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Chemical properties of corn starch as influenced by sprouting periods

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Abstract
The chemical properties of three (3) varieties of corn starch as influenced by sprouting periods were investigated using standard analytical methods. The corn grains (yellow, white and pop corn) were sprouted for 2, 4 and 6 days respectively before processed into starches. The moisture contents for starches from yellow corn ranged from 6.63%-14.91%, 5.52%-11.40% for white corn and 8.20%-14.04% for pop corn respectively. Similarly, the protein contents varied from 1.17%-2.98% for yellow corn starch, 1.64%-3.31% for white corn starch and 1.22%-2.65% for pop corn starch. Ash contents of 1.24%, 1.97%, 2.1% for yellow corn starch, 1.56%, 2.04%, 2.17% for white corn starch and 1.36%, 1.62% and 1.85% for pop corn starch were obtained during the sprouting periods. An increase was observed in the protein, ash , fat, carbohydrate and fibre contents of all starch samples as the sprouting periods progressed while the moisture contents decreased, giving a favourably and relatively longer shelf life for the starches. The amylose and amylopectin contents of the starches differed significantly from one another (P: 0.05) with corn starches with higher amylose content having lower amylopectin and vice versa. Therefore, sprouting of corn grains for the production of starch could be a means of increasing its nutritional composition.

Keywords: chemical properties, corn starch, sprouting

Introduction

Cereals supply the bulk of the food eaten by human race. They are the cheapest source of food energy and constitute a high percentage of calorie and protein intake by man. Cereal is any grass yielding starchy seed suitable for food and are rich in carbohydrate and energy value. The main fraction of the grains is carbohydrate, constituting more than 50-70% (W/W) of the dry matter. Approximately, 86-89% of the endosperm is starch. (Mendez-Montealvo) [1] *et al*., 2007

Maize (*Zea mays* L), The American Indian word for corn literally means "that which sustain life". It is the third most important cereal grain of the world after wheat and rice, providing nutrients for human and animals and serving as basic raw material for the production of starch, oil, protein, alcoholic beverages, food sweeteners and more recently fuel (FAO, 2003).

Corn starch is a valuable ingredient in the food industry, being widely used as a thickener, gelling agent, bulking agent and water retention agent (Singh *et al*., 2003). Starch owes much of its functionality to high – molecular weight carbohydrate components of amylose and amylopectin and to the physical organization of these macromolecules in the granular structure (Fasasi, 2009) [4].

Sprouting is the practice of germinating seeds to be eaten raw or cooked. Sprouts are said to be rich in digestible energy, bio-available vitamins, minerals, amino acids, proteins and phyto-chemicals as these are necessary for a germinating plant to grow. The desirable nutritional changes that occur during sprouting are mainly due to the breakdown of complex compounds into more simple form, transformation into essential constituents and breakdown of nutritionally undesirable constituents (Charan *et al*., 2005) [5].

Several works have been done on sprouting in improving the nutritive values of foods. Jirapa *et al*. (2001) [6] worked on the nutritional quality of germinated cowpea flour and its implication in home prepared weaning food; Mbaeyi and Onweluzo (2010) [7] reported on the effect of sprouting and pre-gelatinization on the physico-chemical properties of sorghum –pigeon pea composite blend used for the production of breakfast cereal; Adedeji *et al*. (2013) [8] reported the effects of germi9nation time on the functional properties of maize flour and the degree of gelatinization of its cookies while Dikshit et bal. (2003) [9] worked on the effect of sprouting on the nutrients, anti-nutrients and in vitro digestibility of the MACS 13 Soybean variety. Therefore, the objectives of this present work is to reveal the chemical properties of corn starch as influenced by sprouting periods as well as knowing its improvements in-terms of nutritional components of the corn starch.

Materials and Methods

Source of Materials: Three (3) varieties of corn viz: yellow corn, white corn and pop corn were purchased from a local market in Ilaro, Ogun State, Nigeria. The grains (corn) were carefully sorted, cleaned to remove sticks, husks, stones cobs, damaged and unwanted seeds. These were achieved through winnowing, sieving and hand picking. The cleaned grains were then kept in high density polyethylene bags to avoid moisture uptake and re-contamination before use. All reagents used are of analytical grades.

Sprouting of cereal grains

1kg of each corn variety was steeped in water at room temperature for 48 hours. The water was drained off after 48 hours and then the steeped grains were spread on the trays for sprouting to occur for 2, 4 and 6 days at room temperature in the food processing laboratory.

Extraction of Starch

Starch was extracted from the sprouted grain samples after 48, 96 and 144 hours (2,4,6 days) according to the procedure of Singh *et al*. (2009) [10]. The corn grains were wet milled using attrition mill into smooth mash and mixed with water (at a ratio of 1:5) for effective starch extraction. The mash was filtered using muslin cloth, then allowed to settle. The supernatant was decanted and the sediment was dewatered with cheese cloth and the starch residue washed three times with clean water. The starch cake obtained after dewatering process was hand broken, spread thinly on trays and dried in a cabinet dryer at 60Oc for 8 hours. The dried starch samples were milled using milling machine, sieved through a mesh sieve of 0.32nm (British Standard Screens).the starch samples were then packaged in high density polyethylene bags prior to further analysis

Fig 1: Flow chart for the production of starch from sprouted corn. Source: Singh etal. (2009) [10].

Laboratory Analyses

Proximate Analysis

Starch samples obtained from the three varieties of corn grains were analyzed for proximate composition according to the standard method described by AOAC (2010) [11]. Determinations were done in triplicates.

Amylose content determination

The amylose contents of the corn starch sample s were determined according to the method described by Udanchan *et al*, (2010). 0.1g of starch sample and 70% amylose standard were weighed into different test tubes, then 1ml of 95% ethanol and 9ml of 0.1Msodium hydroxide solution (1NaoH) were added and then mixed on a vortex mixer. The test tubes were heated in a boiling water bath for 10minutes to gelatinize the starch after which they were allowed to cool. 1.0ml each was taken from the extract into another test tube and made up to 10ml by the addition of 9ml distilled water. From this 10ml diluents, 0.05ml was taken into a new test tube and 0.1ml acetic acid solution and 0.2ml iodine solution was added and made up to 10ml with 9.2ml distilled water. It was left to stand for 20 minutes for colour development into dark blue complex. Text tubes were vortexed and the absorbance was read on the spectrophotometer (Spectrum Lab 22 pc) at 620nm.

$$\% \text{ Amylose} = \frac{\% \text{ Amylose of Standard X Absorbance of Sample}}{\text{Absorbance of Standard}}$$

Amylopectin Content Determination

This was determined by subtracting the % amylose content from 100.

% Amylopectin = 100- % Amylose

Statistical Analysis

The data obtained were statistically analyzed using Analysis of Variance (ANOVA) by completely randomized design (CRD0 with comparison made between the group means using the Duncan s Multiple Range Test to separate the means (at 5% probability level) using SPSS (Statistical Package for Social Science).

Results and Discussions

Results

Table 1: Effect of Sprouting Periods on the Proximate Composition of Yellow Corn Starch

Sprouting periods	Moisture (%)	Ash (%)	Fat (%)	Crude Fibre (%)	Crude Protein (%)	Carbohydrate (%)
Day 2	14.91± 0.01^{a}	1.24±0.02^{b}	1.47±0.04^{c}	0.29±0.01^{c}	1.17±0.02^{c}	80.94+±0.04^{b}
Day 4	7.35±0.02^{b}	1.97±0.03^{a}	3.02±0.02^{b}	0.85±0.01^{b}	2.76±0.01^{b}	84.07±0.07^{a}
Day 6	6.63±0.05^{c}	2.10±0.01^{a}	3.32±0.02^{a}	0.93±0.04^{a}	2.98±0.03^{a}	84.05±0.11^{a}

Values are means and standard deviations of triplicate samples scores. Values followed by different superscript in column are significantly different ($p < 0.05$) from another.

Table 2: Effect of Sprouting Periods on the Proximate Composition of White Corn Starch

Sprouting periods	Moisture (%)	Ash (%)	Fat (%)	Crude Fibre (%)	Crude Protein (%)	Carbohydrate (%)
Day 2	11.40± 0.04^{a}	1.56±0.01^{b}	2.22±0.01^{c}	0.55±0.01^{c}	1.64±0.03^{c}	82.64+±0.02^{b}
Day 4	7.11±0.01^{b}	2.04±0.04^{a}	3.90±0.01^{b}	0.89±0.01^{b}	2.84±0.06^{b}	83.24±0.09^{a}
Day 6	5.52±0.01^{c}	2.17±0.01^{a}	4.13±0.03^{a}	0.99±0.01^{a}	3.31±0.04^{a}	83.90±0.07^{a}

Values are means and standard deviations of triplicate samples scores. Values followed by different superscript in column are significantly different ($p < 0.05$) from another.

Table 3: Effect of Sprouting Periods on the Proximate Composition of Pop Corn Starch

Sprouting periods	Moisture (%)	Ash (%)	Fat (%)	Crude Fibre (%)	Crude Protein (%)	Carbohydrate (%)
Day 2	14.04± 0.03^{a}	1.36±0.04^{b}	1.72±0.01^{c}	0.35±0.01^{b}	1.22±0.02^{c}	81.32+±0.12^{b}
Day 4	9.64±0.03^{b}	1.62±0.01^{a}	2.97±0.02^{b}	0.73±0.04^{a}	1.98±0.06^{b}	83.06±0.03^{a}
Day 6	8.20±0.03^{c}	1.85±0.01^{a}	4.01±0.01^{a}	0.79±0.02^{a}	2.65±0.04^{a}	82.51±0.00^{a}

Values are means and standard deviations of triplicate samples scores. Values followed by different superscript in column are significantly different ($p < 0.05$) from another.

Table 4: Effect of Sprouting Periods on Amylose and Amylopectin Contents of Yellow Corn Starch

Sprouting Periods	Amylose (%)	Amylopectin (%)
Day 2	28.50±0.04^{a}	71.54±0.04^{c}
Day 4	15.19±0.01^{b}	84.81±0.01^{b}
Day 6	8.19±0.01^{c}	91.81±0.01^{a}

Values are means and standard deviations of triplicate samples scores. Values followed by different superscript in column are significantly different ($p < 0.05$) from another.

Table 5: Effect of Sprouting Periods on Amylose and Amylopectin Contents of White Corn Starch

Sprouting Periods	Amylose (%)	Amylopectin (%)
Day 2	25.84±0.06^{a}	74.16±0.06^{c}
Day 4	10.10±0.01^{b}	89.90±0.01^{b}
Day 6	4.95±0.06^{c}	95.05±0.06^{a}

Values are means and standard deviations of triplicate samples scores. Values followed by different superscript in column are significantly different ($p < 0.05$) from another.

Table 6: Effect of Sprouting Periods on Amylose and Amylopectin Contents of Pop Corn Starch

Sprouting Periods	Amylose (%)	Amylopectin (%)
Day 2	26.20±0.03^{a}	73.80±0.03^{c}
Day 4	24.53±0.03^{b}	75.47±0.03^{b}
Day 6	22.81±0.01^{c}	77.19±0.01^{a}

Values are means and standard deviations of triplicate samples scores. Values followed by different superscript in column are significantly different ($p < 0.05$) from another.

Discussion

Effect of Sprouting Periods on the Proximate Composition of Yellow Corn Starch

The results of the effect of sprouting periods on the proximate composition of yellow corn starch are shown in Table 1.the moisture contents for day 2, 4 and 6 were 14.91%, 7.35% and 6.63% respectively, indicating that the moisture contents decreases as the sprouting time increases. These values are different from those reported in a similar work (Ijarotimi,

2012) [13]. However, low moisture content gives a favourable and relatively longer shelf life (Aryee *et al*., 2006) [14]. Ash contents ranged from 1.24%-2.19% for the sprouting periods. Although an increase was observed in terms of ash contents, but values were not too significantly different (P < 0.05) from each other. Mbaeyi and Onweluzo (2010) [7] had earlier reported a decrease in ash content of sprouted sorghum starch. Fat contents of 1.47%, 3.02% and 3.32% were obtained for sprouted yellow corn starch on days 2, 4 and 6.as revealed by the result, there was increase in fat contents as the sprouting periods increased. These values agreed with the report of Mbaeyi and Onweluzo (2010) [7] where an increase in fat contents of sprouted sorghum starch was reported. Crude fibre contents varied between 0.29% and 0.93% for the sprouting periods. The fibre contents increases as the sprouting periods increases and were significantly different (P< 0.05). the protein contents as shown in Table are 1.64%, 2.48% and 3.31% respectively for the sprouting periods of 2, 4 and 6 days. It could be observed that there was increase in the protein content which differed significantly (P<0.05) as the sprouting periods increases. Enujiugha *et al*. 92003) and Fasass (2009) had earlier reported that sprouting helps to improve the nutritional quality of food products. Yellow corn sprouts for 4 and 6 days were not significantly different (P<0.05) in term of the carbohydrate contents (84.07% and 84.05%) while yellow corn sprouted for 2 days had 80.94% carbohydrate content

Effect of sprouting periods on the proximate composition of white corn starch

The results of the effect of sprouting periods on the proximate composition of white corn starch are presented in Table 2. The moisture contents of the white corn starch ranged from 5.52% -11.40%. the corn sprouted for 2 days had the highest moisture while that spouted for 6 days has the lowest and therefore significantly different from each other. Ash content of 1.56%, 2.04% and 2.17% were obtained for the white corn starch sprouted for 6 days respectively and therefore show similar trend as observed for yellow corn starch. Fat content varied from 2.22%-4.13% while the crude fibre varied from 0.55&-0.99% respectively. The increase in fat contents as observed in this present work as the sprouting period increases are in contrast to a similar work reported by Otutu *et al*. (2014) [16] where it was stated that fat contents in sprouted maize starch increases as the sprouting period's increases. In the case of fibre contents obtained there were significant differences (P<0.05) in the values obtained. Protein contents of 1.22%, 1.98% and 2.65% revealed an increase as the sprouting period increases, hence there were significant differences (P^0.05) in values. This result is in agreement with the work of Morgan *et al*. (2002). Carbohydrate contents of 82.64%, 83.24% and 83.90% were obtained for the periods of 2, 4 and 6 days respectively. Mbaeyi and Onweluzo (2010) [7] reported a continuous increase in carbohydrate contents of sorghum starch as the sprouting period increased.

Effect of sprouting periods on the proximate composition of pop corn starch

Table 3 shows the results of effect sprouting periods on the proximate composition of pop corn starch. Moisture content s of 14.04%,, 9.64% and 8.20% were obtained in the sprouting periods under consideration. Ash contents ranged from 13.6%-18.5% while the fat contents varied from 1.72%-4.01%. crude protein contents of 0.38%, 0.73% and 0.79% while crude protein contents were 1.22%, 1.98%,2.65% respectively for 2, 4 and 6days of sprouting periods. Also carbohydrate contents of 81.32%, 83.06% and 82.51% were obtained. These values are in agreement with previous work of Otutu *et al*. (2014) [16].

Effects of sprouting periods on the amylose and amylopectin contents of yellow corn starch, white corn starch and pop corn starch

The results of effect of sprouting periods on the amylose and amylopectin contents of yellow corn starch, white corn starch and pop corn starch are shown in Table 4, 5and 6. It was generally observed that as the sprouting period increased the amylose contents of the corn starches decreases with amylopectin content increases. There were significant differences between values at 5% confidence levels. This observation is in contrast to previous work of Mbaeyi and Onwulizo (2010) and Otutu *et al* (2014) [16]. Mbaeyi and Onwulizo (2010) had reported a continuous increase in amylose content as sprouting periods increases in sorghum starch while Otutu *et al*. (2014) [16] reported an increase in amylose content of maize starch as sprouting period increases.

Conclusion

This research work has shown that sprouting periods has a positive effects on the chemical properties of corn starches. Sprouting periods showed reduced (low) moisture contents in all the samples. The ash, fat, protein and carbohydrates contents were greatly enhanced with reduction in crude fibre contents as the sprouting period increases. However, the amylose and amylopectin contents of the starches differed significantly (P<0.05).

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