Determination of Starch Content in Green Maize Cobs and its Product Development

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ABSTRACT

Maize is an important crop cultivated throughout the country. Although it is nutritious containing nutrients like carbohydrates, fat, protein, some vitamins and minerals, it is often considered as poor people's food. Maize in Bhutan is generally used for human consumption in the form of grits (kharang), roasted flattened form (tengma) and quite often as cattle feed. In light of the limited option for use of maize as food and the stigma attached to its consumption, there is a need for maize product diversification into more attractive and acceptable food forms.

One potential use of maize could be starch extraction and utilization of the extracted starch in baked products. This study was conducted to determine the possibility of extracting and recovering starch, and in developing products from extracted starch. Results from this study indicate that the starch yield ranges from 208.6 g in milk stage, 316.9 g in dough stage, 507.6 g in dent stage and 540 g in physiological maturity stage from fresh 3 kg of maize grain weight. A significant difference in the percentage of starch recovered at different stages of maize grain development was observed. The starch recovered increased with the maturity of the maize grain and varied from 6.9 % at milk stage to 10 % at dough stage, 16 % at dent stage, and 17.9 % at physiological maturity stage. Four different products - cookies, fried cookies, cracker and pancake were developed from the extracted starch. Sensory evaluation results for the four products showed that overall acceptability percentage for cracker, pancake, cookies and fried cookies were 100 %, 90 %, 84 % and 28 % respectively. Based on average scores from the sensory evaluation, cracker was the most liked product and fried cookies the least. The results from the study could be beneficial in maize product development and diversification.

Key words: *Reproductive stages, starch recovery, products, sensory evaluations*

1. Introduction

Maize (*Zea mays* L.) or corn is one the popular staple foods grown across the globe. In Bhutan, maize is cultivated throughout the country, and most commonly in the eastern region of the

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country. It is one of the main cereal crops that is cultivated for consumption and as feed for domestic animals. In 2016, Bhutan produced 82,035 MT of maize from 56,609 acres (DoA, 2016). The crop is cultivated by over 70% of the households and plays a critical role in household food security (NBC, 2008). According to the maize value chain report by UNDP (2016) maize is consumed as substitute of rice by milling kernels into small grits as *kharang*. *Tengma* (beaten corn) is also processed from maize kernels by roasting over a pan and flattened by a crushing machine. To a lesser extent it is also used as ingredient for brewing *Ara* (local brew) while the residues and low grade maize kernels are used as cattle feed. At a global level 64% of maize is used as feed, 16% as food for humans, 19% in industrial starch and beverage, and 1% as seed (Malhotra, 2017).

Maize, besides being used for direct consumption as human food is also a source of starch in industries and confectionaries. Starch is major form of stored carbohydrate in the plants that contains chlorophyll. Starch is produced during photosynthesis. Starch and oil in corn kernel provides energy for the seeds to germinate (CRA, 2006).

Maize kernels consist of seed coat (pericarp), starchy endosperm and the embryo (germ). The endosperm attributes to 80% of the total weight of the kernel. The matured kernel is composed of 70-75% starch, 8-10% protein and 4-5% oil (Öner, 2015). Starch is a carbohydrate reserve found abundantly in plant parts like leaves, flower, fruits, seeds, stems and roots. It's a carbohydrate polymer consisting of linked long chain glucose units from end to end. They are formed in the chloroplasts of green leaves. Amyloplasts and organelles are responsible for the starch reserve synthesis in cereals and tubers (Alcazar-Alay & Meireles, 2015).

Starch is composed primarily of amylose and amylopectin. In the normal maize starch the amylose content varies from 20 to 25% and 75 to 80% amylopectin (Popescu, Alexandru, Bărăscu, & Iordan, 2010). Isolated starch is a dry, soft, white powder which is insoluble in cold water, alcohol, ether and in most organic solvents (CRA, 2006). Maize starch forms a transparent paste and used in gelatinization of food products, powder for kids, bio- plastics which are known to be an indispensable part of packaging industries, as anti-stick agents in medical and pharmaceutical industries and as anti-caking agent in the powdered sugar. It is a valuable ingredient in food processing industries and is used as thicker, gelling, bulking and water retention agent (Sandhu & Singh, 2006).

Although it is a staple food in the eastern region it is often felt as poor cuisine compared to rice (Wangchuk & Katwal, 2014). Many prefer having rice then *kharang* (grits) in their daily diet. Even in the rural households *kharang* on its own is rarely consumed. In fact *kharang* (grits) and *tengma* (pounded corn) are the only maize products that are consumed (Wangchuk & Katwal, 2014). In light of this limited options for use of maize as food and low preference there is need to diversify maize products into more acceptable and palatable forms. Since maize contains high amount of starch a potential use could be starch extraction from maize and utilization in different products in bakeries.

With immense scope to add value and diversify the use of maize, this study was conducted with two key objectives.

- To extract starch from maize kernel at four different reproductive stages manually to develop new products and diversify its uses.
- To use the extracted maize starch to develop different maize products and evaluate the quality of these products through sensory evaluation test.

2. Materials and Method

The study was conducted at the Integrated Food Processing Plant, Lingmethang under Mongar Dzongkhag for two seasons in 2017 and 2018. The starch extraction was done at four different reproductive growth stages of maize corresponding to milk stage (18-22 days after silking), dough stage (24-28 days after silking), dent stage (35-42 days after silking) and physiological maturity at 55-65 days after silking as described in Nielsen (2018). This experiment had four treatments which included starch extraction at milk stage, dough stage, dent stage and at physiological maturity. Each treatment was replicated four times and for each replicate 3kg of maize kernel was used for starch extraction. The maize variety used in this trial was local variety Barpa.

The maize variety Barpa was harvested from farmer's field in Wengkhar separately at four different reproductive growth stages as described above. The cobs were de-husked, shelled and cleaned to obtain 3kgs of maize kernels. The grains were weighted using an electronic weighing balance. The maize grains were then grinded using the heavy duty mixture grinder (Lord Master Hammer 1600) for about 2-3 minutes and 2000ml of water was added to the grinded maize to obtain a suspension of fine particle of starch in water. The mixture was then filtered using double layer white muslin cloth. The juice was left to settle for 2-3 hours. After 2-3 hours, the juice was drained and the sediment (starch) was taken out from the container. The starch was spread on solid sheet in electric dryer (Ezi dryer) and dried at a temperature of 55^0C overnight. Dried starch powder was weighed and the data were recorded accordingly.

Four different products namely cookies, fried cookies, cracker and pancake were prepared from the starch. A sensory analysis was conducted with 50-member panelist comprising food technologist, agriculture researchers, agricultural extension officers and youth entrepreneurs. The panelist evaluated the product based on the colour, taste, texture, appearance and overall acceptability of the product using the 9-point hedonic scale (Table 1). 9-point hedonic scale is widely used method to evaluate the food products developed by Jones, Peryam, and Thurstone (1955).

Table 1. 9. Point hedonic scale

Hedonic rating	Score
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Source: Jones et al. (1955)

The panelists were presented four different products prepared from the maize starch. Testing were performed one after another and their rating were recorded in a 9-point hedonic scale sheet provided to the panelist.

The data from the test were analyzed using Statistical Package for Social Science (SPSS) version 22.0. Quantitative data such as weight were analyzed using One Way ANOVA and Microsoft Excel 2008. P values ≤ 0.05 were considered significant in all the analyses. The results of qualitative data on sensory evaluation were interpreted in percentages.

3. Results and Discussion

3.1 Starch yield from different stages of maize

The result shows that there was significant increase of starch yield with maturity of the maize. There was a significant difference ($P < 0.0001$) among the four different stages of maize. The starch yield ranges from 208.6 g in milk stage, to 316.9 g in dough stage, 507.6 g in dent stage and 540 g in physiological maturity stage from 3 kg of fresh grain weight (Table 2). The maximum starch yield was recorded at physiological maturity stage and minimum in milk stage. As the corn matures the starch content gradually increases from milk stage at 18-22 days after silking, dough stage at 24-28 days after silking, dent stage at 35-42 days after silking and physiological maturity stage at 55-65 days after silking (Nielsen, 2018).

Table 2. Maize starch yield at different stages of maize

Variety	Stages	Mean starch content from 3 kg fresh kernel (g)
Barpa	Milk stage	208.6d
	Dough stage	316.9c
	Dent stage	507.6b
	Physiological maturity stage	540.0a
P-value		*<0.0001*
CV (%)		*0.69*

Means with the same letters in the column are not significantly different at 0.05 probability level using Duncan Multiple Range test

The study also revealed that there was significant difference ($P < 0.0001$) in starch recovery rate for different stage of maize (Figure 1). The recovery rate of starch increased with the maturity of maize kernel. The highest recovery rate of starch was obtained from physiological maturity and lowest recovery rate from milk stages. Similar results were reported by Nleye, Chungu, and Kleinjan (2019) supporting that at kernel milk stage (approximately 18-22 days after silking) starch accumulation occurs rapidly and continues to increase as the kernel develops and reaches physiological maturity stage at 55 to 65 days after silking when black layers develop at the base of kernel. This indicates that the starch content will be minimal at early stages of development and gradually increases with a maximum at the matured stage.

Ketthaisong, Suriharn, Tangwongchai, and Lertrat (2013) also reported similar results in the starch content of waxy corn that showed increasing trend in relation to delay harvesting from optimum stages until physiological maturity stages where starch granular size increased in relation to kernel development. According to Burrell (2003) maize kernel contain about 66% starch and optimum starch is extracted from freshly harvested grain at physiological maturity when the starch content in the endosperm of the kernel will be higher than in other stages. Cui, Dong, Zhang, and Liu (2014) also observed that maize kernel contains about 70% by weight starch.

The starch contained in the endosperm of the kernel was also affected by external factors like altitude and pests. The recovery rate of maize starch extraction also depends on handling and efficient starch extraction process.

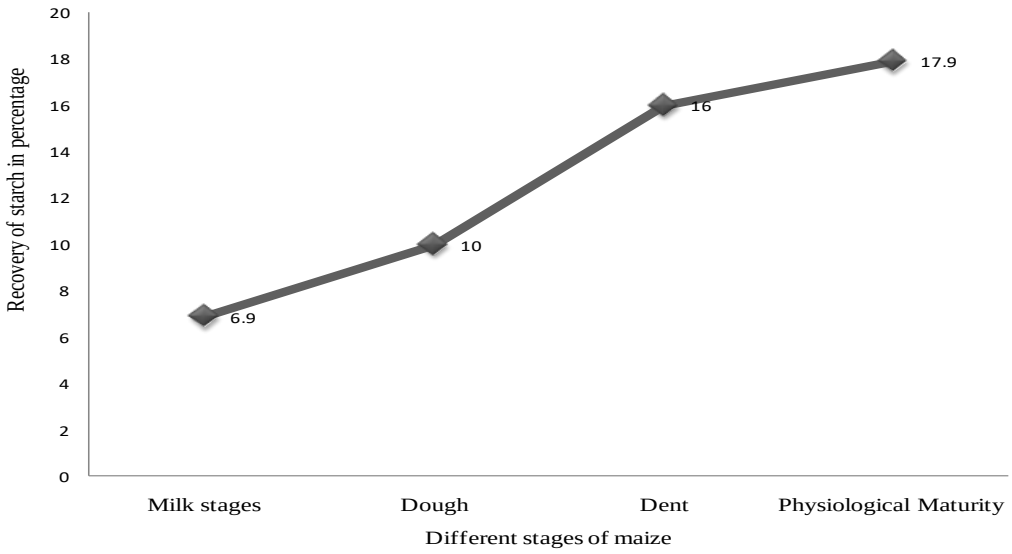

Figure 10. Starch yield in percentage

3.2 Sensory evaluation of the products

Four different products such as cookies, fried cookies, cracker and pancake were developed from the starch powder extracted from maize kernel. The products were evaluated based on colour, flavour, taste, texture, appearance and overall acceptability by the panelist. The results from the sensory evaluation are discussed in two parts. First on the overall acceptability of the product based on the percentage of panelist who as described in the hedonic scale 'liked' or 'disliked' the product, and second on specific parameters based on the average representative score of the products for the evaluated parameters given by 50 panelists.

3.3 Overall acceptability of products

The results from the overall acceptability of products were expressed as percentage of panelist who have rated the overall acceptability as per the hedonic scale as given in Table 3. A cumulative of the percentage of panelist who have rated the product in the 'like scale' and 'dislike scale' are taken to indicate how many panelists liked or disliked the product. 100% of the panelist liked the cracker while 90% of panelist liked the pancake with remaining panelist being neutral. 84% of the panelist liked the cookies, 4% remained neutral and 12% disliked the cookies. It was found that for overall acceptability, the fried cookies was the least liked product with only 28% panelist preferring the product, 50% disliking it and 22% panelist being neutral. Majority of the panelist thus, preferred the cracker followed by pancake and cookies.

Table 3. Percentage of Panelist according to their preference for overall acceptability of maize starch products

	Percentage score for different products (n=50)			
9-Point Hedonic scale	Cookies	Fried cookies	Cracker	Pancake
Dislike extremely	0	0	0	0
Dislike very much	0	0	0	0
Dislike moderately	0	14	0	0
Dislike slightly	12	36	0	0
Neither like nor dislike	4	22	0	10
Like slightly	18	28	4	26
Like moderately	32	0	20	14
Like very much	26	0	48	50
Like extremely	8	0	28	0
Mean score on 9-point hedonic scale	6.80	4.64	8	7.04
Most preferred product (ranking)	3	4	1	2

3.4 Sensory evaluation scores

Average score of the parameters in the sensory evaluation was calculated from the scores given by 50 panelists and plotted out as given in Figure 2. Higher the score (from 9-6), the more preferred is the particular parameter, lower the score (4-1), the less preferred is the parameter and 5 being neither like nor dislike score as per the hedonic scale.

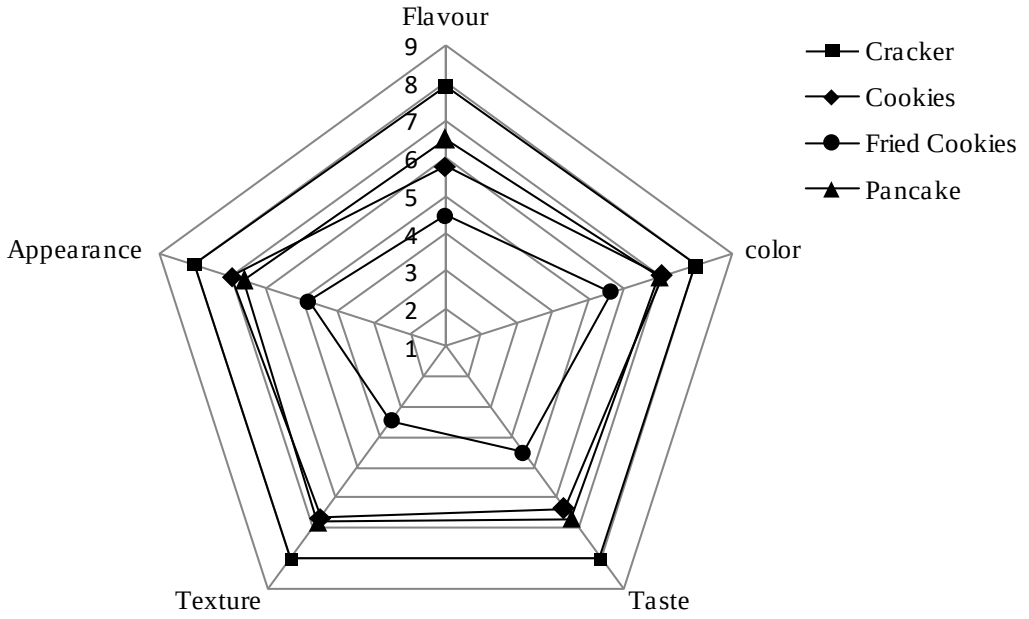

Figure 2. Average sensory score of maize starch products

3.5 Colour of the products

Colour is an important quality attribute in food that influences consumers' choice and preferences. The colour of the food surface is the first quality parameters that consumers consider and are critical to product acceptance (Pathare, Opara, & Al-Said, 2013). As per the average score in Figure 2, the colour of cracker was highly liked, while colours of both the pancake and cookies were liked moderately, followed by fried cookies that was liked slightly.

3.6 Flavour of products

Flavour of a product is described by its aroma and taste, and has impact on the acceptability of the product as well as in promoting interest for its heightened consumption (Barrett, Beaulieu, & Shewfelt, 2010). As per the average scores (Figure 2), the flavor of cracker was liked very much, pancake and cookies was liked moderately and fried cookies were disliked slightly.

3.7 Taste of products

The results of average score for taste showed that the cracker and pancake was liked extremely, cookies liked slightly and the taste of fried cookies was neither liked nor disliked (Figure 2).

3.8 Texture of products

Texture of the food products are important parameters for the quality products leading to consumer acceptance (Rouf Shah, Prasad, & Kumar, 2016). The texture of the cracker was liked very much, liked moderately for pancake and cookies, and disliked moderately for fried cookies.

3.9 Appearance of the products

Appearance of a product consists of the products size, shape, uniformity, surface gloss or dullness, and the nature and degree of pigmentation (MacDougall, 2003). The appearance of the cracker was liked very much, pancake and cookies were liked moderately, and fried cookies were neither liked nor disliked (Figure 2).

4. Conclusion

Maize is an important cereal crop for food, feed, seed, beverages and starch purpose. The major composition of maize kernel constitutes mostly starch and few quantities of protein, oil and minerals. Starch content in the grains varies with growth stages of the crop. There is gradual increase in starch content and its recovery rate from milk stage till physiological maturity. Maximum starch content is found in physiological maturity stage amongst the four growth stages.

Utilization of starch for different product development is one option to make best use of maize crop other than *Tengma* (roasted and flattened) and *Kharang* (grits). Of the four products developed from maize starch, the most preferred was cracker followed by pancake and cookies while the least preferred was fried cookies. All the organoleptic parameters of cracker had scores

corresponding to ‘liked very much’ on the hedonic scale, thereby, justifying why it was preferred the most. Further, improvement on sensory parameters such as flavor, taste and texture of pancake and cookies could increase the overall acceptability of the products.

Maize starch extraction and product development from the starch could be one of the potential enterprises that interested entrepreneurs and community groups could focus on, and that could ultimately encourage our farming communities to go for large scale maize production.

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