi, H. Hannachi, M. Chwikhi, A. B. Aoun, I. Elakesh, and F. Cheour. "Effect of drying methods on the physico-chemical properties of tomato variety Rio Grande", Int. J. F. Eng., vol. 8, no. 2, article 4. DOI:10.1515/1556-3758.2678. 2012.

[30] K. L. Zhou. "Effects of extraction solvent on wheat bran antioxidant activity estimation", Food Sci. Technol., vol. LEB 37, pp. 717–721. 2011.

[31] Q. L. Hu, L. Zhang, J. Li, Y. N. Ding, YJ, and F. L. Li. "Purification and antifatigue activity of flavonoids from corn silk", International Journal of Physical Sciences, vol. 5, pp. 321–326. 2010.

[32] Association of Official Analytical Chemist (AOAC). Official method 980.17 Preservatives in Ground Beef Spectrophotometric Method. Gaithersburg, MA: AOAC International. 2007.

[33] E. Candesa and L. Parker. Handbook of Antioxidant. 2nd ed., New York, NY: Marcell Dekker Inc. 2002.

[34] I. Yinusa, N. I. George, R. G. Ayo, and Y. Rufai. “Vacuum liquid chromatographic isolation and characterization of beta-sitosterol from the bark of Sarcocephalus latifolius (Smith Bruce)”, Journal of Chemistry and Chemical Sciences, vol. 5, no. 9, pp. 480–488. 2015.

[35] I. J. Prasiddha, R. A. Laeliocattleya, T. Estiasih, and J. M. Maligan. “The potency of bioactive compounds from corn silk (Zea mays L) for the use as a natural sunscreen: A review”, Jurnal Pangan dan Agroindustri, vol. 4, no. 1, pp. 40–45. 2016.

[36] T. M. Baye, T. C. Perarson, and A. M. Settles. “Development of calibration to predict maize seed composition using single kernel near infrared spectroscopy”, Journal of Cereal Science, vol. 43, no. 2, pp. 236–243. 2006.

[37] N. R. Riani, M. Amir Akil, and E. O. Momual. “Pengaruh berbagai takaran nitrogen terhadap pertumbuhan dan hasil tanaman jagung hibrida dan bersari bebas”, Risalah Penelitian Jagung dan Serealia Lain, vol. 5, pp. 21–25. 2001.

[38] R. Horax, N. Hettiarachchy, A. Kannan and P. Chen. “Proximate composition and amino acid mineral contents of Mormardica charantia L, pericarp and seeds at different maturity stages”, Food Chem., vol. 122, pp. 1111–1115. 2010.

[39] C. M. Ajila, K. Leelavathi, P. Rao, and UJS. “Improvement of dietary fiber content and antioxidant properties soft dough biscuits with the incorporation of mango peel powder”, J. Cereal Sci., vol. 48, pp. 319–326. 2008.

[40] B. Odhav, S. Beekrum, U. Akula, and H. Baijnath. “Preliminary assessment of nutritional value of traditional leafy vegetables in Kwa Zulu-Natal, South Africa”, J. Food Compos. Anal., vol. 20, pp. 430–435. 2007.

[41] I. Mateos-Aparicio, C. Mateos-Peinado, and P. Ruperez. High hydrostatic pressure improves the functionality of dietary fibre in okra by-product from soybean”, Innov. Food Sci. Emerg. Technol., vol. 11, pp. 445–450. 2010.

[42] J. R. Seebauer, S. P. Moose, B. J. Fabbri, L. D. Crossland, and F. E. Below. “Amino acid metabolism in maize earshoots. Implications for assimilate preconditioning and nitrogen signalling”, Plant Physiol., vol. 136, pp. 4326–4334. 2004.

[43] N. Aukanit, T. Kemngoen, and Ponharn. “Utilization of corn silk in low fat meatballs and its characteristics”, Procedia-Social and Behavioral Sciences, vol. 197, no. 22015, pp. 1403–1410. 2015.

[44] K. Bhuvaneshwari and S. Sivakami. “Analysis of nutrients and phytochemicals content in corn silk (Zea mays)”, International Journal of Science and Research (IJSR), ISSN (Online): 2319-7064:79-81.2015.

[45] Luximon-A. Ramma, T. Bahorun, M. A. Soobrate, and O. I. Aruoma. “Antioxidant activity of phenolic, proanthocyanidin and flavonoid components in extract of Cassia fistula”, J. Agri. Food Chem., vol. 50, pp. 5042-5047. 2002.

[46] D. K. Sari, D. H. Eardhani, and A. Prasetyaningrum. “Pengujian kandungan total fenol Kappahycus alvarezzi dengan metode ekstraksi ultrasonic dengan variasi suhu dan waktu. Jurusan teknik kimia fakultas teknik UNDIP”, in Prosiding SNST ke-3 tahun 2012. Fakultas Teknik Universitas Wahid Hasyim, Semarang. 2012.

[47] Liyana-C. Pathirana and F. Shahidi. “Optimation of extraction of phenolic compounds from wheat using response surface methodology”, Food Chemistry, vol. 93, pp. 47–56. 2005.

[48] T. Vata, M. Skerget, and Z. Knez. “Extraction of phenolic compounds from elderberry and different grape marc varieties using organic solvents and/or supercritical carbodioxide”, J. Food Eng. 2009.

[49] S. Tuminah 2004. “Teh (Camellia sinensis) sebagai salah satu sumber antioksidan”, Cermin Dunia Kedokteran, vol. 144, pp. 52 –54. 2008.

[50] Z. Reblova. “Effect of temperature on the antioxidant activity of phenolic acids”, Czech Journal of Food Science, vol. 30, no. 2, pp. 171–177. 2012.

[51] S. Lenny. Senyawa Flavonoid, Fenilpropanoida dan Alkaloida. Medan: Fak. MIPA, USU. 2006.

[52] L. Y. Qiao, R. Sun, Chen, Y. Fu, W. Zhang, X. Li, J. Chen, Y. X. Shen, and Ye. “Sonochemical effects on 14 flavonoids common in citrus. Relation to stability.” Plos ONE, vol. 9, no. 2:e87766. 2014.

[53] S. H. Huang and L. T. Ng. “Quantification of polyphenolic content and bioactive constituents of some commercial rice varieties in Taiwan”, Journal of Food Composition and Analysis, vol. 26, pp. 122–127. 2005.

[54] F. G. Winarno. 2002. Kimia Pangan dan Gizi. Jakarta: Gramedia. 2002.

[55] A. D. Yondra, C. Jose, and H. Y. Teruna. “Total fenolik, flavonoid serta aktivitas antioksidan ekstrak n-heksana, diklorometan dan metanol amaranthus spinosus l em5-bawang merah”, JOM FMIPA, vol. 1, no. 2, pp. 359–369. 2014.

[56] X. Zhang and D. O. Hayward. “Applications of microwave dielectric heating in environmental related heterogeneous gas-phase catalytic systems”, Inorganica Chimica Acta., vol. 359, pp. 3421-1433. 2006.

[57] S. Das, A. K. Mukhopadhyay, and D. Basu. “Prospect of microwave processing: An overview”, Bulletin of Material Science, vol. 32, no. 1, pp. 1–13. 2009.

[58] I. Dini, G. C. Tenore, and A. Dini. “Effect of industrial and domestic processing on antioxidant properties of pumpkin pulp”, F. Sci and Technol., vol. 53, pp. 382–385. 2013.

[59] T. Blessington. “The effects of cooking, storage, and ionizing irradiation on carotenoids, antioxidant activity and phenolics in potatoes (Solanium tuberosum L.)”, thesis. Texas A&M University. 2005.

[60] A. A. Samin, N. Bialangi and Y. K. Salimi. “Penentuan kandungan fenolik total dan aktivitas antioksidan dari rambut jagung (Zea mays L) yang tumbuh di daerah Gorontalo”, Jurusan Pendidikan Kimia fakultas MIPA, Universitas Negeri Gorontalo. 2010.

[61] Angkasa, Dudung, and A. Sulaeman. “Pengembangan minuman fungsional sumber serat dan antioksidan dari daun hantap (Sterculia oblongata R.Brown)”, thesis, Departemen Gizi Masyarakat, IPB, Bogor. 2012.

[62] R. Yuswantina. "Uji aktivitas penangkapan radikal dari ekstrak petroleum eter, etil asetat dan etanol rhizoma binahong (Anredera cordifolia (Tenore) Steen) dengan metode DPPH (2,2-difenil-1-pikrihidrazil)”, thesis. Fakultas Farmasi. Universitas Muhammadiyah, Surakarta, Surakarta. 2009.

[63] M. Khatun, S. Eguchi, T. Yamaguchi, H. Takamura, and T. Matoba. “Effect of thermal treatment on radical-scavenging activity of some spices”, Food Science and Technology Research, vol. 12, no. 30, pp. 178–185.2006.