Influence of Soaking Time and Drying Temperature on Some Physico-Chemical and Proximate Composition of Flour Produced from Parboiled Cassava

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Abstract
The influence of steeping time and drying temperature on some physico-chemical and proximate composition of flour made from parboiled cassava were investigated using a Three-level Factorial design with two variables. Process variables include steeping time (0, 24, and 48h) and drying temperature (40, 50, and 60^{0}C). The moisture contents ranged from 6.52 to 7.52%, and decreased significantly with increase in the drying temperature from 40 to 60^{0}C. The dry matter contents ranged from 92.48 to 93.48% but not significantly different (p>0.05). The flour yield ranged from 25.84 to 27.8%. Increase in steeping time of parboiled cassava chips from 0 to 48h led to a significant increase in flour yield. Starch yield was not significantly affected by the process variables. The hydrogen cyanide (HCN) ranged from 5.06 to 37.78 mg/kg. The main factor that affected the reduction in HCN content is the time of steeping. Also increase in drying temperature resulted to a decrease in the HCN content. The crude protein, fat, ash, fibre contents decreased significantly with increase in the soaking time of the parboiled cassava chips from 0 – 48 h. The carbohydrate contents of flour samples ranged from 88.86 to 95.52% but were not significantly affected by the process variables (p>0.05).

Keywords: *parboiled cassava flour, steeping of cassava chips, oven drying of cassava, Three-level factorial design.*

Introduction

Cassava is an important food crop in the tropics and a major carbohydrate staple consumed in various forms by humans (Udoro *et al*., 2008). It is estimated that the crop provides about 40% of all the calories consumed in Africa and ranks second only to cereal grains as chief source of energy in Nigerian diet (Nwabueze and Odunsi, 2007). Nigeria is the world's largest producer of cassava with about 19% of the world's output (Njoku and Banigo, 2006). As cassava becomes more important as industrial crop, one alternative is to transform the fresh cassava roots into precooked cassava flour which can then be used as a raw material for making high added-value products like cassava dough, croquette, fried chips or snacks (Rodriguez-Sandoval *et al*., 2008). Unfortunately, cassava deteriorates easily after harvest and contains various amounts of cyanogenic glucosides, linamarin and lotaustralin. Exposure to cyanide-containing foods has been linked to several conditions, such as anaemia, degeneration of the optic nerve in people with vitamin deficiency, and atrophy of the optic nerve (Murano, 2003). However, the "bitter" cassava varieties (containing high concentrations of cyanogenic glycosides) are much more commonly used, and their roots must be fermented before they are consumed so that the toxic cyanide concentration can be reduced to innocuous levels (Numfor*et al*., 1996).

Some indigenous products made from cassava include garri, *fufu*, lafun, abacha, and tapioca. Cassava slices, known as 'Abacha', is a popular indigenous food that is usually eaten with coconuts, groundnuts, smoked fish, palm kernels. It is referred to as 'eberebejiapu', 'mpataka, and 'nsisa' in different Igbo dialects (Njoku and Banigo, 2006). The indigenous methods of 'Abacha' production usually involves peeling, cutting into smaller cylindrical sizes, parboiling, slicing, and soaking in water and sun drying. Studies on the effects of parboiling and soaking of cassava chips were carried out (Chukwuemeka, 2007; Njoku and Banigo, 2006), but the precooked cassava chips were not oven dried.

Oven drying has some advantages over sun drying because of some drawbacks inherent in the sun-drying method. Some of these drawbacks are susceptibility to damage due to inclement weather, contamination and slow drying rates (Mkandawire and Taulo, 2008). The physicochemical properties of cassava starch were shown to have been affected by drying temperature in the range of 40^0C to 60^0C (Aviara *et al*., 2010). In this study, the indigenous method of producing 'Abacha' is modified to produce cassava flour made from oven dried cassava chips.

The objective of this study is to determine the influence of soaking time and drying temperature on some physico-chemical and proximate composition of parboiled cassava flour using the Response Surface of a Three-level factorial design with two variables. The Response Surface Methodology (RSM) is a collection of mathematical and statistical techniques useful for the modeling and analysis of problems in which a response of interest is influenced by several variables and the objective is to optimize and or predict this response (Udensi and Iwe, 2009).

Materials and Method

Source of Materials

Freshly harvested roots of Cassava Mosaic Disease (CMD) resistant variety (97/4769) was obtained from the National Roots Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria, at about 11- 12 months old after planting.

Production of cassava Flours

Cassava flours were produced from the (CMD) resistance variety as shown in Figure 1. The fresh roots were peeled manually and cut into cylindrical pieces (approx. 6-8cm long). Six-kg batches of the cassava roots were cooked by submerged boiling in water. The cooked pieces were allowed to cool, sliced (3-5cm long, 0.5cm thick), soaked in water at ambient temperature (30 ± 3^0C) (one part of cassava to 3 parts of water) for three different times: 0, 24, 48 with changing water after every 24h; as shown in Figure 1. They were dried in an oven at three different temperatures: 40, 50, and 60^0C, and milled to a particle size of 3.0mm using attrition mill (2A premier mill, Hunt and Co., United Kingdom). Sieving was done manually with muslin cloth to obtain fine cassava flour. The cassava flours obtained were properly packaged and stored at room temperature (28 ± 2^0C) until ready for analysis.

Hydrogen Cyanide (HCN) Content

The HCN content of the flour was determined using the AOAC (1990) method. Determinations were made in duplicate.

Flour yield

This is the weight of flour obtained, expressed as a percentage of the weight of fresh peeled tubers before slicing. Determinations were made in duplicate.

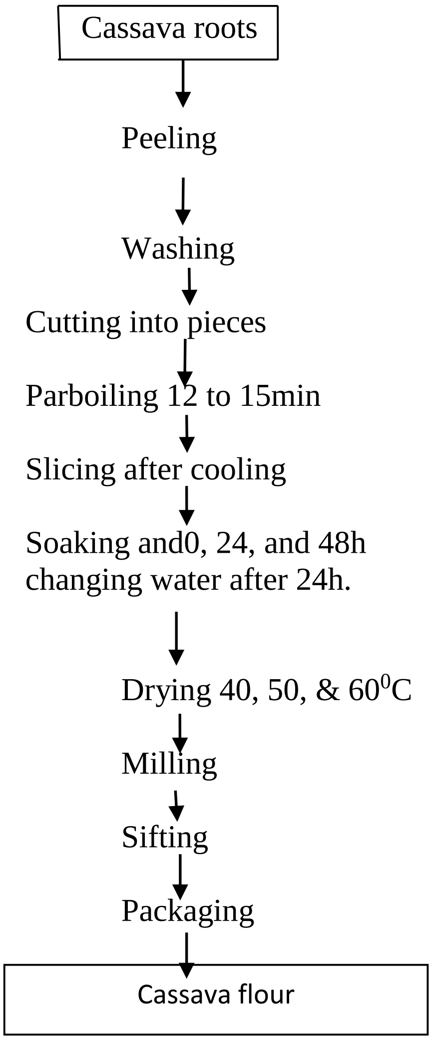

Figure 1: Flow diagram for processing of precooked cassava flour.

Starch Yield

This was determined by the process employed by Nwabueze and Odunsi (2007). A 50g sample of the precooked cassava flour was thoroughly mixed with sufficient water and filtered through a 50g µ sieve. The mixture was allowed to stand overnight. It was decanted and recovered starch was dried in oven to a constant weight. Determinations were made in duplicate.

Starch (%) = (Weight of dried starch/ Weight of sample) x 100.

Proximate Analysis

The proximate composition of the processed roots was determined according to for fat, ash, crude protein, moisture, crude fibre and carbohydrate.

Experimental Design

A three-level factorial design with two variables was adopted for this work. Thus:

$y = ß_0 + ß_1x_1 + ß_2x_2 + ß_{11}x^2_1 + ß_{22}x^2_2 + ß_{12}x_1x_2 + ε$

Where y is the response (dependent) variable or quality parameter, $x_1$and x_2 are the independent variables;x_1 = fermentation time (h), and x_2= drying temperatures (^{0}C) as shown in Table 1.The three levels were coded -1, 0, and +1,which represent maximum, mid, and minimum values of levels of independent variables respectively. The total number of experiment, N, required was, $N = n_f + n_c$ where n_f = number of experiments necessary for the factorial design at three primary levels = 8, and n_c = number experiments carried out at 'center point'= 2. Thus, total number of experiments N = 8 + 2 = 10.

Table 1: Three level factorial design with two variables

S/no	Soaking time (h)	Drying temperature (^{0}C)
1	0	40
2	24	40
3	48	40
4	0	50
5	24	50
6	48	50
7	0	60
8	24	60
9	48	60
10	0	50

Statistical Analysis

The statistical software package Design-Expert 9 (Stat Ease Inc., Minneapolis, USA) was used to generate the experimental design matrix, analyze the experimental data as employed by Tijani *et al.* (2012).

Results and Conclusion

The moisture contents of cassava flour samples ranged from 6.80 to 7.10%.Increase in drying temperature from 40 to 60^{0}C caused a reduction in the moisture content of the flour samples. Figure 2, a 3-dimensional graph indicates a progressive decrease in the moisture contents as the drying temperature increased. The sample with the least moisture content was steeped at 24 h and dried at 60^{0}C while the flour sample with the highest moisture content was soaked for 48 h and dried at 40^{0}C. The moisture contents are generally low, and this is an indication that the dried parboiled cassava flour samples will have stable shelf life when properly packaged and stored. The dry matter contents range from 92.90 to 93.20% (Table 2) but significantly different ($p>0.05$). The general high dry matter contents are signs of desirable quality attribute like good yields, diseases and pest tolerance, high root yields, and meet end-users characteristics (Etudaiye *et al*., 2009).The flour yield ranges from 25.84 to 27.8%, (Table 2).

Flour yield had a progressive significant increase with increase in soaking time from 0 to 48h as indicated in Figure 3.Longer soaking time as practised traditionally favour root tissue softening which resulted in increased flour yield (Nwabueze and Odunsi, 2006). There was also increase in flour yield as the drying temperature increased from 40 to 60^{0}C (Figure 3) but not significant (p>0.05).
The starch yield ranged from 68.25 to 69.13% and was not significantly affected by the process variables.

Table 2: Physico-chemical characteristics of parboiled cassava flour

S/no	Moisture content (%)	Dry Matter (%)	Flour Yield (%)	Starch Yield (%)	HCN content (mg/kg)
1	7.52^a±0.04	92.48±0.04	25.84^b±0.01	68.25±0.01	37.78^a±0.40
2	7.49^{ab}±0.06	92.51±0.06	27.03^{ab}±0.01	68.34±0.02	7.45^b±0.10
3	7.50^a±0.03	92.50±0.03	27.69^a±0.03	69.13±0.04	5.18^d±0.03
4	6.98^{ab}±0.05	93.02±0.05	26.04^b±0.01	68.05±0.07	37.16^a±0.23
5	6.95^{ab}±0.03	93.05±0.03	27.66^{ab}±0.01	68.83±0.04	6.73^c±0.04
6	7.00^{ab}±0.03	93.00±0.03	27.80^a±0.14	69.06±0.15	5.17^d±0.05
7	6.54^b±0.05	93.48±0.05	25.95^b±0.01	68.82±0.01	36.16^a±0.30
8	6.52^b±0.03	93.48±0.03	27.61^{ab}±0.01	68.68±0.00	6.67^c±0.01
9	6.56^b±0.05	93.44±0.05	27.83^a±0.04	68.55±0.04	5.06^d±0.01
10	6.96^b±0.04	93.04±0.04	25.71^b±0.01	68.14±0.20	6.71^c±0.01

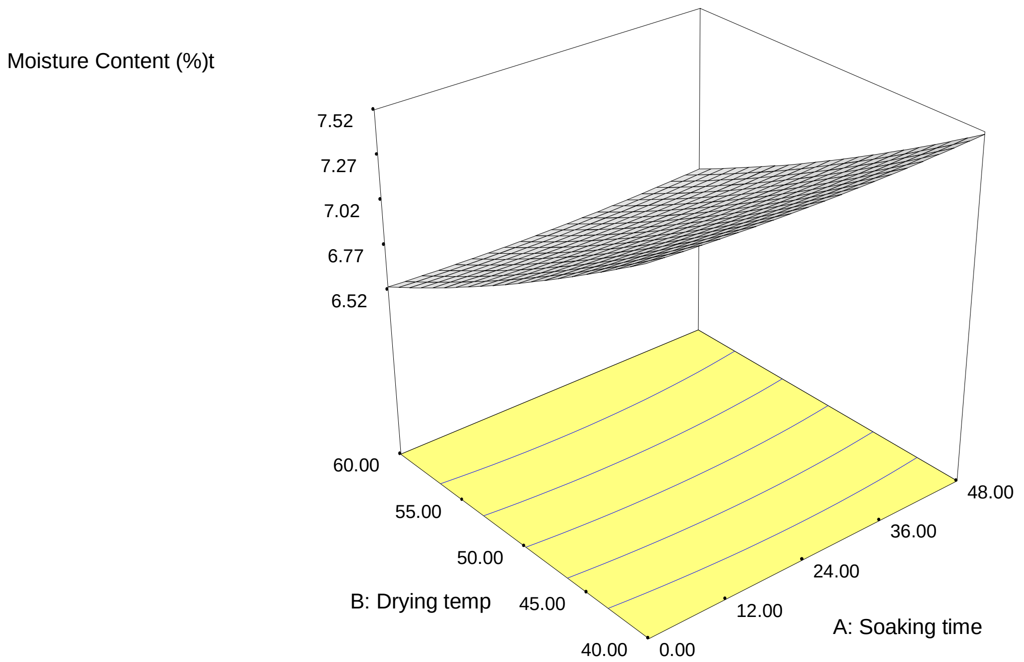

Fig. 2: Influence of soaking time and drying temperature on the Moisture content of cassava flour made from parboiled parenchyma

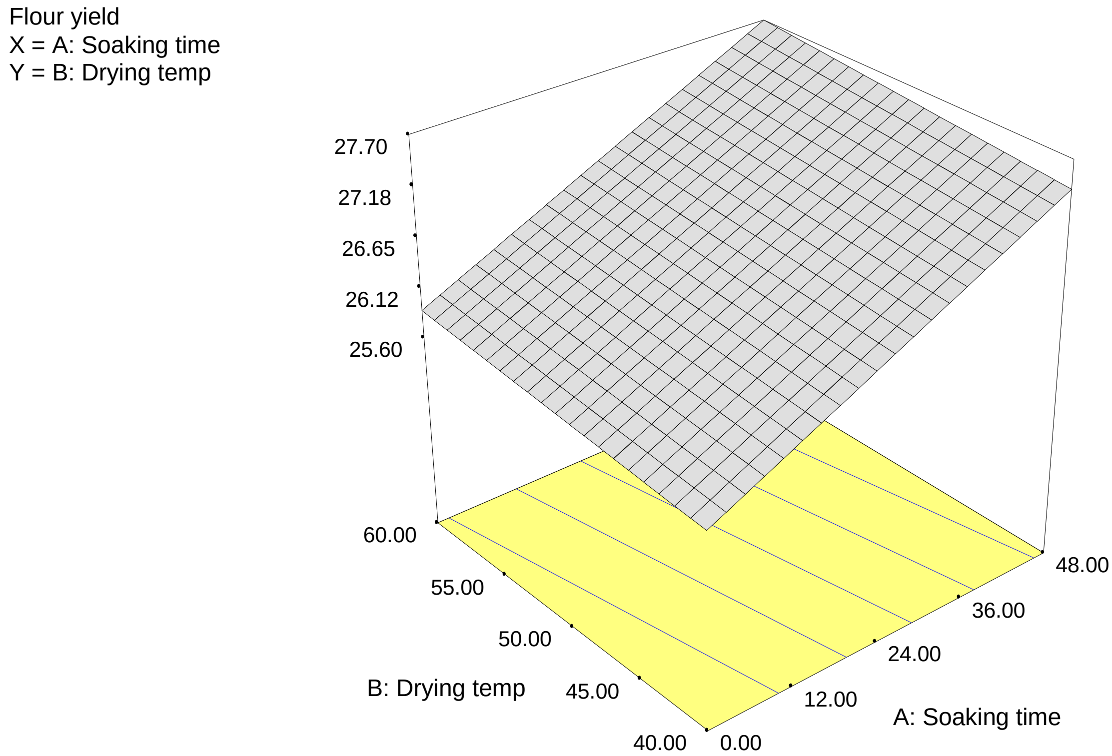

Fig. 3: Influence of soaking time and drying temperature on the Flour Yield of cassava flour made from parboiled parenchyma

The hydrogen cyanide (HCN) content ranges from 5.06 to 37.78 mg/kg. The main factor that affected the HCN content is the time of steeping. The response surface (Figure 4) shows a highly significant reduction ($p<0.05$) in the HCN content as the soaking time increased from 0 to 48 h. Also, increase in drying temperature from 40 to 60^0C also caused a reduction in HCN content (Figure 2). These significant reductions in cyanide contents as soaking time increase was due to the fact that free cyanide is both water soluble and heat volatilizable while bound cyanide can be converted by enzyme or heat hydrolysis to give water soluble, and heat volatilizable hydrogen cyanide (Onimawo and Egbekun, 1998).

The proximate composition of flour samples made from parboiled cassava chips is shown in Table 3. There was significant reductions in the protein contents from (2.44 - 2.04%), ash contents (0.74 - 0.43%), fat contents (0.68 - 0.36%), and fibre contents (0.09 - 0.06%) as the time of steeping increased. Leaching out of these nutrients might have occurred during steeping operations in which the water was changed after every 24 h. The carbohydrate contents ranged from 88.86 to 90.52% but not significantly different ($p>0.05$).

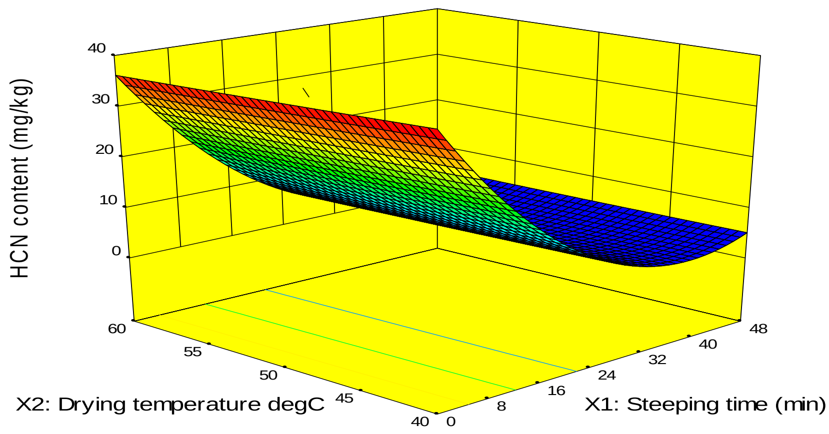

Fig. 4: Influence of soaking time and drying temperature on the HCN content of cassava flour made from parboiled parenchyma

Table 3: Proximate Composition of cassava flour samples made from parboiled parenchyma

S/no	Crude protein (%)	Ash (%)	Fat (%)	Crude fibre (%)	CHO (%)
1	$2.22^a±0.04$	$0.74^a±0.04$	$0.68^a±0.03$	$0.08^a±0.01$	88.86±0.03
2	$2.10^{ab}±0.03$	$0.56^b±0.03$	$0.43^b±0.02$	$0.07^{ab}±0.01$	89.35±0.04
3	$2.04^b±0.05$	$0.44^c±0.04$	$0.36^c±0.02$	$0.06^b±0.01$	89.7±0.03
4	$2.44^a±0.03$	$0.72^a±0.02$	$0.64^a±0.03$	$0.08^a±0.01$	89.14±0.03
5	$2.22^b±0.05$	$0.48^c±0.03$	$0.55^a±0.04$	$0.08^a±0.02$	89.62±0.02
6	$2.06^b±0.05$	$0.43^c±0.09$	$0.39^c±0.03$	$0.07^{ab}±0.01$	89.98±0.04
7	$2.34^a±0.07$	$0.79^a±0.07$	$0.66^a±0.02$	$0.08^a±0.01$	89.97±0.03
8	$2.23^{ab}±0.04$	$0.47^b±0.04$	$0.37^c±0.03$	$0.07^{ab}±0.01$	90.04±0.04
9	$2.05^b±0.03$	$0.45^c±0.02$	$0.36^c±0.02$	$0.06^b±0.01$	90.52±0.03
10	$2.36^a±0.01$	$0.71^a±0.03$	$0.65^a±0.03$	$0.09^a±0.01$	89.57±0.04

Conclusion and Recommendation

The moisture contents decreased significantly with increase in the drying temperature from 40 to 60^0C. The dry matter contents were generally high but not significantly different ($p>0.05$). Increase in steeping time of parboiled cassava chips from 0 to 48h led to a significant increase in flour yield. Starch yield was not significantly affected by the process variables. The main variable that affected the reduction in HCN content is the time of steeping from 0 to 48 h. Also increase in drying temperature was observed to cause a decrease in the HCN content. The crude protein, fat, ash, fibre contents reduced significantly as the time steeping of the parboiled cassava chips increased from 0–48h. The carbohydrate contents of flour samples ranged from 88.86 to 95.52% but were not significantly affected by the process variables ($p>0.05$). For the least moisture content, higher dry matter, higher flour yield, and least HCN content, soaking time of 48 h and drying temperature of 60^0C is hereby recommended as the best processing conditions.

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