ANTI-NUTRITIONAL PROPERTIES OF COCOYAM FLOUR AS INFLUENCED BY SOME PROCESSING PARAMETERS

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ABSTRACT

This study investigated the influence of some processing parameters (blanching time, X_1, drying temperature, X_2 and drying time, X_3) on some anti-nutritional properties (oxalate and tannins) of cocoyam flour. A-three factor central composite design (CCRD) was employed to process cocoyam samples into flour. Analysis of variance indicates that the linear, quadratic and interaction effects of X_1, X_2 and X_3 significantly ($p<0.05$) affected the anti-nutritional properties evaluated. Oxalate content of the cocoyam flour samples showed a significant difference ($P<0.05$) with increase in drying temperature. Blanching and drying time had no significant effect on the oxalate content of the flour, as their values tend to be higher than 0.05. Tannin content of the cocoyam flour samples showed significant difference ($P<0.05$) with increase in drying temperature and time. The regression analysis for tannin indicated that the linear effect of the drying temperature affected the tannin content significantly ($P < 0.05$). The regression models fitted to the experimental data showed that the R^2 values were 0.53 and 0.91 for oxalate and tannins respectively. Based on the desirability concept (0.581), the optimal conditions obtained for process variables and anti-nutritional properties of the cocoyam flour were, blanching time 5mins, drying temperature 77.28^{O}C, drying time 14hr, 11.1mg/g for oxalate and 18.0184mg/g for tannins.

Keywords: Cocoyam flour; blanching time; drying temperature; oxalate; tannin.

1. INTRODUCTION

Cocoyam (Colocasia esculenta) is an edible, greatly nutritious and underused plant belonging to the Araceae family. About 30 – 40 cocoyam species have been recognized, but only 5 – 6 species generate edible components (Nwanekezi, 2013). In Nigeria, cocoyam is one of the very nutritious under-exploited tropical root plants, but its use is still at subsistence level and an extremely overlooked crop (Chukwu *et al.*, 2009). Some scientists have denounced the extinction of cocoyam in Nigeria despite its various nutritional and health advantages (Nwosu, 2007).

Cocoyam belongs to the Araceae family, consisting of big family monocots of about one thousand five hundred (1500) species with a significant percentage distribution over the tropics (Ngoka, 1997). According to Opara (2002), the two most significant species of the Araceae family in Nigeria are taro (*Colocasia esculenta*) and tannia (*Xanthosoma sagittifolium*). Unlike cocoyam, the expanded uses of other tuber plants such as cassava and sweet potato have been widely researched, particularly in flour manufacturing. These have been used to create composite flour with wheat flour for a variety of pastry products that have market value and have led to decreased imports of wheat flour (Sanful and Darko, 2010). In this respect, however, cocoyam remains an underexploited tuber crop. Cocoyam's use and market choices are very restricted owing to restricted handling methods, bad understanding of the available varieties ' dietary, biochemical, molecular and anti-nutritional characteristics.

Cocoyam has been discovered to contain calcium oxalate crystal, phytate, tannins and saponins (Agwunobi et al., 2002), the impacts of which could be minimized by boiling, baking and fermentation. Therefore, cocoyam's processing is directed at creating product stability in terms of shelf-life, nutrition and palatability. Prathibha *et al.*, (1998) noted that handling techniques such as frying, boiling, baking and cooking pressure led to thermal inactivation and important losses in the activity of α-amylase, trypsin and chymotrypsin-inhibiting cocoyam activity and finished frying was the most efficient technique of eliminating enzyme inhibitors.

It has been commonly reported that cocoyam has the lowest starch grain size compared to other roots and tubers. This makes cocoyam appropriate for several food products for possibly allergic children, people with gastrointestinal disorders as well as diabetic patients (Onyenobi et al., 2010). Cocoyam's smallest starch molecules have been correlated with enhanced digestibility over other plants, making it appropriate for feeding invalids, confectionery manufacturing, and baby food (Eneh, 2013). It has therefore become imperative to investigate the desirability of cocoyam flour in terms of anti-nutritional properties as influenced by processing parameters.

2.0 MATERIALS AND METHODS

2.1 Materials

Freshly harvested tubers of cocoyam (*Xanthosoma sagittifolium*) (Plate 1) used for the study were obtained from a farm in Minna, Niger State.

2.2 Methods

2.2.1. Processing of Cocoyam Tuber

Freshly harvested cocoyam tubers were sorted to remove immature cormels and foreign materials. The cocoyam cormels were sliced with a knife and washed to remove sand and dust. The washed and peeled cormels were cut into round chips of 5 mm uniform size. The slices of cocoyam were split into twenty equal samples. Each sample was weighed, labeled and blanched in water baths maintained at a steady temperature of 100^{O}C as stated by Peluola-Adeyemi *et al.,* (2016). The blanched chips were spread in stainless plate and dried in an oven at different temperatures and time based on the experimental design (Table 1).

The dried samples were groud into fine flour using a milling machine.

The samples were sieved and packaged in properly labelled airtight polythene sachets for further analys is. The samples of sliced fresh cocoyam, oven dried and packaged cocoyam flour are shown in plates 2, 3 and 4 respectively.

2.2.2 Experimental design for production of cocoyam flour

Central composite design was used for a three-factor experimental set up, with blanching time (X_1), drying temperature (X_2) and drying time (X_3) as the independent factors at three levels each. The experimental design and analysis of data were done using Design-Expert Software version 7.0.3.1 (Stat-Ease Inc., Minneapolis, USA).

2.2.3 Determination of Anti-Nutritional Properties

The anti- nutritional properties of the cocoyam flour that were determined include oxalate and tannin. The oxalate content was determined using the method of Igbabul *et al.*, (2014). While the tannin content was determined using the method described by Ezegbe (2012).

3.0 RESULTS AND DISCUSSION

3.1 Results

The results for the three factor Central composite design and responses of the anti-nutritional factors of cocoyam flour samples are shown in Table 2.

3.2 Discussion

3.2.1 Oxalate content

Oxalate content of cocoyam flour samples showed a significant difference ($P<0.05$) with increased drying temperature. It is known that oxalate forms an insoluble complex with calcium ions, and it is often expected that when eaten, oxalate containing foods may interfere with calcium metabolism.

The ANOVA result (Table 3) indicates that the model (linear) is significant. The linear term of the model indicated that increasing the drying temperature resulted in the decrease in oxalate content of the flour. Blanching and drying time had no significant effect on the oxalate content of the flour, as their values tend to be higher than 0.05. The predicted R^2 of 0.2788 is in reasonable agreement with the Adjusted R^2 of 0.4522. The 3D plots showing the effect of variables on oxalate content is shown in Figures 1 and 2.

Final equation in terms of coded values:

$$Oxalate = 12.27 + 0.24X_1 - 1.86X_2 - 0.86X_3 \quad (1)$$

Equation in terms of actual values

$$Oxalate = +40.765 + 0.047X_1 - 0.371X_2 - 0.0859X_3 \quad (2)$$

3.2.2 Tannin content

Tannin content of the cocoyam flour samples showed significant difference (P<0.05) with increase in drying temperature and time. The values ranged from 18.2mg/g – 68.2 mg/g (Table 1), with sample **I** having the lowest value and sample **S** had the highest value. The reduction in tannin content during drying might be due to the loss of compounds while treating at a high temperature (Nithya *et al.*, 2007). It may also be due to the degradation or interaction with other components of the flour, such as proteins, to form insoluble complexes (Embaby, 2010).

The ANOVA result (Table 4) showed that tannin content was significantly influenced by the quadratic impact of drying temperature and time ($P < 0.05$). However, there was no significant effect observed by the interaction terms on the tannin content of the flour. The regression analysis for the tannin showed that the linear impact of the drying temperature considerably influenced the tannin content. ($P < 0.05$). The R^2 and adjusted R^2 values are 0.9111and 0.8311respectively. The predicted R-Squared of 0.4013 is not as close to the adjusted R-Squared of 0.8311as one might expect. This may be due to a large block effect or a possible error during the data analysis. The 3D plots showing the effect of variables on tannin content is shown in Figures 3 and 4 respectively.

Final equation in terms of coded values:

$$Tannin = 24.14 + 2.05X_1 - 15.10X_2 - 2.95X_3 - 0.32X_1X_2 + 0.43X_1X_3 - 2.02X_2X_3 + 1.22X_1^2 + 6.10X_2^2 + 4.47X_3^2 \quad (3)$$

Equation in terms of actual values

$$Tannin = +2026.386 - 0.697X_1 - 34.258X_2 - 89.810X_3 - 0.013X_1X_2 + 0.085X_1X_3 - 0.404X_2X_3 + 0.049X_1^2 + 0.244X_2^2 + 4.474X_3^2 \quad (4)$$

4.0 CONCLUSIONS

Studies were conducted using Central composite design for the production of cocoyam flour. Response surface methodology (RSM) was effective for estimating the effect of three independent variables; blanching time(X_1), drying temperature(X_2) and drying time (X_3) on the anti-nutritional properties of cocoyam flour.

Analysis of variance for oxalate indicated that the model (linear) is significant. The linear term of the model indicated that increasing the drying temperature resulted in the decrease in oxalate content of the flour. Blanching and drying time had no significant effect on the oxalate content of the flour, as their values tend to be higher than 0.05.

Tannin content of the cocoyam flour samples showed significant difference (P<0.05) with increase in drying temperature and time. The quadratic effect of the drying temperature and time showed significant ($P < 0.05$) influence on the tannin content. However, there was no significant effect observed by the interaction terms on the tannin content of the flour. The regression analysis for the tannin indicated that the linear effect of the drying temperature affected the tannin contents significantly ($P < 0.05$).

The R^2 values for oxalate and tannins were 0.53 and 0.91 respectively. Based on the desirability concept (0.581), the optimal conditions obtained for process variables and selected properties of cocoyam flour were, blanching time 5mins, drying temperature 77.28^{O}C, drying time 14hr for the following values of 11.1mg/g for oxalate and 18.0184mg/g for tannins.

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Plates

Plate 1: Samples of fresh cocoyam tubers (Xanthosoma sagittioilium)

Plate 2: Sliced fresh cocoyam

Plate 3: Oven dried cocoyam

Plate 4: Packaged cocoyam flour samples

Tables

Table 1: Design matrix for production of cocoyam flour

Variables	Unit	Levels		
		-1	0	+1
Blanching time(X_1)	Minute	5	10	15
Drying Temperature(X_2)	^{O}C	70	75	80
Drying time (X_3)	Hour	12	13	14