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Full Length Research Paper

Optimization of process conditions for cassava (*Manihot esculenta) lafun* production

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Optimization of cassava (*Manihot esculenta*, NR8082 clone) *lafun* production and evaluation was carried out using response surface methodology. The selected experimental design had three variables and five levels referred to as central composite design. Process variables were inoculum volume, fermentation time and drying temperature. Inoculum volumes were 1.50, 2.00, 2.50, 3.00 and 3.50 l. Fermentation times were 24, 36, 48, 60 and 72 h while drying temperatures were 35, 41, 47, 53 and 59°C. Response surface data on *lafun* yields, colour index and cyanogenic potentials were analyzed in a regression model while three-dimensional response surface plots were made. Effects of process variables on *lafun* parameters varied depending on which response was analyzed. Maximum and minimum yields were 82.68 and 66.68% for *lafun* flour and 68.24 and 56.20% for *lafun* starch, respectively. Photometric colour index ranged from 10.03 to 30.51 while cyanogenic potentials of the flour ranged from 1.88 to 5.31 mg HCN/kg and that of the paste from 0.93 to 3.11 mg HCN/kg. Models developed by response surface analysis for these responses were significant at low (1 to 5%) levels of probabilities and could be explained by regression coefficients in the models. Variabilities explained by the models were low for *lafun* flour yield (R^2 = 0.3188) but high for photometric colour index (R^2 = 0.8098). Optimum process conditions obtained for starch yield, photometric colour index and cyanide reduction were 2.0 l, 36 h and 41°C; 2.50 l, 48 h and 35°C; and 2.50 l, 72 h and 41°C, respectively.

Key words: Cassava, *lafun*, *fufu*, hydrogen cyanide, optimization, response surface methodology.

INTRODUCTION

Cassava (*Manihot esculenta*) is an important food in the tropical areas of African, Asia and Latin America. It is estimated (IITA, 1990) 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 (Ngoddy, 1989). By this, cassava plays important role in alleviating African Food Crisis though poor in protein (1.20%) and rich in cyanide (> 10 mg/100g fresh weight) in some varieties such as TMS 50395 (IITA, 1990; Janssens, 2001). The variety/clone NR8082 is low cyanide high-yielding cassava developed by the National Root Crops Research Institute, Nigeria and commonly distributed to Nigerian farmers.

Raw cassava has been reported (Onabolu, 1989; Cereda and Mattos, 1996) to contain two cyanogenic glycosides known as linamarin and lotaustralin with the former being the most representative glucoside, accounting for about 80% of the total cassava glucoside (Dicar, 1993). Linamarin and lotaustralin are β-glucosides of acetone cyanohydrin and ethyl-methyl-ketone-cyanohydrin, respectively (Cereda and Mattos, 1996). Linamarin produces the toxic compound (hydrogen cyanide, HCN), which can be hazardous to the consumer. Cassava processing by fermentation is one of the most widespread techniques used in Africa and is considered an efficient means of reducing cyanogenic potential in the resulting food (Brainbridge, 1994).

Lafun is fermented cassava flour popular among the people in the Southwestern States of Nigeria (Cereda and Mattos, 1996). The traditional method of processing cassava into *lafun* though unique for its ability to reduce

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the toxic cyanogenic compound to a least possible level (Numfor, 1983) imparts a strong smell to the product (Cereda and Mattos, 1996). *Lafun,* like *gari*, another fermented product from cassava, is a dry product, which can be preserved for a long time under the prevailing local environment. It is a cheap and popular meal in the rural areas of Nigeria and can be prepared into ready food much more quickly than *gari* (Latunde-Dada, 1997). *Lafun* is generally prepared into a thick paste in boiling water and eaten with vegetable soup or stew.

Oyewole and Ogundele (2001) reported that *lafun* quality varies with processing methods and with rocessors. In spite of various reports in literature (Oyewole and Odunfa, 1990; Oyewole and Afolami, 2000; Oyewole and Ogundele, 2001) on *lafun* production from different cassava varieties, there is scarcity of information on efforts to optimize known process conditions for maximum product quality in mind. The need to optimize process conditions to enhance product quality in terms of yield, cyanogenic potentials and sensory acceptability through response surface methodology, becomes relevant given the present need for small scale food processing and spread of consumers.

In many applications, the system to be optimized can be formulated as a mathematical model. With the advent of high-speed computers, very large and complex systems can be modeled and optimization can yield substantially improved benefits. Although optimization has become popular in many sectors of the Food Industry, it is a procedure for developing the best possible product in its class (Ruguo, 1999). The intention of optimization is to provide a more precise map of the path that has the highest probability of leading to a successful food product (Ruguo, 1999; Crapiste, 2000). The objective of this study is to use the response surface application to optimize process variables to maximize cassava *lafun* yields, colour and sensory attributes or reduce cyanogenic potentials without large changes in the operational parameters. These process variable conditions investigated included inoculum volume (l), fermentation time (h) and flour drying temperature (°C). The process variable combination that gave maximum cassava *lafun* response is recommended for scale up production in that response.

MATERIALS AND METHODS

Source of cassava roots

Cassava roots of the NR8082 clone were obtained from the National Root Crops Research Institute, Umudike, Abia State, Nigeria. The Cassava roots were freshly harvested at 10 – 12 months of age.

Cassava roots preparation

Freshly harvested cassava roots of the NR8082 clone were peeled, washed and fermented according to the method described in literature (Oyewole, 1994; Oyewole and Odunfa, 1990). The cassava roots were then grated with a local grating machine and fermented with appropriate inoculums from a 4-day-old starter culture containing about 10 cfu/g of microorganisms comprising mainly *Corynebacterum manihot* and *Geotricum candida.*

Processing variables

Process variable conditions investigated for optimization in *lafun* production included inoculum volume (l), fermentation time (h) and flour drying temperature (°C).

Inoculums

The methods described by Mathew (2002) and Numfor (1983) were used with minor modifications. Inoculums from the starter culture were introduced into the cassava pulp at various volumes of 1.5, 2.0, 2.5, 3.0 and 3.5 l (x_1). The medium was stirred to bring about uniform distribution of the microorganisms.

Drying temperature of lafun flour

The fermenting liquor was decanted and the pulp processed using a local screw press. The dewatered pulp was dried in the oven (Carbolite MD 1430, England) at variable temperatures of 35, 41, 47, 53 and 59°C (x_2).

Fermentation time of the cassava pulp

The cassava pulp was allowed to ferment at room temperature for variable time intervals of 24, 36, 38, 60 and 72 h (x_3).

Lafun flour yield

The percent yield of *lafun* flour was calculated from the weight of *lafun* obtained from known weight of the peeled cassava roots used (Oyewole and Ogundele, 2001).

Lafun starch yield

A 50 g sample of *lafun* flour was thoroughly mixed with sufficient water and filtered through a 50 µ sieve. The mixture was allowed to stand overnight (Oyewole and Afolami, 2001). It was decanted and recovered starch was dried in oven to a constant weight.

$$\text{Starch (\%)} = \frac{\text{Weight of dried starch}}{\text{Weight of sample}} \times 100 \qquad (1)$$

Photometric colour index

Photometric colour of various lafun flours was determined on 1 g sample according to the method described by Pike (2003). The sample was weighed and dissolved in 20 ml water/ethanol mixture. The mixture was filtered after standing for 30min. The absorbance of the filterate was measured at 400, 550, 620 and 670 nm using

Table 1. Central composite experimental design of 3 variable five level process conditions for production of *lafun* flour from cassava root.

Exptal[a] Run	Inoculum volume (l)	Fermentation time (h)	Drying temperature(°C)
1	2.0 (-1)	36 (-1)	41 (-1)
2	2.0 (-1)	36 (-1)	53 (+1)
3	2.0 (-1)	60 (+1)	41 (-1)
4	2.0 (1)	60 (+1)	53 (+1)
5	3.0 (+1)	36 (-1)	41 (-1)
6	3.0 (+1)	36 (-1)	53 (+1)
7	3.0 (+1)	60 (+1)	41 (-1)
8	3.0 (+1)	60 (+1)	53 (+1)
9	3.5 (+a)	36 (-1)	41 (-1)
10	1.5 (-a)	36 (-1)	53 (+1)
11	2.5 (0)	72 (+a)	41 (-1)
12	2.5 (0)	24 (-a)	53 (+1)
13	2.5 (0)	48 (0)	59 (+a)
14	2.5 (0)	48 (0)	35 (-a)
15	2.5 (0)	48 (0)	47 (0)
16	2.5 (0)	48 (0)	47 (0)
17	2.5 (0)	48 (0)	47 (0)
18	2.5 (0)	48 (0)	47 (0)
19	2.5 (0)	48 (0)	47 (0)
20	2.5 (0)	48 (0)	47 (0)
21	2.5 (0)	48 (0)	47 (0)
22	2.5 (0)	48 (0)	47 (0)
23	2.5 (0)	48 (0)	47 (0)

Numbers in brackets are the coded values of the independent variables in the experimental design. Exptal = experimental.

spectrophotometer (Unican He λ105Y, England). The solvent was used as blank. Photometric colour index was calculated as:

$$pci = 1.29 (A_{400}) + 69.70 (A_{500}) + 41.20 (A_{620}) - 56.41 (A_{670}) \qquad (2)$$

where A = absorbance**.**

Cyanogenic potentials of lafun flour and paste

Cyanogenic potentials of *lafun* flour and paste were determined using picrate paper kits method described by Bradburg (1999). One-gram sample of *lafun* flour was homogenized in a 250 ml conical flask containing 25 ml water. A strip of spot paper soaked in an alkaline sodium picrate solution was fixed in the solution with the cork. The flask was kept for 18 h at room temperature. The strip was removed and eluted in 60 ml water and the absorbance was read at 540 nm using a spectrophotometer (Unican Heλ105Y, England).

Sensory evaluation of lafun paste

Lafun flour was first sifted through a 50 µ sieve. It was then cooked into a paste by turning the flour in boiled water at flour/water ratio of 1:4 (w/v). Sensory evaluation was carried out within ten minutes of preparation (Oyewole and Afolami, 2001) following the method described by Stone and Sidel (1985) with minor modifications.

A small consumer acceptance panel (Stone and Sidel, 1985) familiar with *lafun* consumption and with the sensory scale and method of assessment were drawn from Southwestern Nigeria students of Michael Okpara University of Agriculture, Umudike and used to evaluate sensory attributes of the cooked paste.

The samples were arranged randomly in similar plates each with coded 3-digit non-misleading or biasing numbers. A 9-point Hedonic scale was used to make panelists express their feelings of like and dislike for the flavour, colour, texture, taste and overall acceptability of the pastes. On the scale score, 9 represented like extremely, 1 represented dislike extremely while 5 represented neither like nor dislike. Data generated from scores were analyzed for variance as described by Larmond (1977).

Experimental design

The experimental design of 3-factor factorial in Completely Randomized Design (CRD) as reported by Meilgaard et al. (1999) as shown in Eq. (3) was adopted. Thus:

$$Y = \beta_o + \sum_{i=1}^{k} \beta_i X_i + \sum_{i=1}^{k} \beta_{ii} X^2_i + \sum_{i=1}^{k} \sum_{\substack{j=1 \\ i<j}}^{k} \beta_{ij} Xi\, X_j + \varepsilon \qquad (3)$$

where Y is the dependent variable, X_i and X_j the independent variables in the model, k the number of independent variables, β_o the intercept (constants and regression coefficients of the model), and ε the random error term.

Table 2. Analysis for quality parameters of *lafun* flour and starch yields (%), photometric colour index and cyanogenic potentials (mg HCN/kg) for flour and paste[a].

Exptal[b] Run	Yields (%)		Photometric colour index	Cyanogenic potentials[c]	
	Flour	Starch		Flour	Paste
1	82.68	68.24	14.47	3.75	2.17
2	80.00	64.62	14.52	4.06	2.17
3	78.68	56.72	19.74	3.13	1.86
4	66.68	64.32	29.26	3.44	2.17
5	80.26	58.74	14.54	3.75	2.48
6	78.68	64.32	13.80	4.06	2.48
7	80.08	56.20	15.48	3.75	2.48
8	73.32	56.70	17.59	4.06	2.17
9	71.04	58.68	12.04	4.06	1.86
10	67.04	65.70	13.44	4.38	2.48
11	77.32	55.80	10.03	1.88	0.93
12	66.68	57.20	10.08	5.63	3.11
13	77.32	57.80	12.74	5.31	2.80
14	66.68	64.66	30.51	4.38	2.48
15	73.32	60.86	20.83	4.69	2.48
16	77.32	60.72	22.34	4.69	2.48
17	66.68	62.72	24.79	4.69	2.17
18	73.32	60.24	29.59	5.00	2.48
19	66.68	62.30	26.62	5.00	2.48
20	78.68	60.30	21.06	4.69	2.17
21	78.68	61.28	18.41	4.69	2.48
22	77.32	60.74	21.10	5.00	2.48
23	77.32	60.24	20.46	4.69	2.17

[a]*lafun* flour cooked into paste by stirring in boiled water ready for consumption, [b]Experimental, [c]Cyanogenic potentials (mg HCN/kg).

The three variables; inoculum volume (l), fermentation time (h) and flour drying temperature (°C) and five levels coded -a, -1, 0, +1 and +a gave 15 variable combinations which when replicated 8 times at the center point (0) generated a total of 23 experimental runs. The experimental design had upper (+a), intermediate (0) and lower (-a) values of process variable conditions (Table 1).

Statistical analysis

Data collected were analyzed using an appropriate Statistics package (SPSS/PC +) in a regression model. Three-dimensional response surface plots were made using a Statgraphic computer package (Statistica, Statsoft, Inc., Tulsa, OK).

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_{11} X_1^2 + \beta_{22} X_2^2 + \beta_{33} X_3^2 + \beta_{12} X_3^2 + \beta_{12} X_1 X_2 + \beta_{12} X_1 X_2 + \beta_{13} X_1 X_3 + \beta_{23} X_2 X_3 + \varepsilon \quad (4)$$

Where

Y = dependent variable, β0 …. B3 =estimated regression coefficient, X1….X3 = independent variables, and ε = random error.

RESULTS AND DISCUSSION

Response surface analysis for lafun flour

Data on quality parameters of cassava *lafun* are presented in Table 2. Optimum process condition for maximum yield (82.68%) was 2.0 l, 36 h and 41°C. (inoculum volume, fermentation time and drying temperature, respectively). Lower or upper process conditions reduced flour yields. The independent variable with most significant ($p \leq 0.1$) effect on flour yield was the length of fermentation. Short fermentation times impair root tissue softening while long fermentation times as in the traditional practice favour it and result in increased flour yield. Tissue softening is a product of associative interaction of several microbes and enzymes such as polygalacturonase, pectinase and cellulase with tissue degrading activities (Meilgard et al., 1999; Okolie and Ugochukwu, 1988).

The polynomial equation (Eq.5) shows that only cross product effects of process variables had significant ($p \leq 0.05$) effect on *lafun* flour yield. Essentially, length of

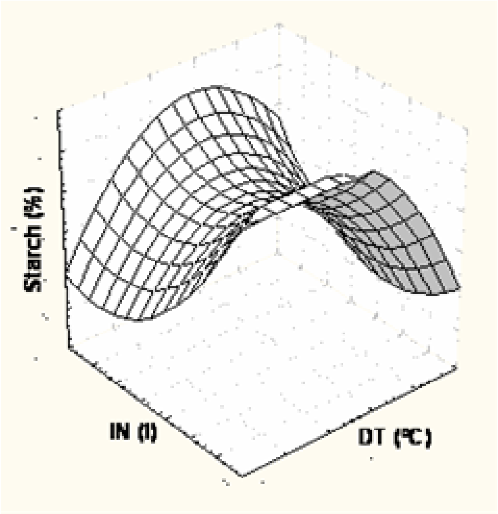

Figure 1. Effect of process conditions on *lafun* starch yield (IN = inoculum volume (l) and DT = drying temperature (°C)).

Table 3. Estimated regression coefficients for starch content of *lafun* four.

Source	Coeficient	Std error	df	*p*–value
Regression on				
Constant	33.576623	84.594281		
X_1	-258.193308	54.030059	1	0.004
X_2	5.933780	3.073175	1	0.0756
$X_1.X_1$	10.087864	4.386095	1	0.0387
$X_2.X_2$	-0.102818	0.021418	1	0.0003
$X_3.X_3$	-0.042018	0.009088	1	0.0005
$X_1.X_2$	4.105445	1.210963	1	0.0048
$X_1.X_3$	4.553212	0.865245	1	0.0002
$X_2.X_3$	0.060312	0.054932	1	0.2921
R^2	0.85464			

fermentation was central in this effect on *lafun* flour yield. Fermentation time (x_3) had a cross product order effect when interacted with either the inoculum volume (x_1) or the drying temperature (x_2). Inoculum volume increased microbial load in the medium and hence favoured fermentation while drying temperature limited their activities. Since flour yield was relative to the intact cassava root, loss of moisture and volatile components of fermentation (Bokanga, 1992) could affect the actual values obtained for *lafun* flour in Table 2:

$$Y_{flour} = 30.14444–0.52332x_1.x_3–0.03695x_2.x_3 \qquad (5)$$

The model for this parameter explained only 31.89% of the total variations in flour yield showing a significant ($p \leq 0.05$) lack of fit.

Response surface analysis for lafun starch

Lafun flour was essentially of starch material with maximum yield of 68.24% at optimum process condition (Table 2). Response surface plot of *lafun* starch yield had a twisted shape (Figure 1) and linear, quadratic and cross product order effects were significant at 1 – 5% levels of probability. The plot showed that starch yield increased with inoculum volume and drying temperature effect up to a maximum of 2.0 l and 41°C, respectively, before a twist effect of these variables occurred at an increased fermentation time.

At longer fermentation times, disintegrated tissue pulps have the chances of leaching into the fermenting water, there by reducing starch yield. *Corynebacterum manihot* population in the fermenting medium which initiates cassava starch break down could have bond breaking effect thereby lowering water holding capacity of the pulp. This activity invariably culminates in loss in moisture and consequently starch as a soluble cassava constituent. The response surface equation developed from the regression Table (Table 3) after removal of non significant ($p>0.05$) terms becomes:

$$Y_{starch} = 33.57662 – 258.19331x_1 + 10.08764x_1^2 – 0.10282x_2^2 – 0.04202x_3^2 + 4.10545x_1.x_2 + 4.55321x_1.x_3 \qquad (6)$$

The model accounted for 85.46% of the total variation in *lafun* starch yield and significantly ($p \leq 0.05$) fitted.

Response surface analysis of lafun colour index

All *lafun* flour samples were visually white in colour. However the photometric determinations presented in Table 2 showed that flour whiteness reading varied from 10.03 to 30.51. The highest index was obtained at process variable condition of 2.5 l (inoculum volume), 48 h (fermentation time) and 35°C (drying temperature). Cassava pulps fermented with higher or lower (≥ 2.5 l ≤) inoculum volumes and for longer or shorter (≥ 48 h ≤) periods, produced *lafun* flours with lower photometric colour indices particularly when dried at higher temperature range of 47 to 59°C (Figure 2). The Figure confirms that white flour is produceable with >1.5l (inoculum volume) and <47°C (drying temperature). *Lafun* flour from 72 h fermented pulp had the least colour index (10.03) indicating that long fermentation times could encourage microbial breakdown of colour pigments as well as increase availability of reactive groups which can go on to take part in reactions in low molecular weight carbohydrates during drying. This effect was stronger at higher drying temperatures (47-59°C) where mild reactions such as caramelization of carbohydrates and Millard browning involving amino acid compounds of natural proteins and

Table 4. Estimated regression coefficients for photometric colour index of *lafun* flour.

Source	Coeficient	Std error	df	*p*–value
Regression on				
Constant	63.100223	80.738146		
X_1	-82.826304	51.567161	1	0.1322
X_2	-5.308687	2.933088	1	0.0935
$X_1.X_1$	-6.880421	4.186160	1	0.1242
$X_2.X_2$	-0.008258	0.020442	1	0.6928
$X_3.X_3$	-0.050130	0.008674	1	0.0001
$X_1.X_2$	4.207685	1.155763	1	0.0030
$X_1.X_3$	3.866535	0.825804	1	0.0004
$X_2.X_3$	0.214220	0.052428	1	0.0013
R^2	0.80980			

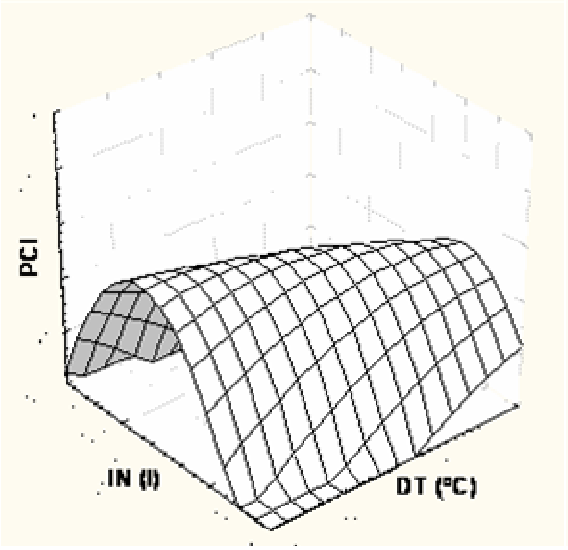

Figure 2. Effect of process conditions on photometric colour index (PCI) of *lafun* flour. IN = inoculum volume (l) and DT = drying temperature (°C)

reducing sugars affect flour whiteness. Badrie and Mellowes (1992) who considered effect of cassava starch or amylose on characteristics of cassava extrudate, reported the potentials for interactions between lipids, proteins and carbohydrates and their breakdown products, which under the present processing conditions could affect flour colour.

The response surface analysis of data on the photometric colour index (Table 4) showed that the response depended more significantly ($p \leq 0.05$) on cross product order effects of independent variable interactions than on linear order effects of individual variables.

Fermentation time had significant ($p \leq 0.05$) quadratic and cross product effect on the flour colour. The interactive cross product effects of inoculum volume with drying temperature was most significant ($p \leq 0.05$) (Eq. 7) followed by that with fermentation time, while drying temperature and fermentation time was the least. On removal of non significant ($p > 0.05$) terms and recomputing, the polynomial becomes:

$$Y_{colour} = -\ 63.10022 - 0.05013x_3^2 + 4.20769x_1.x_2 + 3.86654x_1.x_3 + 0.21422x_2.x_3 \qquad (7)$$

The model accounted for 80.98% of total variation in *lafun* colour and significantly ($p \leq 0.05$) fitted.

Response surface analysis of cyanogenic potentials of lafun flour and paste

The independent process variable most affecting cyanide reduction was the length of fermentation. Fermentation times of 60 to 72 h reduced cyanogenic potentials from 79.80 mg HCN/kg originally present in the raw cassava root (NR8082 clone) to a range of 3.75 to 1.88 mg HCN/kg in the flour and 2.17 to 0.93 mg HCN/kg in the paste. Shorter fermentation times (24 –48 h) reduced the cyanide potentials from 5.63 to 3.75 mg HCN/kg in flour and from 3.11 to 2.17 mg HCN/kg in the paste (Table 2).

Optimum process variable condition of 2.5 l, 72 h and 41°C produced *lafun* flours with least cyanogenic potentials in flour (1.88 mg HCN/kg) and paste (0.93 mg HCN/kg). Long fermentation periods gave fermenting microorganisms ample opportunity to produce enzyme linamarase which when combined with retting and drying drastically reduced cyanide content in the flour. Optimum independent process condition of 2.0 l, 36 h and 41°C (inoculum volume, fermentation time and drying temperature), reduced cyanogenic potentials to 95.30% in the flour and 97.28% in the paste. Cooking the flour into paste resulted in a loss of 50.53% and 98.83% of cyanide

Table 5. Estimated regression coefficients for cyanogenic potentials of *lafun* paste[a].

Source	Coeficient	Std error	df	*p*–value
Regression on				
Constant	- 3.469850	6.468992		
X_1	5.184381	4.131722	1	0.2317
X_2	-0.043815	0.235008	1	0.8550
$X_1.X_1$	-0.868747	0.335408	1	0.0224
$X_2.X_2$	0.001506	0.001638	1	0.3747
$X_3.X_3$	-0.000705	0.000695	1	0.3291
$X_1.X_2$	-0.026021	0.092603	1	0.7831
$X_1.X_3$	0.019166	0.066166	1	0.0466
$X_2.X_3$	0.000196	0.004201	1	0.0636
R^2	0.68678			

[a] *lafun* flour cooked into paste by stirring in boiled water ready for consumption.

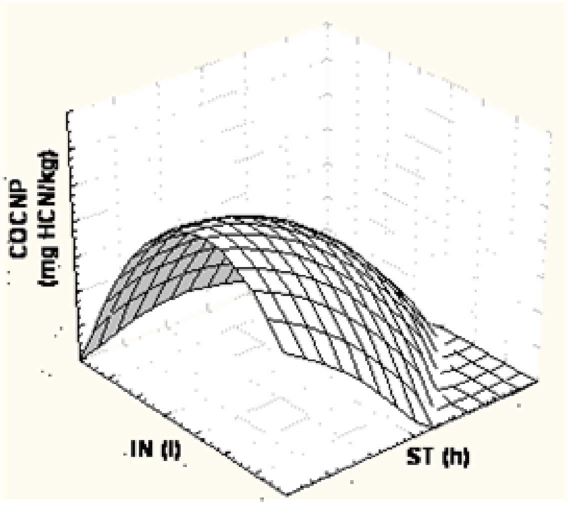

Figure 3. Effect of process conditions on cyanogenic potential (COCNP) of *lafun* paste. IN = inoculum volume (l) and ST = fermentation time (h).

present in the flour and raw cassava root (NR8082), respectively. The high percentage loss is attributable to its solubility and heat labile nature particularly in the paste. This is one major nutritional benefit of traditional practice of combining long period of fermentation (about 96 h) and *twice* cooking as unit operations in local cassava processing and utilization in Africa. This observation agrees with the report (Brainbridge, 1994) that fermentation is the most widespread techniques used in Africa as effective means of reducing cyanogens in cassava products.

Response surface analysis of the cyanogenic potentials of *lafun* paste (Table 5) indicated that quadratic and cross product coefficients of the model were significant ($p \leq 0.05$) while the plot showed a dome shape (Figure 3). Reduction in cyanide increased quadratically with inoculum volume corresponding to 48 h fermentation time before declining. The cross product order effect of fermentation time and inoculum volume was significant up to 55 h before linear effect of fermentation time took over, being maximum at 72 h.

Effect of inoculum volume on cycanide reduction was due to heavy microbial concentration, which favoured fermentation. On removing the non significant ($p>0.05$) terms and recomputing, the polynomial equation becomes:

$$Y_{paste} =– 3.46985 – 0.8687x_1^2 – 0.01917x_1.x_3 \quad (8)$$

The model contributed 68.68% of the total variation in cyanide content of *lafun* paste.

Sensory evaluation

Table 6 shows sensory evaluation of the *lafun* paste. One significant observation in this study is that all the *lafun* paste samples were acceptable to the panelists for the sensory attributes evaluated. The samples visually looked alike but for the experience of the traditional *lafun* consumers. Differences in sensory data were not statistically significant ($p > 0.05$). Panelists had been used to consuming traditionally processed cassava *lafun* pastes*,* which are odourous, stickier, and darker in colour than products of this experimentation. They describe *lafun* pastes with little or no odour, having a characteristic white colour and good texture as good quality *lafun* (Oyewole and Afolami, 2001). Perhaps loss of volatile products of fermentation during decanting and subsequent cooking operations reduced the offensive smell of the product.

Conclusion

Optimization of process variables to maximize cassava *lafun* yields, colour and sensory attributes or reduce cyanogenic potentials without large changes in the operational parameters was achieved in this study. The process variable condition that gave maximum cassava *lafun* flour (82.68%) and starch (68.24%) yields were 2.0 l, 36 h and 41°C (inoculum volume (l), fermentation time (h) and drying temperature (°C)). Under these variable condition, cyanogenic potentials reduced by 95.30% in the flour and 97.28% in the paste from its 79.80 mg HCN/kg in the raw cassava pulp (NR8082 clone). Since all *lafun* flours were visually white and the corresponding pastes generally liked by sensory panelists, the optimum

Table 6. Sensory evaluation of *lafun* paste*

Run	Colour	Flavour	Texture	Taste	Overall acceptability
1	7.3±0.25^{ab}	7.3±0.37^{a}	7.5±0.44^{a}	7.6±0.22^{a}	7.6±0.23^{a}
2	6.9±0.38^{ab}	7.00±0.44^{a}	7.7±0.27^{a}	7.3±0.32^{a}	7.1±0.34^{a}
3	6.7±0.27^{a}	6.8±0.53^{a}	6.8±0.38^{a}	7.2±0.34^{a}	7.0±0.27^{a}
4	7.5±0.25^{ab}	7.3±0.42 ^{a}	7.9±0.24^{a}	7.8±0.22^{a}	7.7±0.24^{a}
5	7.0±0.24^{ab}	7.2±0.27^{a}	7.5±0.36^{a}	7.3±0.25^{a}	7.3±0.20^{a}
6	7.6±0.23^{ab}	7.8±0.13^{a}	7.2±0.23^{ab}	7.6±0.23^{a}	7.7±0.23^{a}
7	7.8±0.21^{ab}	7.5±0.13^{a}	7.3±0.46^{a}	7.7±0.23^{a}	7.9±0.23^{a}
8	7.3±0.31^{ab}	7.7±0.23^{a}	7.5±0.26^{a}	7.2±0.23^{a}	7.8±0.20^{a}
9	7.4±0.33^{ab}	7.3±0.31^{a}	7.7±0.28^{a}	7.6±0.30^{a}	7.4±0.28^{a}
10	7.0±0.30^{ab}	7.8±0.40^{a}	7.6±0.23^{a}	7.9±0.19^{a}	7.4±0.20^{a}
11	7.6±0.23^{ab}	7.7±0.22^{a}	7.7 ±0.31^{a}	7.7±0.31^{a}	7.7±0.24^{a}
12	7.8±0.21^{ab}	7.4±0.31^{a}	7.5±0.43^{a}	7.6±0.35^{a}	7.5±0.25^{a}
13	7.4±0.22^{ab}	7.6±0.20^{a}	7.1±0.51^{a}	7.7±0.28^{a}	7.3±0.33^{a}
14	7.3±0.32^{ab}	7.3±0.39^{a}	7.0±0.45^{a}	7.3±0.37^{a}	7.6±0.31^{a}
15	7.1±0.29^{ab}	7.4±0.32^{a}	7.5±0.41^{a}	7.4±0.28^{a}	7.4±0.23^{a}
16	7.6±0.16^{ab}	7.3±0.28^{a}	7.5±0.38^{a}	7.2±0.20^{a}	7.5±0.17^{a}
17	6.6±0.36^{ab}	7.2±0.33^{a}	7.6±0.23^{a}	7.4±0.43^{a}	7.6±0.32^{a}
18	7.3±0.26^{ab}	7.3±0.28^{a}	7.9±0.30^{a}	7.1±0.35^{a}	7.1±0.29^{a}
19	7.4±0.16^{ab}	7.3±0.36^{a}	7.4±0.32^{a}	7.2±0.26^{a}	7.3±0.34^{a}
20	7.3±0.10^{ab}	7.3±0.23^{a}	7.6±0.24^{a}	7.3±0.34^{a}	7.3±0.24^{a}
21	6.7±0.38^{ab}	6.7±0.32^{a}	7.1±0.32^{a}	7.0±0.36^{a}	6.9±0.42^{a}
22	7.6±0.19^{ab}	7.6±0.27^{a}	7.0±0.44^{a}	7.9±0.32a	7.8±0.20^{a}
23	7.9±0.17^{a}	7.0±0.16^{a}	7.9±0.45^{a}	7.7 ±0.32a	7.2±0.20^{a}

**lafun* flour cooked into paste by stirring in boiled water ready for consumption.

process condition producing highest *lafun* yields in terms of flour and starch with low flour and paste cyanide concentration (2.0 l, 36 h and 41°C), is recommended for scale up production when using cassava NR8082 clone, on the basis of yield, safety and acceptability.

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