

ORIGINAL ARTICLE

Optimization of functional and sensory attributes of raphia palmwine with central component design (CCD).

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ABSTRACTS

Palmwine has a high commercial importance. Its general acceptability has been weak due to inconsistent quality identity, and variety. 3³ central composite design was used to optimize the important palmwine processing factors of *S. gabonensis*, pasteurization temperature, and pasteurization time were employed. Optimization of alcoholic content, (ml/100ml), pH, colour, flavour and taste, general acceptability and preference. The test revealed that the models for alcohol content, pH, colour, taste, preference to buy were significant, ($p < 0.05$) while general acceptability were not ($p > 0.05$) significant, flavor was marginally significant ($p = 0.0895$). Optimization result showed that 80.25g/100g, 46°C and 59min. of *S. gabonensis*, pasteurization temperature and pasteurization time respectively produced 7.62ml/100ml, 5.69, 4.69, 4.85, 4.46, and 4.82 of alcoholic content, pH, colour, taste, general acceptability and preference respectively at 100% reliability. The result of this work will serve as a benchmark for the production of different levels of attributes for domestic and commercial consumption.

Key words:

Introduction

Raphia palmwine is the sap of a monocarp crop and is widely grown along the coast of west and central Africa (Ekanem, 1959, Bassier, 1968), palmwine is an important socio-economic, nutrition and health item of many Nigerians especially the low-income rural dwellers. The sap can be fermented and distilled for alcohol (*ogogoro*), (Ezeronye and Okerentugba, 1998). The major chemical constituents of palm wine are sugar, protein, water-soluble vitamin of the B-group, titratable organic acids, alcohol and water (Eschie, 1978, Ojmelukwe, 2000).

Palmwine and its distillate are important solvent in herbal medicinal administration, pregnant women consume it fresh for the sweetness and nutrition while nursing mothers drink it warm to enhance breast milk production. (Ekpe, Pers. Comm: 2006). *Please include date.* However, different consumers have different preference for the quality of palm wine they consume. Most often, this preference is based on the freshness, sweetness and the level of alcohol (Ezeronye and Okerentugba, 2002)

Due to the high demand for palm wine and the problem of extending the shelf life of the juice, several storage methods have been investigated. For example, Levi and Oruchie, (1957); Okafor, (1975a); Uriah and Izuagbe, (1999); (Morah, 1984 and Morah, 1986) preserved palmwine with synthetic chemicals while Ojmelukwe, 2000, Okafor, 1975b and Izuagbe, 1990; Uriah and Izuagbe, 1990) used plant products to extend the shelf life of palm wine. However, the environmental and health related problems associated with the use of chemicals as preservatives for palm wine have been given attention (Mossel, 1971, NAFDAC, 1999). In view of these, the use of plant materials for the preservation has been given preference.

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Most chemicals current used for preservation of palmwine are no longer generally regarded as safe (GRAS). Awareness of negative health effects of synthetic chemicals in food systems has led to an increased acceptance of plant products as safe food preservatives and processing factors (Okoye, 1998a) (Okafor, 1975). (Oluruinidare *et al*, 1992, Oyadoge, 1997, Omoregbe and Osaghae, 1997).

The present study is aimed at investigating the effective percentage of *S. gabonensis*, and its interaction with pasteurization temperature and pasteurization time on the sensory attributes and shelf life of palmwine as processed in Essien Udim Local Government Area, Akwa Ibom State, Nigeria using response surface methodology.

Materials and methods

Early morning raphia palmwine was obtained from local wine tappers on specials arrangement. *S. gabonensis* was obtained from Obo Annang Market, in Essien Udim Local Government Area, Akwa Ibom State, Nigeria. The *S. gabonensis* was cleaned, tampered with water and cut into small pieces, pulverized to fine particles (*capable of passing* through No. 100 screen) and preserved for use.

About two hours after delivery, fresh palmwine from the different sources were mixed together in a plastic basin, filtered through a 150 mesh number and the specific gravity noted. Weighed quantities of *S. gabonensis* powder were introduced into pasteurization clay pots for the pasteurization temperature and time treatment to complete, the treated palmwine were poured into their appropriate sterilized bottles in triplicate and corked, as specified by the experimental design in Tables 1 and 2 stored away for 10 days.

Table 1: Assignment of variables into the experimental runs

Variables	Codes units	-1	0 Real values	1
$X_1 = S. gabonensis$	g	0	50	100
$X_2 =$ Pasteurization temperature	°C	27	55	70
$X_3 =$ Pasteurization time	Min	30	45	60

Table 2: Experimental runs and responses influence of x_1 , x_2 , x_3 on market and sensory attributes of stored palmwine

Std	<i>S. gabonensis</i> (X_1)	Past. Temp. (X_2)	Past. time. (X_3)	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8
3	0.00	70.00	30.00	8.11	6.50	2	3	1	3	2	3
7	0.00	50.00	60.00	10.16	6.10	2	3	2	3	2	3
8	100.00	50.00	60.00	7.10	6.80	5	5	1	4	5	5
1	0.00	30.00	30.00	15.11	4.60	2	2	1	4	2	2
10	50.00	70.00	47.00	17.11	4.70	4	4	1	1	1	2
11	50.00	30.00	60.00	8.12	4.11	4	4	2	4	5	5
12	50.00	70.00	60.00	8.13	7.10	4	4	1	5	4	4
14	50.00	50.00	30.00	10.12	6.77	5	4	1	4	3	3
15	50.00	50.00	30.00	14.11	7.91	4	1	1	4	4	4
9	50.00	30.00	47.00	15.11	3.01	3	5	2	1	1	2
4	100.00	70.00	30.00	8.15	6.81	4	4	1	3	4	4
13	50.00	50.00	30.00	11.301	6.71	4	5	2	4	4	4
2	100.00	30.00	30.00	9.22	6.99	5	1	1	5	4	4
6	100.00	50.00	47.00	17.00	6.11	4	4	1	2	4	1
16	50.00	50.00	30.00	11.15	6.66	3	4	1	4	2	3
5	0.00	50.00	47.00	14.00	2.00	1	1	1	1	4	1

Y_1 = Alcoholic content, Y_2 = pH, Y_3 = colour, Y_4 = Flavour, Y_5 = Foam retaintion, Y_6 = Taste and Y_7 = General acceptability, Y_8 = Preference to buy

The processed palm wine bottles were opened and subjected to pH, alcohol content of taste, colour, aroma, and general acceptability and preference to buy. A 5 point hedonic scale was used, (5 = like extremely, 1 = dislike extremely). The semi-trained panel was made up of 15 experienced palm wine drinkers, the samples were served in clear drinking glasses coded randomly, the testing environment was conducive for the test, (Iwe, 2002). Water was provided for removal of aftertaste of previous tasting.

Alcoholic content was determined by measurement of relative density. according to the method adopted by James (1995): pH was determined by dipping the probe of pre-calibrated Orion 520 pH meter into the sample.

Experimental design

Box-Behnken statistical design for the optimization of the sensory attributes and general acceptability and preference to buy and consume the stored palm wine. This screening design was used to optimize main, interactions, and quadratic effect of processing variables, A 3- factor, 3-level (3^3) design was

used to explore quadratic response surfaces and construction of second order polynomial model (Box and Behnken, 1960). The non-linear computer generated (Design Expert, Ver. 7.1.1 Stat-Ease Inc., Miniapolis, MN), quadratic model is given by equation (1):

$$Y_i = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_{11}X_1^2 + b_{22}X_2^2 + b_{33}X_3^2 + b_{12}X_1X_2 + b_{13}X_1X_3 + b_{23}X_2X_3 + e \quad (1)$$

Where Y_i , b_0 , b_1 , b_{ij} , b_{ii} , e is predicted response, overall mean effect of the terms, linear effect, interaction term, quadratic term and random error respectively. Selection of dependent and independent variables is shown in Table 1, the low, middle and high levels were selected from experience, percentage *S. gabonensis* (X_1), pasteurization temperature (X_2), and pasteurization time (X_3) used in the preparation of the 15 formulations and values of responses are also shown in Table 2.

Results and discussion

Model of influence of quantity of *S. gabonensis*, pasteurization temperature and pasteurization time on alcohol content of stored palmwine. The model was marginally significant ($p=0.0602$, $\alpha = 0.05$). *S. gabonensis*, pasteurisation temperature were not significant ($p>0.05$) on alcholic content of the product, but pasteuristion time was ($p<<0.05$). Interaction and quadratic effects were not significant ($p>0.05$). the R^2 value of the model showed 0.8496 with and Adj. R^2 of 0.6241 and a mean value of 11.50%. The response surface surface surface plot of the model Fig. 1 shows high percentage alcoholic content in stored product with less pasteurisation time than highly, while the effect of quantity of *S. gabonensis* did not show stron effect. This result shows that fermentation in pasteurised palmwine with less resident time continued to produce alcohol at the storage condition, this may be attributable to the fact that pasteurisation temperature only attenuates yeast which becomes active again under favourable conditions.

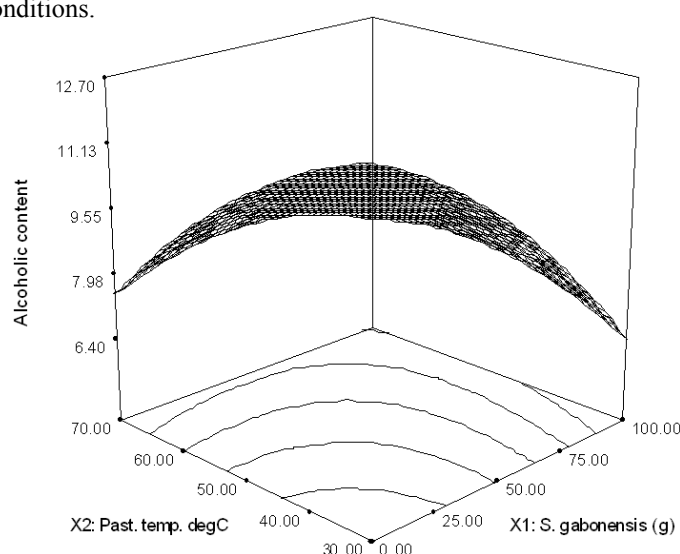


Fig. 1: Response surface plot of the model of *S. gabonensis*, pasteurization temperature, pasteurisation time on alcoholic content of stored palmwine.

Table 3: shows the pH of pasteurized palmwine stored for 10 days storage. The table shows that all independent variables, their interactions and quadratic terms were significant ($p<0.05$) except x_1x_3 , x_1^2 and x_2^2 which showed no and marginal signifcnce ($p= 0.3455$, 0.4916 and 0.1311) respectively.

The R^2 of the model showedd strong value of 0.9387, and an Adj. R^2 pf 0.08469 and a mean vlaue of 5.75. the response surface plot of percentage *S. gabonensis* and pasteurisation temperature on pH Fig. 2 showed that pH peaked at pasteurisation temperature of about 70°C and *S. gabonensis* of about 100% while high acidity was observed at low pasteurisation temperature of 30°C and 25g *S. gabonensis*. This result shows that the effect of pasteurisation temperature and amount of *S. gabonensis* had some influence on the pH of the palmwine. Fermentation was pregressing and conversion of alchol to acetic acid at the low values of the variables. The observation was also confirmed by Fig 3.

Table 3: Analysis of variance and regression table of desirable attributes of palmwine.

	Dependent variables					
	Alcohol content	pH	Colour	Taste	General accept.	Preference to buy
Model	0.0602*	0.005	0.0008	0.0072	0.0895*	0.0004
Independent variable						
X_1 - <i>S. gabonensis</i>	0.3566	0.0092	0.0001	0.2735	0.0513	0.0228
X_2 - Past. temp	0.3454	0.0119	1.0000	0.4590	0.7625	1.0000
X_3 - Past. Time.	0.0024	0.0059	0.1514	0.0012	0.0883	<0.0001
Interaction						
X_1X_2	0.2063	0.1526				
X_1X_3	0.1978	0.3455				
Quadratic effects						
X_{33}^2		0.0016				
Regression parameters						
R^2	0.8496	0.9387	0.7386	0.6204	0.4066	0.7684
Adj. R^2	0.6241	0.8469	0.6733	0.5255	0.2583	0.7105
C.V%	18.20	11.03	19.78	28.44	35.87	0.6800
Mean	11.50	5.75	3.50	3.28	3.19	3.13

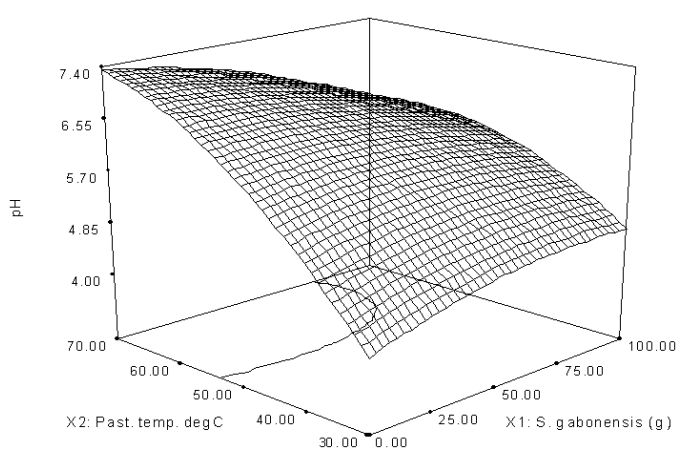
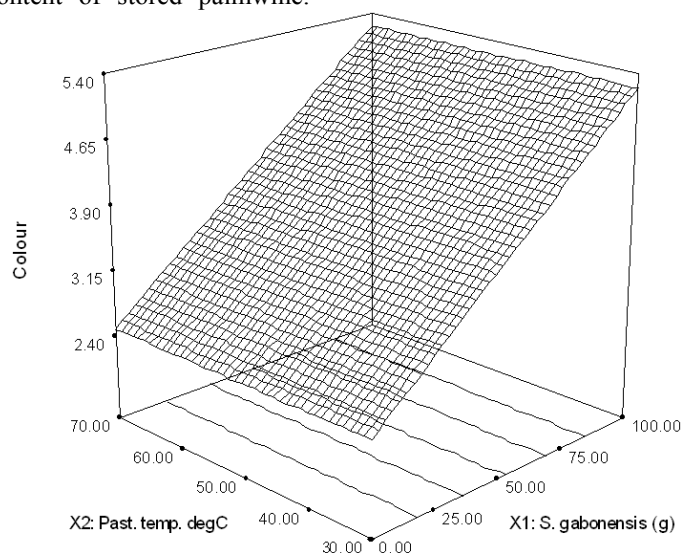
**Fig. 2:** Response surface plot of the model of, pasteurisation time and quantity of *S. gabonensis* on alcoholic content of stored palmwine.**Fig. 3:** Response surface plot of the model of quantity of *S. gabonensis* pasteurisation temperature on colour of palmwine.

Table 4 shows that the model was significant with ($p < 0.05$, $p = 0.0008$) and R^2 of 0.7386 and Adj. R^2 of 0.6733. *S. gabonensis* was significant ($p = 0.0001$) in the model but not pasteurisation temperature ($p = 1.000$). The mean score for colour was at 3.50. The response surface plot

Fig. 4 shows a linear relationship between the quantity of *S. gabonensis* and colour. Pasteurisation temperature showed a near constant effect on colour while pasteurisation temperature and time showed marginal effect ($p=0.1514$). The observation is real because the pink colour of the plant product actually enhances the colour hence it linear relationship with colour.

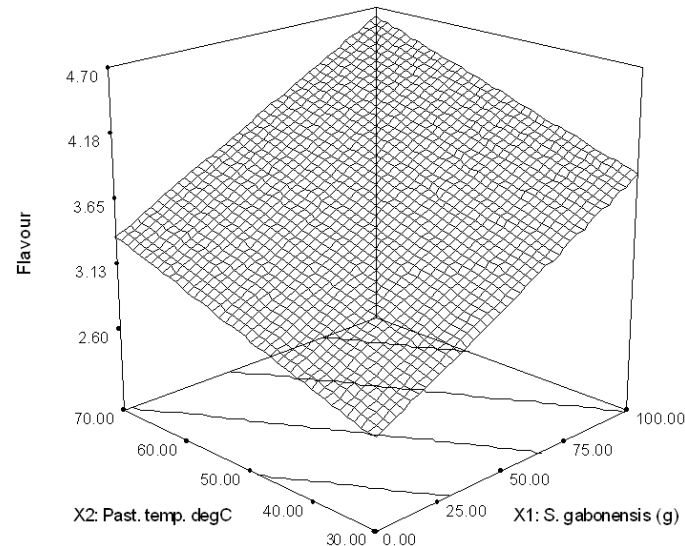


Fig. 4: Response surface plot of the model of quantity of *S. gabonensis* pasteurisation temperature on flavour of palmwine.

Table 5 shows that the model was not significant ($p>0.05$), and a weak R^2 of 0.1597. this values indicate that flavour of fresh raw palmwine is what determines the flavour of its processed version.

Figure 5 shows a nearly flat surface plot to indicate marginal effect of the variables.

The table shows that the model was significant ($p<0.0072$), and R^2 value of 0.6204, the surface plot Fig. 5 shows marginal influence of the variables to the taste of the product, this can be attributale to the strangeness in the cooking flavour in the wine, wine is taken fresh, any processing method that alters the freshness.

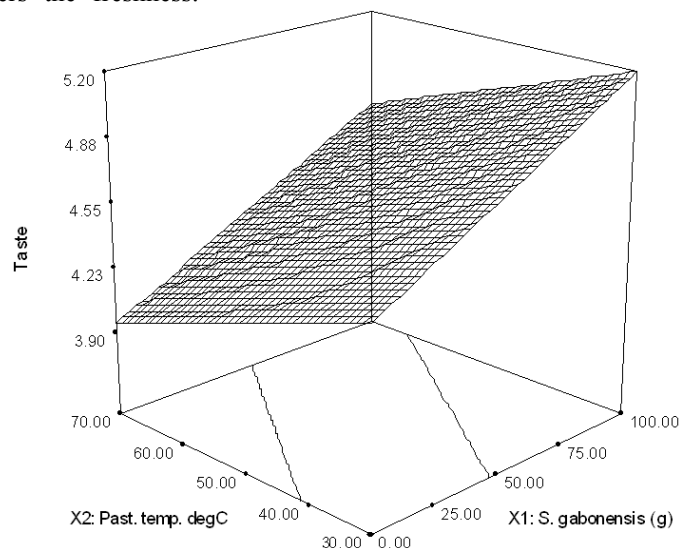


Fig. 5: Response surface plot of the model of quantity of *S. gabonensis* pasteurisation temperature on taste of palmwine.

Acceptability model, Table 8 of the product was marginally significant ($p=0.0895$, $\alpha = 0.05$), *S. gabonensis* and pasteurization temperature were marginally significant ($p=0.0513$ and $p=0.883$) respectively. The R^2 of the model showed a weak power of 0.4066 and adj. R^2 of 0.2583. The response surface plot of effect of *S. gabonensis* and pasteurisation temperature on general acceptability of product showed a linear relationship with *S. gabonensis* with pasteurisation temperature showing almost a constant effect. This observation may be attributed to the brightening colour of the plant product on the palmwine which is independent of the pasteurisation temperature nor time, traditionally, the acceptability of palmwine is influenced by colour before other attributes are considered, hence its adulteration with prohibited artificial colourants by traders.

The model showed in Table 9 showed significance ($p<<0.05$), R^2 value of 0.7684 and a mean responses of 3.13, amount of *S. gabonensis* and pasteurisation time were significant ($p=0.0228$, and <0.0001) respectively, pasteurisation temperature did not show any influence on the parameter. The response surface plot of percentage *S. gabonensis* and pasteurisation temperature Fig. 7 on the parameter show that preference to buy the product had a linear relationship with percentage *S. gabonensis* while effect of pasteurisation temperature tended to remain constant

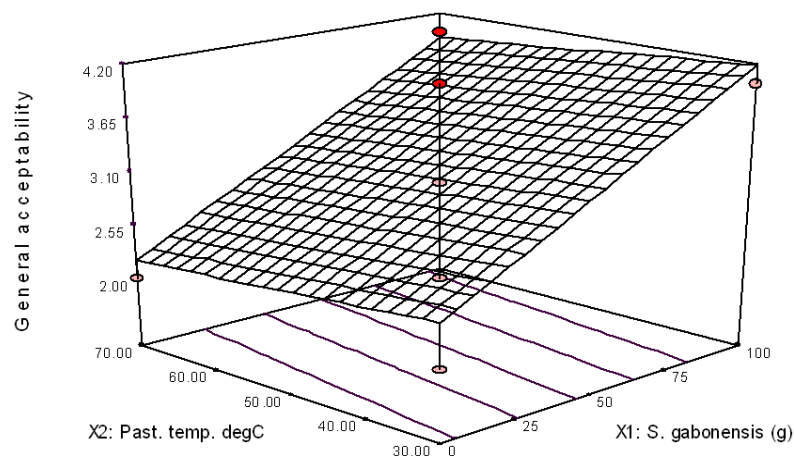


Fig. 6: Response surface plot of the model of quantity of *S. gabonensis* pasteurisation temperature on general acceptability of palmwine.

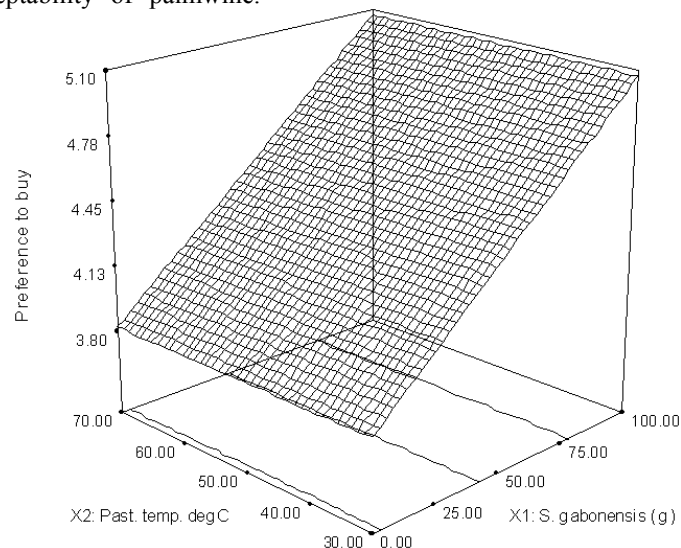


Fig. 7: Response surface plot of the model of quantity of *S. gabonensis* pasteurisation temperature on preference to buy palmwine.

This observation suggested that palmwine can be accepted in the condition provided the colour, and other parameters are acceptable, this why the similarity of the response surface plot between general acceptability and preference to buy.

Conclusion

Palmwine trading is a serious source of adulteration and contamination all in an attempt to maintain sensory and marketing attributes of the product. This is so because it is a living substance, in storage it continues its natural process of fermentation and other biochemical changes, posing a serious economic losses. Optimization result showed that 80.25g/100g, 46°C and 59 minutes of *S. gabonensis*, pasteurization temperature and pasteurization time respectively produced 7.62mi/100ml, 5.69, 4.69, 4.85, 4.46, and 4.82 of alcoholic content, pH, colour, taste, general acceptability and preference respectively at 100% reliability. The result of this work will serve as a benchmark for the production of different levels of attributes for domestic and commercial consumption.

The findings in this study may contribute to the preparation of palmwine with shades of taste to fit the desire of all groups of consumers. It may also create employment and planting of the palmwine.

The models are not final to the production of high quality palmwine but a pointer to the proper method of quality production.

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