Effects of Pre-treatments and Drying Methods on Cyanide and Functional Properties of Cassava (*Manihot esculenta* Crantz) Flour

ABSTRACT

The main purpose of this research was to determine the effect of different pre-treatments and drying methods on the cyanide content and functional properties of cassava flour in Yola, Adamawa State. Cassava has been considered the 4th most important food security crop, but there is a high content of cyanide, which renders the crop unsafe for human consumption. The cassava tubers (*Manihot esculenta* Crantz) were obtained during the 2022 and 2023 seasons at the sub-station of National Root Crops Research Institute (NRCRI), Nyanya, Abuja and the variety used was “TME-419”. The harvested tubers were subjected to different pre-treatments (48 hrs soaking in water, 2 and 4 minutes blanching) prior to three different drying methods (shade, sun, and oven). The time taken for the drying were 75^0C for 74 hours, 27.42^0C for 8 days, and 25.65^0C for 10 days for oven, sun, and shade drying, respectively, before milling into flour and the flour samples were analyzed for their cyanide content and functional properties. There was no significant difference ($P>0.05$) observed among the pre-treatments and drying methods on cyanide content in 2022 but there was a significant difference ($P\leq0.05$) in 2023. In 2023, the highest of 0.092 mg/100g was obtained from 2 minutes of blanching followed by 4 minutes blanching with 0.081 mg/100g, while the least of 0.077 mg/100g was found from 48 hrs soaking in water. On the other hand, the highest cyanide of 0.081 mg/100g was equally obtained from sun and oven drying while the least of 0.079 mg/100g was obtained from shade drying. All the pretreatments and drying methods used in this experiment were capable of lowering the cyanide content within the acceptable limit. However, oven drying was found to be faster than sun and shade drying methods, but sun and shade drying were cheaper and accessible than oven. Therefore, any of the pretreatments used in this research should be adopted before drying in order to reduce the cyanide content, improve functional properties and also extend the shelf life of cassava flour.

Keywords: Cassava, pre-treatment, drying, cyanide, flour

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a perennial shrub cultivated in tropical and sub-tropical climates. It is grown for its tuberous bulky roots, which contain about 80 percent carbohydrates (Erhabor*et al.,* 2007). The root takes about 6-18 months to mature and is the world’s fourth most important staple crop after rice, wheat, and maize and is, therefore, an essential component in the diet of over one billion people (FAO, 2018). Cassava is an important staple crop recognized as a 21st-century crop primarily for smallholder farmers (FAO, 2013; Droppemann*et al.,* 2018). It is one of some 100 species of tree, shrub, and herbs of the genus Manihot believed to have been introduced from northern Argentina to the United States of America (FAO, 2013). Other studies opined cassava has several centers of origin, beginning from the southern edge of the Brazilian Amazon (Nassar, 1978; Olsen and Schaal, 1999; Allem, 2002). According to Liu *et al.* (2014), cassava production may be said to have originated in the northeastern part of Brazil/Paraguay to Mexico/Guatemala more than 4,000 years ago. It was believed to have been introduced to western Africa in 1588 through Portuguese merchants and was first cultivated in the Gulf of Guinea and the Congo Basin. The cultivation later spread to Madagascar and another eastern part of Africa. Towards the middle of the nineteenth century, cassava production and consumption became an essential staple food widely cultivated in Africa (Liu *et al.*, 2014).

A critical advantage of cassava is that it has a wide range of uses, from consumption to industrial use, based on the level of final cassava processing. The cassava is boiled or steamed before eating but can also be processed into starch, tapioca, and dried chips. Further processing involves grinding and milling into flour. The principal users of cassava products are flour mills, biscuit factories and confectionaries, glue and adhesive producers, ethanol distillers, pharmaceutical industries, livestock and aquaculture farmers, and restaurants, among others (Fasuyi and Aletor, 2005). Rising oil prices, coupled with the need to address concerns about emissions from transportation fuels and the requirements of carbon emission, has led to the promulgation of a mandatory blending of biofuels (ethanol) with fossil fuels in Europe by 2020, which will require cassava chips as the alternative raw material feedstock (UNCTAD, 2009). Over 90% of cassava production is estimated to be processed into food (Nweke *et al.*, 2002; Phillips *et al.*, 2004). However, a significant industrial demand exists for cassava, primarily as a substitution for imported raw materials and semi-finished products. There is high demand for High Quality Cassava Flour (HQCF), primarily from 10% replacement in bread flour and for use in bouillon, noodles, and the adhesive industry (dextrins). Similarly, it is useful in the production of native and modified starches. It is also useful in the paint, pharmaceutical, and sweetener industries (FGN, 2011).

One massive challenge to cassava production and processing is its high moisture content of about 65%, making it highly perishable. According to IITA (1990), once tubers are harvested, they deteriorate within 40-48 hours due to some physiological changes and decay by rot organisms. However, small-scale holders can only use these methods, and do not apply to large-scale commercial production units. Processing cassava into dry forms is therefore necessary to reduce the moisture content and convert it into a more durable and stable produce with less volume, which makes it easier for transportation to reduce post-harvest losses also to eliminate or reduce the level of hydrocyanic acid (HCN) and to improve the palatability of the food product (CSIR-FRI, 2009). The cyanogenic glycosides in cassava tissues are related to illnesses in populations where cassava is the staple food. These illnesses include tropical ataxic neuropathy and epidemic spastic paraparesis(Nzwalo and Cliff, 2011). These problems have been reported in the Democratic Republic of Congo, Nigeria, and Mozambique (Nhassico*et al*., 2008; Mlingi*et al*., 2011; Cigleneck*iet al*., 2011). Such illnesses occur when there are prolonged cyanide exposures associated with food shortage, social instability, under-nourishment, and deficiency in essential nutrients such as sulphur amino acids and iodine (Nzwalo and Cliff, 2011). The cassava roots need to be processed if these negative aspects are to be overcome, and experienced cassava producers are aware of different ways and methods of processing cassava (Nyirenda *et al*., 2011). Given these, this study will be carried out with the objective of determining the effects of pre-treatments and drying methods on the cyanide content and functional properties of cassava flour.

MATERIALS AND METHODS

Experimental Site

The pre-treatments and subsequent drying were done in the Department of Biological Sciences, Abubakar Tafawa Balewa University, Bauchi. At the same time, the experiment was conducted in the Crop Production and Horticulture Department at Modibbo Adama University, Yola, Adamawa State. The proximate, functional, and sensory evaluations were conducted in the Food Science and Technology Department, Modibbo Adama University, Yola, Adamawa State.

Source of Cassava Root

Cassava variety (TME-419) was obtained from the National Root Crops Research Institute (NRCRI), Nyanya sub-station, for experimental purposes in the 2022 and 2023 growing seasons.

Sample collection

Cassava tubers at full maturity were harvested, and the undamaged and diseased tubers were selected for the experimental purpose.

Preparation of tuber for drying

The tubers were peeled and sliced into almost uniform sizes to maintain uniform drying. They were washed thoroughly with sodium hypochlorite to deactivate the microbial load on the surface of the tuber after peeling. The washed tubers were pre-treated (48 hrs soaking in H_2O, 2 and 4 minutes blanching in boiling water). After drying, the dried cassava chips were ground into a flour mill.

Treatments and Experimental Design

The treatments were arranged in a Split-Split Plot in Completely Randomize Design (CRD) with pre-treatments (48 hrs soaking in H_2O, 2 min and 4 min blanching) were placed in the main plot, drying methods (oven drying, sun drying and shade drying) were placed in the sub-plot and replicated three times.

Cyanide determination

For total cyanide determination in cassava root and flour, protocol A is followed using kit A according to the method developed at Australia National University (Bradbury, 2006; Cardoso *et al*., 1998).

Functional Properties

Bulk density determination

Bulk density was determined according to Odoemelan's method (2005). A calibrated centrifuge tube was weighed, and flour samples were filled to 5 ml by constant tapping until there was no further change in volume. The content was then weighed, and from the difference in weight, the bulk density of the sample was calculated.

Water absorption capacity determination

This was determined as described by Odoemelan (2005). One gram (1 g) of flour was mixed thoroughly with 10 ml of distilled water (density, 0.89 gml^{-1} in a Kenwood blender for 30 seconds. The mixtures were allowed to settle for 30 minutes at room temperature and then centrifuged. The volume of free water will be decanted and discarded. The weight of water absorbed by 1 g of flour was calculated and expressed as water absorption capacity. It was expressed as grams of water absorbed per 100 g of sample.

Swelling capacity determination

Flour (1.0±0.1g) was transferred into a test tube and re-weighed. The flour was then dispersed in 50 mL of distilled water. The slurry was heated at different temperatures (65, 75, 85, and 95℃) for 10 mins in a water bath. The mixture was cooled to 28±2℃ and centrifuged at 2200 rpm for 15 mins to separate the gel and supernatant. After the supernatant was removed, the weight of the swollen was determined by Ikegwu*et al.* (2010).

Gelatinization capacity determination

Gelatinization capacity was determined according to Abbey and Ibeh's (1988) method. The flour sample was mixed with 5 ml of distilled water in test tubes to obtain 2-20% (w/v) concentrate suspensions. The test tubes were heated for 1 hour in a boiling water bath, cooled rapidly under running tap water, and cooled for 2 hours in a refrigerator at 4^{0}C. The gelatinization capacity was the least determined as the concentration at which the sample from the inverted test tube did not fall or slip.

Data Analysis

The data obtained from the experiment were subjected to statistical analysis of variance (ANOVA). Means that were significantly different at ($p \leq 0.05$) were separated using Least Significant Difference (LSD).

Results and Discussion

The result of the effects of pre-treatments and drying methods on cyanide, water absorption capacity, bulk density, swelling capacity and gelatinization capacity are presented in Table 1 and 2 of 2022 and 2023 respectively. The result on cyanide content indicated that there was no significant difference ($p>0.05$) among the pre-treatments and drying methods in 2022, but there was a significant difference ($p \leq 0.05$) among the pre-treatments and drying methods in 2023. In 2023, the highest of 0.092 mg/100g was obtained from 2 minutes blanching followed by 4 minutes blanching with 0.081 mg/100g while the least of 0.077 mg/100g was found from 48 hrs soaking in water. As for the drying methods, the highest cyanide of 0.081 mg/100 was equally obtained from sun and oven drying while the least of 0.079 mg/100g was obtained from shade drying. The cyanide content of cassava flour from different pre-treatments and drying methods of 0.032 mg/100 g – 0.092 mg/100 g were within the values recommended by SON (<10 mg HCNeqv/kg) (Sanni *et al.*, 2005). The blanched sample had the least HCN content, a significant difference existed in the HCN content of the flour samples. There is no consensus on the safe levels of cyanide for both human and animal consumption (Maziya-Dixon *et al.*, 2007) by scientists and international regulatory agencies. Drying of cassava roots reduces the cyanide content by about 50%. The effect of processing on the cyanide content of cassava roots reported in this study is in agreement with Ismaila *et al.*, (2018), Emmanuel *et al.*, (2012), and Blanshard *et al.*, (1994), who reported that a combination of processing procedures that involved fermentation significantly reduced the levels of cyanide contents to within 10 mg HCN per 100 g maximum tolerated level in consumable food. Processing of cassava roots into flour significantly reduces the cyanide content Muoki *et al.,* (2015). Cyanide is one of the key toxicants in cassava roots, and it occurs in both Sweet and bitter cassava varieties. Acute cyanide toxicity can lead to death if not treated, and thus, there is a need to reduce the cyanide contents Gacheru *et al.*, (2015). Presently, in Nigeria, grating/crushing is being promoted in the production of High Quality Cassava Flour (HQCF) because it leads to the production of flour with negligible amounts of residual cyanide contents after drying.

The water absorption capacity of cassava flour from different pre-treatments and drying methods ranged from 0.37-2.88 mg/100 g. The result on water absorption capacity indicated that there was no significant difference ($p>0.05$) among the pre-treatments in 2022, but there was a significant difference (p≤0.05) among the pre-treatments in 2023. In 2023, the highest of 2.88 mg/100g was obtained from 4 minutes blanching followed by 2 minutes blanching with 2.87 mg/100g while the least of 1.77 mg/100g was found from 48 hrs soaking in water. There was no significant difference (p>0.05) among the drying methods on water absorption capacity in 2022, but there was also a significant difference (p≤0.05) in 2023. In 2023, sun drying had the highest water absorption capacity of 2.74 mg/100g followed by shade drying with 2.63 mg/100g while the least of 2.13 mg/100g was found from oven drying. Generally, 4 min blanching was found to be statistically better than other pretreatments. This could be attributed to cell wall disruption during blanching, which thereby facilitates drying more efficiently. It has been reported that blanching cassava chips and drying them between the temperature range of 40 to 70°C resulted in higher water absorption capacity values than unblanched one Ekwu and Ugwu (1998). Beuchet (1977) also observed that processing techniques influenced the water absorption capacity of flour. Flour containing high water absorption capacity is important in food products such as bakery products, which require hydration to improve the dough handling characteristics. Besides, confectionery products and foodstuffs such as thickeners require high water absorption capacity (Alimi *et al.*, 2016). Therefore, flour with the highest water absorption capacity can accommodate more water quantity and improve the dough handling feature.

The bulk density of cassava flour from different pre-treatments and drying methods ranged from 0.58-0.86. The result on bulk density indicated that there was significant difference (p≤0.05) among the pre-treatments in 2022 and 2023. In 2022, the highest of 0.65 mg/100g was obtained from 2 minutes blanching followed by 4 minutes blanching with 0.64 mg/100g while the least of 0.59 mg/100g was found from 48 hrs soaking in water. In 2023, the highest of 0.86 mg/100g was obtained from 4 minutes blanching followed by 2 minutes blanching with 0.77 mg/100g while the least of 0.63 mg/100g was found from 48 hrs soaking in water. There was a significant difference (p≤0.05) on bulk density among the drying methods in both 2022 and 2023. In 2022, oven drying had the highest bulk density of 0.71 mg/100g, followed by shade drying with 0.59 mg/100g, while the least of 0.58 mg/100g was found from sun drying while in 2023, sun drying had the highest bulk density of 0.77 mg/100g, followed by shade drying with 0.76 mg/100g, while the least of 0.74 mg/100g was found from oven drying. The functionality of foods is the properties of food ingredients other than a nutritional attribute, which has a great impact on its application. The functional characteristic determines the utilization and use of food material for various food products. Generally, 4-minute blanching had the highest bulk density, and this could be a result of structural changes in the sample that eased the water removal during drying. This shows that blanching affected the bulk density of the cassava flour. Balagopalan *et al.*,(1988) reported that blanching confers a harder consistency to chips due to the gelatinization of starch. This, ultimately, toughened the chips, leading to the production of coarse materials, which had higher bulk density than unblanched flours. This experiment is not in agreement with the findings of Elkhalifa*et al*. (2005) and Onimawo*et al*. (2003), who reported that fermentation results in a reduction in bulk density. On the other hand, oven drying was found to be better than sun and shade drying in terms of bulk density. This probably explains the lower bulk densities observed in the flours produced from sun drying (Nelson-Quartey *et al*., 2007).

The swelling capacity of cassava flour from different pre-treatments and drying methods ranged from 0.47-1.50. The result on swelling capacity indicated that there was no significant difference ($p>0.05$) among the pre-treatments in 2022, but there was a significant difference ($p\leq0.05$) among the pre-treatments in 2023. In 2023, the highest of 1.50 mg/100g was obtained from 2 minutes blanching followed by 4 minutes blanching with 1.40 mg/100g while the least of 0.47 mg/100g was found from 48 hrs soaking in water. There was no significant difference ($p>0.05$) among the drying methods on swelling capacity in 2022, but there was also a significant difference ($p\leq0.05$) in 2023. In 2023, oven drying had the highest swelling capacity of 1.17 mg/100g, followed by sun drying with 1.20 mg/100g, while the least of 1.00 mg/100g was found from shade drying. Generally, 2 & 4 minutes of blanching were found to be statistically better than soaking in water in terms of swelling capacity. High swelling power is an important requirement for good-quality flour. Swelling power is associated with amylose content. The abundant amylose content has a strong structural structure because its crystalline structure has a strong network, and this will block the swelling (Babu *et al.*, 2014). Swelling capacity is important in manufacturing and maintaining structures for different food products, such as bakery products, i.e., during and after the process (Awolu*et al.*, 2016). This often correlates with final product qualities. On the other hand, oven and sun drying methods were statistically better than shade in enhancing the swelling capacity of cassava flour during further processing. Swelling of granules, accompanied by leaching of starch biopolymers, increased the viscosity. During further heating, granules would rupture further, which resulted in a decrease in the viscosity (Noorfarahzilah*et al.*, 2017).

The gelatinization capacity of cassava flour from different pre-treatments and drying methods ranged from 0.38-0.53. The result on gelatinization capacity indicated that there was no significant difference ($p>0.05$) among the pre-treatments in both 2022 and 2023, likewise among the drying methods. When starch is heated in the presence of enough water, i.e., excess water, starch granules swell, and the crystalline organization in starch decomposes to form amorphous regions. This molecular disordering is called gelatinization (Mamat *et al.*, 2018).

Table 1: Effects of Pre-Treatments and Drying Methods on Cyanide Content and Functional Properties of Cassava Flour at in 2022

Treatments	**Cyanide (mg/100g)**	**H_2O Absorption (mg/100g)**	**Bulk Density (mg/100g)**	**Swelling Capacity**	**Gelatinization Capacity**
Pre-Treatments					
48 hrs Soaking in H_2O	0.038	0.47	0.59	0.57	0.40
2 min Blanching	0.036	0.34	0.65	0.64	0.42
4 min Blanching	0.047	0.44	0.64	0.66	0.47
P<F	0.087	0.751	0.008	0.904	0.730
LSD	0.0432	0.460	0.031	0.603	0.228
Drying Methods					
Oven	0.041	0.42	0.71	0.59	0.44
Shade	0.048	0.37	0.59	0.61	0.47
Sun	0.047	0.47	0.58	0.67	0.38
P<F	0.088	0.319	<.001	0.688	0.308
LSD	0.032	0.137	0.025	0.199	0.125
Pre-treatments X Drying	NS	NS	**	NS	NS

NS = Not Significant, ** = Highly Significant

Table 2: Effects of Pre-Treatments and Drying Methods on Cyanide Content and Functional Properties of Cassava Flour at in 2023

Treatments	**Cyanide (mg/100g)**	**H_2O Absorption (mg/100g)**	**Bulk Density (mg/100g)**	**Swelling Capacity**	**Gelatinization Capacity**
Pre-Treatments					
48 hrs Soaking in H_2O	0.077	1.77	0.63	0.47	0.40
2 min Blanching	0.092	2.87	0.77	1.50	0.47

4 min Blanching	0.081	2.88	0.86	1.40	0.53
P<F	0.003	<.001	<.001	<.001	0.546
LSD	0.0021	0.080	0.0062	0.053	0.112
Drying Methods					
Oven	0.081	2.13	0.74	1.17	0.47
Shade	0.079	2.63	0.76	1.00	0.47
Sun	0.081	2.74	0.77	1.20	0.47
P<F	0.048	<.001	<.0001	<.001	1.000
LSD	0.0017	0.052	0.011	0.087	0.017
Pre-treatments X Drying	**	**	**	**	NS

NS = Not Significant, ** = Highly Significant

Conclusion

Food drying is one of the methods that is used to preserve some perishable agricultural produce in order to ensure their availability almost all year round, reduce postharvest losses, and achieve food security. Therefore, in this study, all the pretreatments used were capable of lowering the cyanide content and improving the functional properties. On the other hand, all three drying methods were also able to lower the cyanide content within the acceptable limit, but shade and sun drying were more affordable and accessible than oven drying. However, oven achieved efficient drying within the shortest time as compared to sun and shade drying methods.

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