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Storage Effect on Orange Fleshed Sweet Potato Flour Processed Using Different Pretreatment and Drying Methods

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Abstract
Studies were carried out on the storability of flour processed from UMUSPO 1, a carotene-rich orange fleshed sweet potato variety newly released at National Root Crop Research Institute (NRCRI) Umudike Nigeria. Changes in the proximate composition of the flour processed using different pretreatment methods (sulphiting with 0.5% sodium metabisulphite, blanching and control without treatment) and two drying methods (oven and sun drying) were investigated during storage. The processed flour was stored in low-density polyethylene packaging material for 1-3 months at an ambient temperature of 27°C and a relative humidity of 70%. There were significant differences ($P<0.05$) in the proximate composition of the samples during storage and this varied among pretreatment and drying methods. The samples showed a steady increase in the moisture content which ranged from 8.23% - 12.01% with sun-dried samples having the highest, however, the result obtained was still within the acceptable limit. There were significant differences ($P<0.05$) in carbohydrate (75.36%-83.62%), crude fibre (1.7% -2.65%), protein (6.50% - 8.00%), fat (0.47% -1.7%) and ash (1.63% - 1.89) content of the flour samples. A slight increase in the protein content of the samples was observed, however carbohydrate, crude fibre, fat and ash content of the sundried samples recorded more decreases during 3months of storage
Keywords: Carotene, sweet potato, flour, pre-treatment, proximate composition

Introduction

Sweet potato (*ipomoea batatas*) is a starchy herbaceous plant known as a food security crop because of its high yield, low cost of production and easy adaptability to different climate conditions and soil types (Motsa et al., 2015). A bulk quantity of sweet potatoes are produced in the harvest season, however, their short storage life (Van Hal, 2000) owing to high moisture content poses a great challenge as post-harvest time advances. Processing sweet potatoes into stable products such as flour helps extend the shelf life (Chalom et al., 1995) for subsequent use in the production of composite for confectionaries, weaning foods, etc. hence making it available throughout the year. During processing, losses in some of the important nutrients found in orange fleshed sweet potatoes have been observed and even more loss during extended storage. Therefore, this study aims to evaluate the extent of loss on the proximate composition and the total carotenoid content of the orange sweet potato flour as a result of storage for three months.

Materials and Methods

Sources of Materials/Sample Collection

Orange fleshed sweet potato roots named Umuspo I was harvested from the National Root Crops Research Institute Umudike experimental farm. They were harvested at 5 months of maturity.

Sample Preparation of Orange Fleshed Sweet Potato Flour

6kg sample of fresh orange-fleshed sweet potato roots of Umuspo 1 were washed with clean water and divided into four portions according to the treatment that was to be given to each. One portion was blanched, the second portion was boiled, and the third portion was treated with sodium metabisulphite while the fourth portion was given no treatment. This last portion was used as control. The four portions were further divided into two portions each for sun drying at 40^{0}C for 3 days (done at National Root Crop Research Institute (NRCRI) Umudike, Latitude 5.489^{o}N and Longitude 7.547^{o}E and oven drying (60^{0}C for 4hrs)

Blanched Samples (Treatment I)

One portion of 1.5kg was peeled using a sharp kitchen knife. Thereafter it was washed and diced into cubes of about 2.5mm each. The diced potato roots were blanched directly by immersing them in a boiling water bath at 80^{0}C for 5 minutes and were cooled using running tap water. The blanched samples were divided into two portions for the oven (60^{0}C for 4 hours) and sun drying (40^0C for 3 days) after which it was milled and packaged.

Boiled Sample (Treatment 2)

The second portion was peeled, washed with tap water, sliced into pieces 2.5mm thick and then boiled (95^0C) with clean water in a covered pot until it was soft and tender. This took about 10-15min. It was drained using a sieve, allowed to cool to ambient temperature and was divided into two portions for oven drying (60^0C for 4hrs) and sun drying (40^0C for 3 days) after which it was milled and packaged in black nylon for analysis.

Pretreatment with Sodium Metabisulphite (Treatment 3)

The third portion was peeled, washed with clean water, sliced into 2.5mm thick and soaked in 0.5% sodium metabisulphite solution for 10 minutes. It was drained and divided into 2 for oven drying (60^0C for 4hrs) and sun drying (40^0C for 3 days) after which it was milled and packaged in black nylon for analysis.

Preparation of the Control Sample (Untreated Sample)

The fourth portion was peeled, washed and sliced into 2.5mm thicknesses and thereafter divided into two portions for oven drying (60^0C for 4hrs) and sun drying (40^0C for 3 days) after which it was milled and packaged in black nylon for analysis.

Preparation of the Fresh Sample for Proximate Composition and Carotenoid Content Analysis

The fresh sample was peeled washed and diced. It was later analyzed for proximate composition and total carotenoid content in its fresh state. Each of the samples was labelled as UOD (Untreated oven-dried), MOD (Metabisulphite treated oven-dried), BOD (Blanched oven-dried), BoOD (Boiled oven-dried), BSD (Blanched sun-dried), BoSD (Boiled sun-dried), USD (Untreated sun-dried) and MSD (Metabisulphite treated sun-dried)

Proximate Analysis

The proximate composition (moisture, crude fibre fat, crude protein and carbohydrate) of the fresh OFSP and OFSP flour samples was done in triplicates using the AOAC method (2002). Data obtained were analyzed using ANOVA.

Results and Discussion

The result of the effect of pretreatment on the moisture contents of the flour samples as shown in Table 1 indicated that there were significant differences in the moisture content of the samples during storage. At 0 month of storage (down the column), moisture content (8.20-10.89%) in the blanched sundried sample was the highest while the boiled sundried sample had the lowest. At month 1, the untreated and blanched sundried sample had the highest (11.31 and 11.11%) while the blanched oven-dried sample had the lowest (9.07%). The boiled oven-dried sample had the lowest moisture at months 2 and 3 (9.44 and 10.44%) respectively while the blanched sundried sample and untreated sundried samples had the highest (11.82 and 12.01) respectively. All the oven-dried samples recorded lower moisture content (10.45 -10.90%) when compared to the sun-dried samples (11.08 -12.01%) at the end of 3 months of storage. There was a steady increase in the moisture content of all the samples from zero month to 3rd month (across the row) during storage and Hruskova and Machova (2002) in their work also observed increased moisture content during the short storage of rice flour. An increase in moisture absorption from the environment by the flour during storage observed in this work may be a result of changes in the environmental conditions such as increased relative humidity during storage, hence the tendency of the flour to absorb moisture irrespective of packaging. As flour samples are hygroscopic, according to Hruskova and Machova (2002), the permeability of water vapour through the polythene package may result in poor keeping quality of the flour samples (Navaratne, 2013). Moisture content indicates the dry matter content of food products and does not add to the nutritional quality but affects the shelf life of the flour. For flour to last long, its moisture content needs to be at a level where it will not support microbial attack and have extended storage. Moisture content obtained in this work is a little above that reported by Ojokoh *et al.* (2013) however, the value of all the flour samples showed that they will be stable during storage since moisture content was still within the 13%, the acceptable range for flours by Codex (1995).

The effect of storage on carbohydrate content is shown in Table 2. The result down the column showed significant differences among the samples during storage. Boiled oven-dried samples had high carbohydrate content at 0 month i.e., at the point of production while metabisulphite-treated sundried samples had the lowest however, during storage, decreases were observed among the samples at 1st,2nd, and 3rd months except in the untreated oven dried sample which had the highest carbohydrate content and ranged from 78.45% at 0 month to 83.62% at the end of the 3 months storage (across the row) while the untreated sundried sample recorded the lowest carbohydrate content (75.36%) at the end of storage period and this implied that there were losses in the sample during storage however the values obtained were still high enough to supply the energy needs of sweet potato flour consumers needed in daily meals (Igbabul *et al.,* 2014). Carbohydrate is calculated by difference; it is a function of the values of the other components, hence the variations in the carbohydrate content of the different samples were considered to be a result of apparent changes in the proximate composition of other components during drying since the removal of moisture from the samples cause increments in the concentration of the other nutrients in the flour sample. (Nicanuru *et al*., 2015).

Table 3 represents the effect of storage on the fibre content of orange fleshed sweet potato flour. All the samples had high fibre content at month 0 but as storage progressed to the 3rd month, the fibre content of the samples decreased (across the row). UOD, MOD and BOD recorded the highest fibre content across the months while the lowest was observed in BSD and

BOSD in 0, 1st and 2[nd] months. USD recorded the lowest fibre content. Down the column, there was no significant difference in the fibre content of UOD, MOD and BOD in months 0, 1, and 2. There were of relatively slightly lower values for the crude fibre of the sundried sample compared with the oven-dried flours during storage. Fiber as part of carbohydrates includes some components like pectin, lignin, hemicelluloses and cellulose among which pectin and lignin may be reasonably affected by boiling. Haung *et al.* (1999) have it that the fibre content of sweet potatoes ranges between 2.01 – 3.87g/100g. Variations could be a result of genomic differences. Dietary fibre has been known to aid digestion (Marer and Martin, 2003).

The effect of storage on the protein content of the OFSP flour during storage is shown in Table 4. The result showed that the metabisulphite-treated sun-dried sample had the highest protein content across the storage months (down the column) while the boiled oven-dried sample had the lowest protein content although it had no significant difference with the protein content of the blanched oven-dried sample at month 0. Boiled oven-dried samples had the lowest (6.73% and 7.10%) in month 1 and month 3 respectively while blanched oven-dried samples had the lowest in month 2. All the samples had increases in their protein content from 0 - 3rd month only metabisulphite treated sundried sample remained relatively constant at the end of the storage period. Nutrient compositions of dried samples are usually high because, during drying, significant loss of water is observed, leading to an increase in the nutrient composition of the remaining mass (Nicanuru *et al*., 2015). Dietary protein helps in the synthesis of new cells in the body, repairs worn-out tissue, production of hormones and maintains the body system for balance (Oloyede and Kolawole, 2004).

Table 5 showed that storage had a significant effect on the fat content of the samples. Down the column, the untreated oven-dried sample had the highest fat content in month 0 (1.17%), month 1 (1.15%), month 2 (1.14%) and month 3 (1.10%) however, it had no significant difference with the fat content of metabisulphite treated oven dried sample. The boiled sundried sample had the lowest fat content at 0 and 2 months while the untreated sun-dried sample had the lowest at month 1. The boiled oven-dried sample had the lowest fat content of 0.47% at the end of the storage period. The higher fat content recorded in the metabisulphite-treated oven-dried flour at the end of the storage period could be due to reduced oxidative and microbial activity on the flour as a result of the pretreatment method used on the sample. Across the rows, the entire sample had reduced fat content at the end of the storage period of 3 months. Some microorganisms produce metabolites (enzymes) which can degrade fats into fatty acids and glycerol resulting in a decrease in the gross fat content (Agrahar-Murugkar and Jha, 2011). Foods containing high fat content promote rancidity which leads to off-flavor development (Ihekoronye and Ngoddy, 1985). Hence, the relatively low-fat content obtained from the orange-fleshed sweet potato flour is desirable when used in baking.

The result in Table 6 showed the effect of storage on the ash content of the OFSP flour sample and it indicated that down the column, BOD had the highest ash content at months 0, 1, 2 and 3 while BSD had the lowest at month 0, 2 and 3. BoOD had the lowest fat content in month 1. The result also showed that all the samples had high ash content but as storage advanced (across the rows), decreases in the ash content of the sample were observed. Among the samples, blanched sundried flour recorded the lowest ash content as it decreased from 1.71%-1.63% in the 3[rd] month while the blanched oven-dried sample had the highest ash content of 1.85%. From the result, there was generally low ash content in the sundried flour samples when compared to the oven-dried samples during storage and this was attributed to lower nutrient density occasioned by the high moisture content absorbed by the orange fleshed sweet potato flour samples during storage (Nicanuru *et al*., 2015). The ash contents of the samples evaluated are within the ranges reported by Ingabire and Vasanthakaalam, (2011).

Conclusion

The study shows that the proximate composition of orange fleshed sweet potato flour samples may be affected by processing and drying methods, as well as the length of storage as was observed in the results obtained. This can serve as a guide to processors and consumers of orange fleshed sweet potato flour on the best method to process as well as how long to store the flour to avoid nutrient loss.

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Table 1: Effect of storage on the moisture content (%) of flour

Sample	Month 0	Month 1	Month 2	Month 3
UOD	$8.68^{(c)d} \pm 0.04$	$9.44^{(d)c} \pm 0.04$	$10.18^{(e)b} \pm 0.04$	$10.90^{(d)a} \pm 0.04$
MOD	$8.40^{(d)d} \pm 0.04$	$9.30^{(d)c} \pm 0.08$	$10.22^{(e)b} \pm 0.02$	$10.90^{(d)a} \pm 0.02$
BOD	$8.29^{(e)d} \pm 0.03$	$9.07^{(e)c} \pm 0.01$	$10.02^{(e)b} \pm 0.01$	$10.82^{(e)a} \pm 0.01$
BoOD	$8.23^{(f)d} \pm 0.01$	$8.95^{(f)c} \pm 0.15$	$9.44^{(f)b} \pm 0.02$	$10.45^{(f)a} \pm 0.01$
USD	$10.23^{(b)d} \pm 0.02$	$11.31^{(a)c} \pm 0.03$	$11.65^{(b)b} \pm 0.01$	$12.01^{(a)a} \pm 0.03$
MSD	$10.21^{(b)d} \pm 0.01$	$10.43^{(c)c} \pm 0.01$	$10.95^{(d)b} \pm 0.01$	$11.08^{(c)a} \pm 0.04$
BSD	$10.89^{(a)d} \pm 0.01$	$11.11^{(a)c} \pm 0.10$	$11.82^{(a)b} \pm 0.04$	$11.95^{(b)a} \pm 0.01$
BOSD	$8.20^{(e)d} \pm 0.00$	$10.92^{(b)c} \pm 0.04$	$11.37^{(c)b} \pm 0.03$	$11.69^{(b)a} \pm 0.04$

For each variety means in the same row with the different superscripts are significantly different (p<0.05) while means with the same superscript in parenthesis down the column are not significantly different (p>0.05). This applies to all other tables below.

Table 2: Effect of storage on carbohydrate composition (%) of OFSP flour

Sample	Month 0	Month 1	Month 2	Month 3
UOD	$78.45^{(d)b} \pm 0.00$	$77.76^{(c)c} \pm 0.08$	$76.90^{(d)d} \pm 0.00$	$83.62^{(a)a} \pm 0.00$
MOD	$78.79^{(c)a} \pm 0.00$	$77.94^{(c)b} \pm 0.00$	$77.84^{(b)c} \pm 0.20$	$77.83^{(c)c} \pm 0.00$
BOD	$79.38^{(b)a} \pm 0.00$	$78.32^{(b)b} \pm 0.00$	$77.31^{(c)b} \pm 0.00$	$78.23^{(b)b} \pm 0.00$
BoOD	$79.89^{(a)a} \pm 0.00$	$79.61^{(a)a} \pm 0.01$	$78.44^{(a)c} \pm 0.00$	$77.72^{(c)b} \pm 0.00$
USD	$76.66^{(g)a} \pm 0.00$	$76.11^{(e)b} \pm 0.00$	$75.67^{(f)c} \pm 0.00$	$75.36^{(e)d} \pm 0.00$
MSD	$76.47^{(h)a} \pm 0.00$	$76.36^{(d)a} \pm 0.00$	$75.77^{(e)b} \pm 0.00$	$75.88^{(d)b} \pm 0.00$
BSD	$76.60^{(f)a} \pm 0.00$	$76.46^{(d)a} \pm 0.00$	$75.78^{(e)b} \pm 0.00$	$75.67^{(d)c} \pm 0.00$
BOSD	$77.431^{(e)a} \pm 0.00$	$76.44^{(d)b} \pm 0.00$	$75.97^{(e)c} \pm 0.00$	$75.64^{(d)d} \pm 0.00$

Table 3: Effect of storage on the fibre content (%) fibre of OFSP flour

Sample	Month 0	Month 1	Month 2	Month 3
UOD	$2.65^{(a)a} \pm 0.01$	$2.62^{(a)a} \pm 0.00$	$2.59^{(a)a} \pm 0.01$	$2.55^{(a)a} \pm 0.01$
MOD	$2.64^{(a)a} \pm 0.00$	$2.62^{(a)a} \pm 0.00$	$2.56^{(a)a} \pm 0.00$	$2.53^{(a)b} \pm 0.00$
BOD	$2.64^{(a)a} \pm 0.02$	$2.61^{(a)a} \pm 0.01$	$2.58^{(a)a} \pm 0.00$	$2.54^{(a)b} \pm 0.00$
BoOD	$2.57^{(b)a} \pm 0.01$	$2.52^{(b)b} \pm 0.02$	$2.51^{(b)b} \pm 0.01$	$2.47^{(b)c} \pm 0.00$
USD	$2.56^{(b)} \pm 0.00$	$2.53^{(b)} \pm 0.00$	$2.51^{(b)} \pm 0.00$	$1.70^{(c)} \pm 0.00$
MSD	$2.58^{(b)a} \pm 0.00$	$2.57^{(b)a} \pm 0.00$	$2.57^{(a)a} \pm 0.01$	$2.54^{(a)a} \pm 0.01$
BSD	$2.43^{(c)a} \pm 0.01$	$2.42^{(c)a} \pm 0.00$	$2.40^{(c)a} \pm 0.00$	$2.38^{(b)a} \pm 0.00$
BOSD	$2.49^{(c)a} \pm 0.01$	$2.46^{(c)a} \pm 0.00$	$2.43^{(c)a} \pm 0.01$	$2.41^{(b)a} \pm 0.01$

Table 4: Effect of storage on the protein content (%) of OFSP flour

Sample	Month 0	Month 1	Month 2	Month 3
UOD	$7.18^{(c)d} \pm 0.01$	$7.24^{(c)c} \pm 0.03$	$7.36^{(d)b} \pm 0.00$	$7.88^{(a)a} \pm 0.01$
MOD	$7.17^{(c)c} \pm 0.05$	$7.18^{(c)c} \pm 0.02$	$7.30^{(e)b} \pm 0.00$	$7.68^{(b)a} \pm 0.00$
BOD	$6.64^{(d)d} \pm 0.00$	$6.98^{(d)c} \pm 0.02$	$7.14^{(f)b} \pm 0.00$	$7.40^{(c)a} \pm 0.02$
BoOD	$6.50^{(d)d} \pm 0.01$	$6.73^{(e)c} \pm 0.01$	$6.92^{(d)b} \pm 0.00$	$7.10^{(d)a} \pm 0.02$
USD	$7.31^{(b)b} \pm 0.04$	$7.41^{(c)c} \pm 0.00$	$7.57^{(b)b} \pm 0.00$	$7.66^{(b)a} \pm 0.02$
MSD	$7.85^{(a)b} \pm 0.01$	$7.85^{(a)b} \pm 0.07$	$8.00^{(a)a} \pm 0.00$	$7.89^{(a)b} \pm 0.06$
BSD	$7.27^{(b)c} \pm 0.04$	$7.32^{(c)c} \pm 0.02$	$7.39^{(c)b} \pm 0.00$	$7.43^{(c)a} \pm 0.02$
BOSD	$7.18^{(c)d} \pm 0.01$	$7.51^{(b)c} \pm 0.06$	$7.63^{(b)b} \pm 0.00$	$7.70^{(b)a} \pm 0.01$

Table 5: Effect of storage on the fat content (%) of OFSP flour

Sample	Month 0	Month 1	month 2	month 3
UOD	$1.17^{(a)a} \pm 0.01$	$1.15^{(a)a} \pm 0.00$	$1.14^{(a)b} \pm 0.00$	$1.10^{(a)b} \pm 0.00$
MOD	$1.15^{(a)a} \pm 0.01$	$1.15^{(a)a} \pm 0.01$	$1.08^{(a)b} \pm 0.00$	$1.06^{(a)b} \pm 0.01$
BOD	$1.12^{(b)a} \pm 0.00$	$1.10^{(b)b} \pm 0.01$	$1.06^{(a)c} \pm 0.00$	1. $0.7^{(a)c} \pm 0.01$
BoOD	$1.00^{(b)a} \pm 0.00$	$0.97^{(d)b} \pm 0.00$	$0.95^{(d)b} \pm 0.01$	$0.47^{(d)c} \pm 0.01$
USD	$0.95^{(c)a} \pm 0.01$	$0.91^{(e)b} \pm 0.01$	$0.91^{(e)b} \pm 0.03$	$0.85^{(c)c} \pm 0.01$
MSD	$1.13^{(b)a} \pm 0.01$	$1.06^{(b)b} \pm 0.00$	$1.01^{(c)c} \pm 0.01$	$1.00^{(b)c} \pm 0.00$
BSD	$1.10^{(b)a} \pm 0.00$	$1.02^{(c)a} \pm 0.01$	$0.97^{(d)b} \pm 0.01$	$0.94^{(c)b} \pm 0.00$
BOSD	$0.90^{(c)a} \pm 0.04$	$0.93^{(e)a} \pm 0.01$	$0.90^{(e)a} \pm 0.03$	$0.90^{(c)a} \pm 0.01$

Table 6: Effect of storage on the Ash content (%) of OFSP flour

Sample	Month 0	Month 1	month 2	month 3
UOD	$1.87^{(b)a} \pm 0.01$	$1.85^{(b)a} \pm 0.01$	$1.83^{(b)b} \pm 0.01$	$1.82^{(a)b} \pm 0.00$
MOD	$1.85^{(b)a} \pm 0.01$	$1.81^{(b)b} \pm 0.01$	$1.81^{(b)b} \pm 0.01$	$1.78^{(b)c} \pm 0.03$
BOD	$1.93^{(a)a} \pm 0.01$	$1.92^{(a)a} \pm 0.00$	$1.89^{(a)b} \pm 0.01$	$1.85^{(a)c} \pm 0.01$
BoOD	$1.81^{(c)a} \pm 0.01$	$1.40^{(e)c} \pm 0.05$	$1.74^{(c)b} \pm 0.03$	$1.73^{(c)b} \pm 0.01$
USD	$1.77^{(d)a} \pm 0.01$	$1.73^{(c)a} \pm 0.02$	$1.69^{(e)c} \pm 0.00$	$1.65^{(d)c} \pm 0.14$
MSD	$1.76^{(d)a} \pm 0.01$	$1.73^{(c)b} \pm 0.00$	$1.70^{(d)c} \pm 0.00$	$1.70^{(c)c} \pm 0.00$
BSD	$1.71^{(e)a} \pm 0.01$	$1.67^{(d)b} \pm 0.01$	$1.68^{(e)b} \pm 0.03$	$1.63^{(e)c} \pm 0.01$
BOSD	$1.75^{(d)a} \pm 0.01$	$1.74^{(c)a} \pm 0.03$	$1.70^{(d)b} \pm 0.03$	$1.66^{(d)c} \pm 0.01$