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Full Length Research Paper

Studies on wine production from pawpaw (*Carica papaya*)

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Wine was produced from pawpaw (*Carica papaya*) at a ratio of 1:4 for pawpaw must: water in fermentation vessels A to D. Fermentation vessel A pawpaw must contained natural yeast and water; B contained natural yeast from pawpaw and sugar solution; C contained natural yeast, activated baker's yeast and sugar solution; and D (control) contained sugar solution and Baker's yeast. Pawpaw wines produced had average values of 3.84, 29.6, 0.628, 0.9950, 0.464, 1.348, 6.66 and 0.54; 3.76, 29.6, 0.631, 1.0036, 0.623, 1.358, 6.89 and 0.37; 3.86, 29.8, 0.718, 0.9994, 0.419, 1.354, 6.32 and 0.78; and 3.33, 29.6, 0.659, 0.9974, 0.216, 1.351, 6.72 and 0.8 for pH, temperature (°C), optical density (at 560 nm), specific gravity, percentage titratable acidity, percentage alcohol (v/v), total aerobic count (log_{10}cfu/ml) and retardation factor (R_f) (cm). Fermentation was carried out for 144 h, and it was observed that malo-lactic fermentation after 48 h was evident. Testing of the wine's taste showed very little differences in the wines from Recipes A – C, while statistical analyses at 95% confidence level showed no significant differences. The wine from the control had similar taste and characteristics with natural palm wine. Pawpaw wine could thus be produced for immediate consumption, or preserved by refrigeration using Recipes A - C. More research is, however, required to determine the shelf stability of the pawpaw wine.

Key words: Pawpaw, flora, fermentation, sugar, wine, flavor, yeast.

INTRODUCTION

Pawpaw (*Carica papaya*), a flowering plant, belongs to the family Caricaceae, which include about 20-25 species of short- lived evergreen shrubs or small trees growing to 5-10 m tall. Pawpaw originated from Southern Mexico, Central America and South America. It is also cultivated in most countries with topical climate, such as Brazil, India, South Africa, Nigeria, Haiti and South East Asia (Anon, 2010). The ripe fruit is usually eaten raw, without the skin or seed, because of its high sugar content (59%) and thus could be used in wine production as any fruit with a good proportion of sugar may be used (Anon, 2008a).

Wine plays almost an indispensable role in the life of man ranging from social, religious as well as economic benefits. It is an alcoholic beverage typically made from fermented juice of different fruits using yeasts. Wine fermentation may be natural with innate wild yeasts or artificial using grown yeast cultures such as Baker's yeast. Nigeria is not a major producer of wines though some companies have been involved in wine production including the Nigeria Institute For Oil Palm Research (NIFOR), which produces bottled palm wine from sap of oil palm (Okafor, 2007). Wine could be preserved by chemical or physical means. Chemicals used include bisulphites, diethyl pyrocarbonates and sorbic acid while the physical means include pasteurization and sterile filtration (Okafor, 2007). However data from the United States Food and Drug Administration (USFDA) (2009) show that about 1% of the United States population is sensitive to sulphites, particularly those with asthma (Svans, 2008). Thus, these chemicals used in wine preservation could become toxic due to bioaccumulation.

This research was aimed at producing wine from pawpaw for immediate consumption or preservation using refrigeration whenever the need arises.

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Table 1. The compositions of various fermenting vessels.

Vessel	Composition
A	1.5 liters of pawpaw slurry + 6.0litres of water.
B	1.5 liters of pawpaw slurry + 6.0liters of sugar solution.
C	1.5 liters of pawpaw + 6.0 liters of sugar solution + activated baker's yeast.
D(control)	7.5 liters of sugar solution + activated baker's yeast

NB: The water used was boiled and allowed to cool.

MATERIALS AND METHODS

Ripe edible pawpaw fruits were collected directly from various trees within Abraka (Delta State, Nigeria), using a clean/new black-cellophane bag. The bags were tied and fruits kept for 72 h for ripening. Granulated sugar, and Baker's yeast were purchased from Abraka main market, Delta State, Nigeria.

Preparation of sugar solution

Clean water was boiled for five minutes and allowed to cool. One (1) teacup-full of granulated sugar was dissolved in one liter of water to obtain the sugar solution.

Preparation of must juice

This was carried in accordance with the method of Uraih (2003). The compositions of various fermenting vessels are presented in Table 1.

Fermentation of pawpaw juice (must)

This was carried out using a modification of the method of Uraih (2003) using the flowchart in Figure 1.

Determination of pH, Optical density 560 nm, % titratable acidity and % alcohol

These were determined in accordance with the methods of Kunkee and Amerine (2002). Samples were collected after one hour of fermentation and thereafter after every 24 h for 6 days.

Determination of specific gravity (SG)

This was carried out in accordance with the method of Fawole and Oso (2008).

Determination of Retention front (R_f)

This was carried out in accordance with the method of Ogunkoye and Olubayo (1977) at 72 and 144 h of fermentation.

Determination of total aerobic and fungal counts

These were carried out in accordance with the methods of Cowan and Steel (2004) after one hour of fermentation and thereafter after every 24 h for 6 days.

Fungal Isolation and identification

These were carried out in accordance with the methods of Harrigan and McCane, (2001) after 48 h of fermentation.

RESULTS AND DISCUSSION

The changes in pH of pawpaw wine are presented in Figure 2. The pH values decreased to 24 h and remained constant till the end of the fermentation for all the recipes. The low pH values could be due to microbial succession from yeast to lactic acid bacteria resulting in the production of more acids as is evident in the Malo-lactic acid fermentation observed. These results agree with the reports of Anon (2008b) and Okafor (2007).

The changes in temperature of pawpaw wine during fermentation are presented in Figure 3. Temperature of Recipes A and B was constant till 24 h and reduced thereafter to 144 h while Recipes C and D were higher than A and B at 1h but followed the same trend except Recipe C which increased from 72 to 144 h. These temperature changes could be due to microbial metabolism of available nutrients to produce alcohol and other fermentation products with the resultant generation of heat. These results agree with the reports of Robinson (2006) and Okafor (2007).

The changes in optical density of pawpaw wine during fermentation are presented in Figure 4. The values for A increased to 72 h and became constant thereafter; B increased to 72 h and thereafter decreased while C and D, whose values were higher than values for A and B, increased with period of fermentation. These increases could be due to microbial succession from yeast to lactic acid bacteria that metabolized the alcohol produced by the yeast to various end products. These results agree with the reports of Okafor (2007).

The changes in specific gravity of pawpaw wine during fermentation are presented in Figure 5. The values in A decreased to 24 h, increased to 72 h and decreased to 144 h while B – D decreased to 72 h and increased thereafter to 144 h. The values for C and D were higher than for A and B. These changes could be due to changes in microbial type and metabolism of available nutrients – sugar initially and alcohol at the end of 48 h. These results agree with the reports of Uraih (2003),

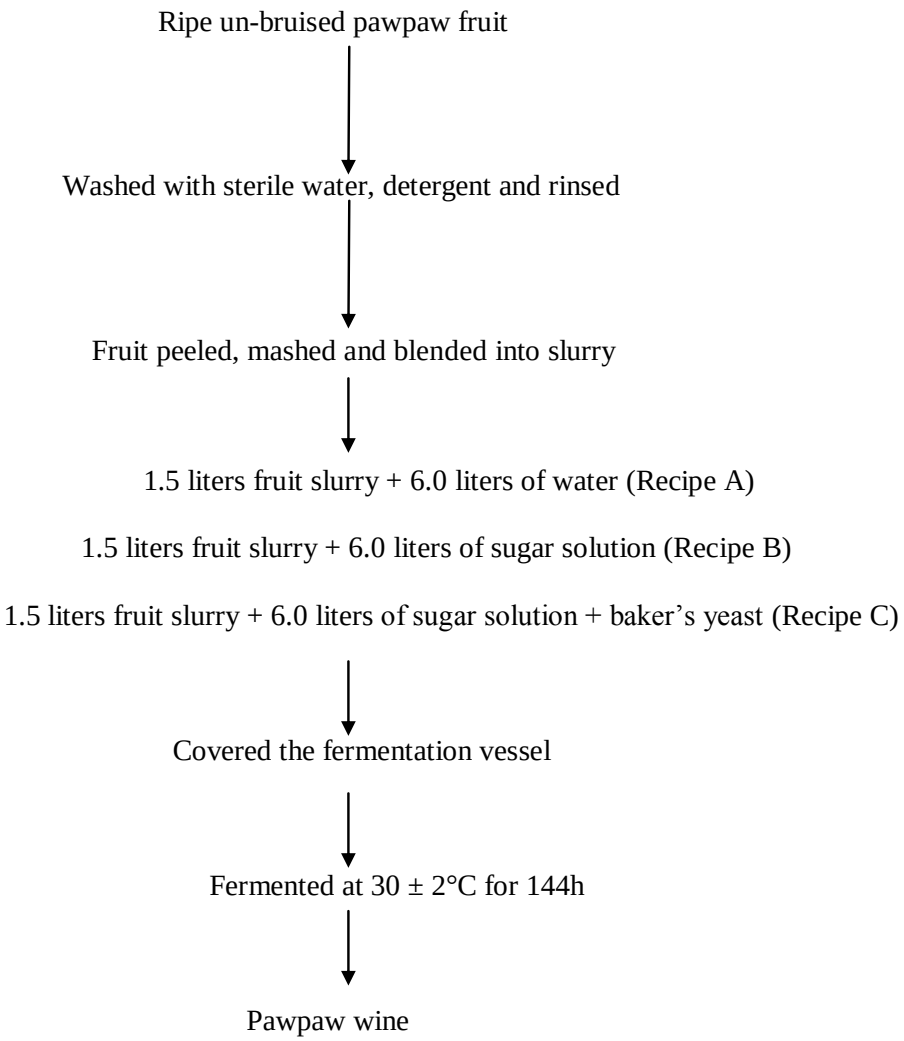

Figure 1. Flow chart for pawpaw wine production.

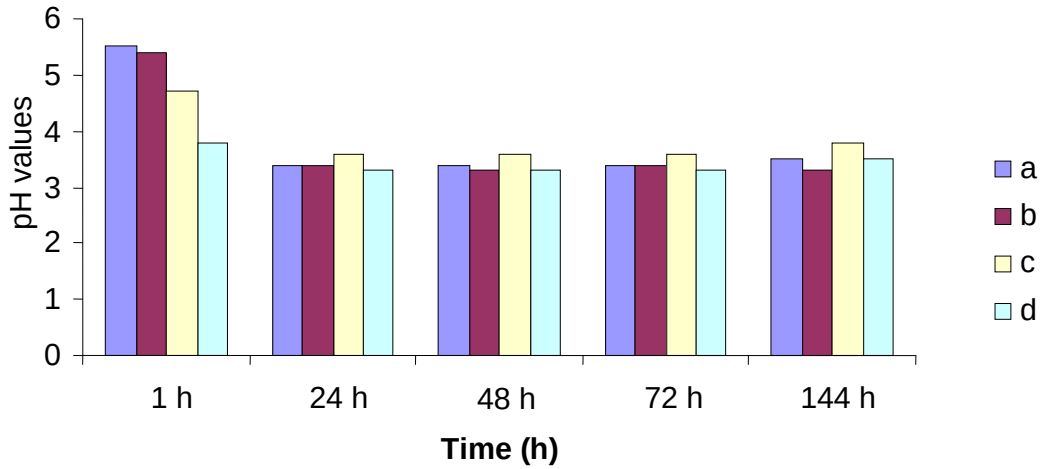

Figure 2. Changes pH of pawpaw wine. Key: a = Natural fermentation (1.5 L fruit slurry + 6 L water; b = 1.5 L fruit slurry + 6 L sugar solution; c = 1.5 L fruit slurry + 6 L sugar solution containing activated Baker's yeast; d = 7.5 L sugar solution containing activated Baker's yeast.

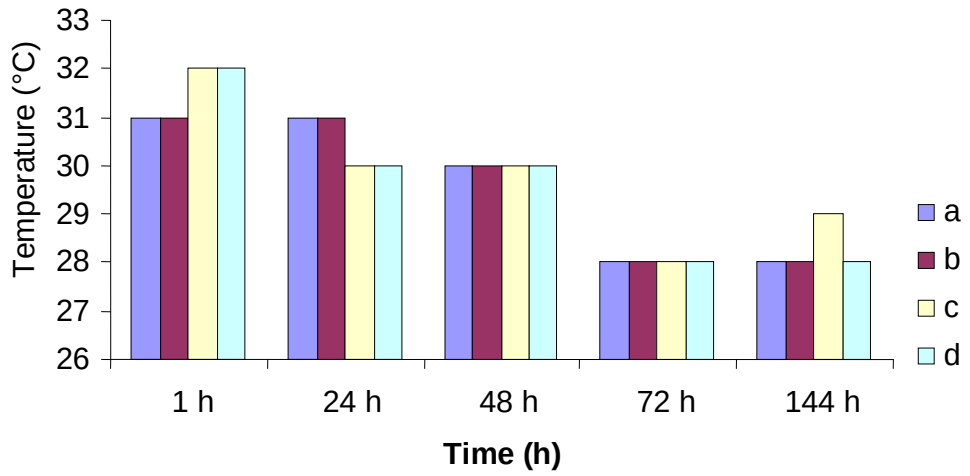

Figure 3. Changes temperature of pawpaw wine.

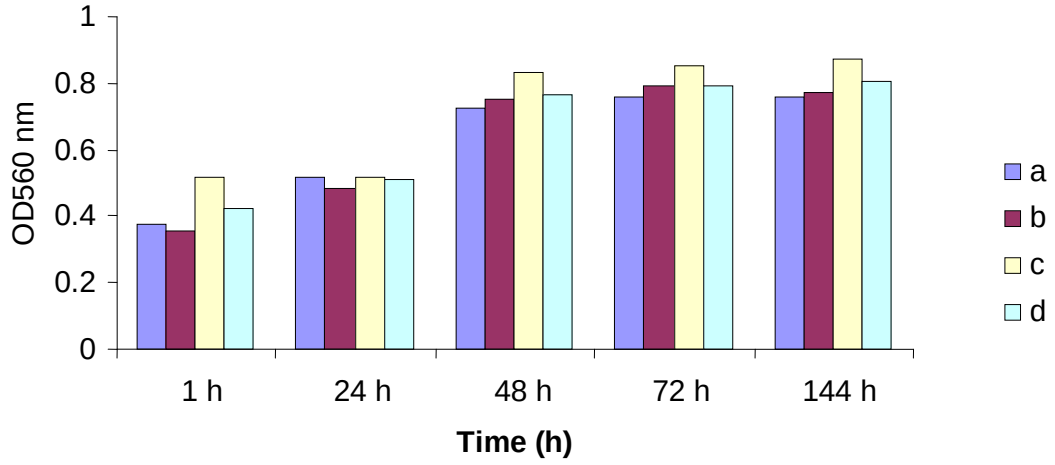

Figure 4. Changes Optical density of pawpaw wine.

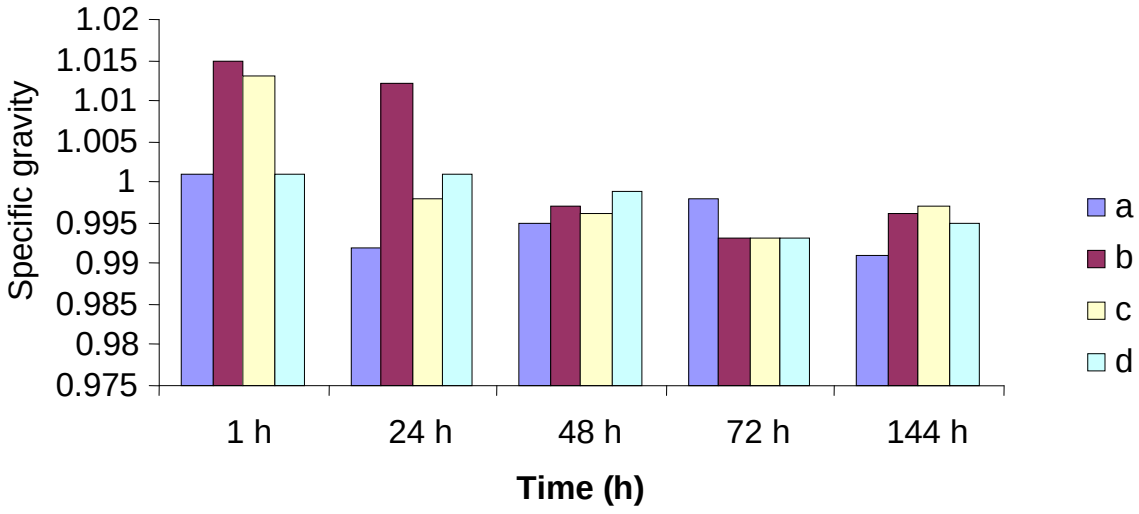

Figure 5. Changes specific gravity of pawpaw wine.

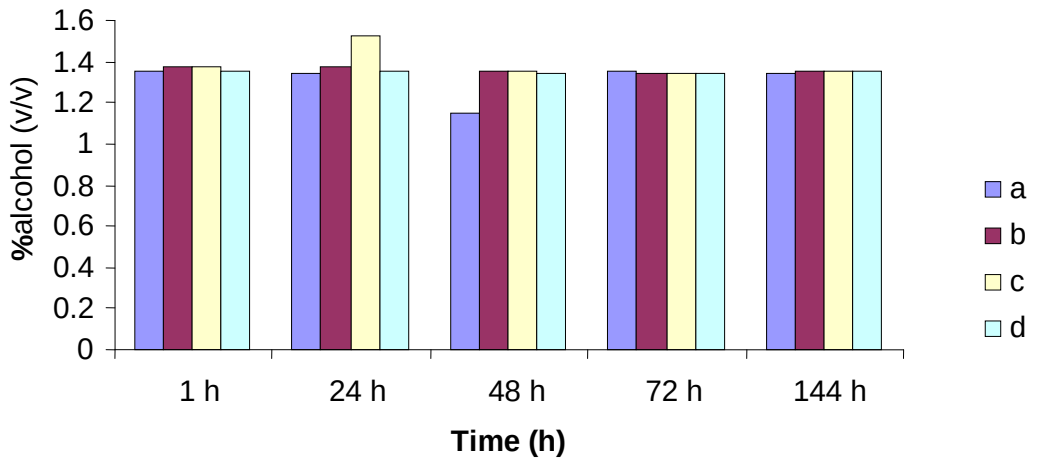

Figure 6. Changes % alcohol of pawpaw wine.

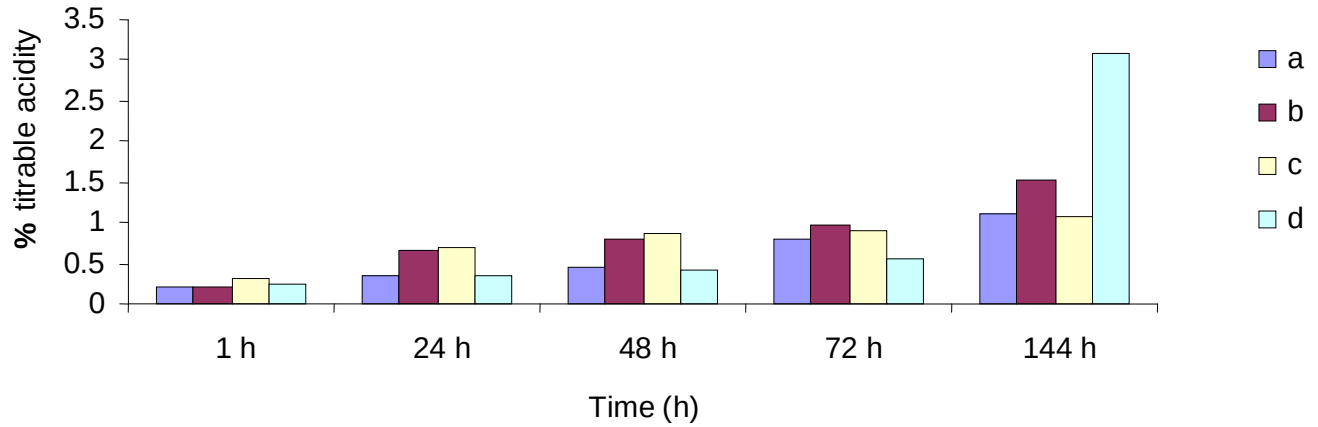

Figure 7. Changes in % titratable acidity of pawpaw wine during production.

Robinson (2006), Okafor (2007) and Riley (2011).The changes in the percentage alcohol of pawpaw wine during fermentation are presented in Figure 6. The values increased slightly till end of fermentation for all the recipes. Increases till 48 h could be due to yeast metabolism of sugars to alcohol while the increase thereafter could be due various alcohols produced by metabolism of lactic acid bacteria and other types of microbes that may be present. These results agree with reports of Robinson (2006) and Okafor (2007).

The changes in the % titratable acidity of pawpaw wine during fermentation are presented in Figure 7. The values increased with period of fermentation for all the Recipes. These could be due to the microbial succession evident after 48 h of fermentation with the concomitant production of intermediate acids from the alcohol initially produced by yeast metabolism. These results agree with reports by previous workers (Uraih, 2003; Robinson, 2006; Okafor, 2007; Riley, 2011). The changes in the total aerobic count of pawpaw wine during fermentation are presented in Figure 8. The values were fairly constant with period of fermentation except for C which decreased to 24 h then increased to 72h and remained almost constant to 144h. These results agree with reports of previous workers (Uraih, 2003; Robinson, 2006; Okafor, 2007; Riley, 2011).

The average values of the tested parameters for fermented pawpaw are presented in Table 2. The values ranged from 3.33 – 3.86, 29.6 – 29.8, 0.628 – 0.718, 0.995 – 1.004, 0.216 – 0.623, 1.348 – 1.358 and 6.32 – 6.89 for pH, temperature, optical density, % titratable acidity, % alcohol and total aerobic counts respectively. The values for C were highest for pH, temperature and optical density while values for B were highest for % TA, % alcohol and total aerobic counts. F-stat of 0.00218 obtained was lower than F-crit of 3.008787 at 95% confidence level. Thus null hypothesis of no significant statistical difference was accepted. These results agree with the reports of Okafor (2007), Anon (2010).

The retardation factor of the fermented pawpaw at

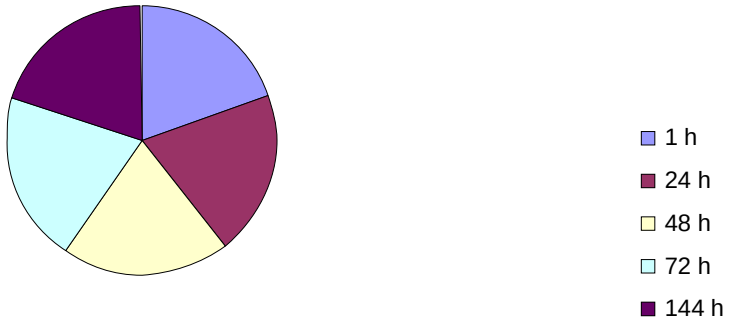

Figure 8. Changes total aerobic counts of pawpaw wine.

Table 2. Average values of fermented pawpaw wine.

Parameter	A	B	C	D
pH	3.84	3.76	3.86	3.33
Temperature (°C)	29.6	29.6	29.8	29.6
Optical density (at 560 mm)	0.628	0.631	0.718	0.659
SG	0.9950	1.004	0.9994	0.9974
% titratable acidity (% v/v)	0.464	0.623	0.419	0.216
% alcohol (% v/v)	1.348	1.358	1.354	1.351
Total aerobic count (CFU/ml) in $\log_{10}$	6.66	6.89	6.32	6.72

F-stat = 0.00218 < F-crit = 3.008787 at 95% confidence level. Thus, null hypothesis was accepted.

Table 3. Values of R_f for Pawpaw wine.

	48 h	144 h
A R_{fx}	1.9 cm	3.0 cm
R_{fy}	0.47	0.75
B R_{fx}	1.5 cm	1.8 cm
R_{fy}	0.37	0.45
C R_{fx}	3.8 cm	2.6 cm
R_{fy}	0.95	0.65
D R_{fx}	3.6 cm	3.2 cm
R_{fy}	0.9	0.8

R_{fx} = Retention front (cm); R_{fy} = Retardation factor; Solvent front = 4.0 cm.F-stat = 0.002322 < F-crit = 4.60011 at 95% confidence level. Thus, null hypothesis was accepted.

48 and 144 h of fermentation are presented in Table 3. It was observed that there was evidence of a Malo-lactic fermentation as the R_f value was within the range for lactic acid. Malo-lactic fermentation imparts desirable flavor often 'buttery' to the wine during maturation. F-stat of 0.002322 obtained was lower than F-crit of 4.60011 at 95% confidence level. Thus null hypothesis of no significant statistical difference was accepted. These results are in agreement with reports of previous studies (Ogunkoye and Olubayo, 1977; Todd, 1999; Anon, 2008b).

The colonial morphology of fungi isolates at 48 h of fermentation indicates that both the natural yeast and Baker's yeast had similar morphological features. It was observed that the yeast possessed the characteristics of *Saccharomyces cerevisiae.* These results agree with the

Table 4. Observed changes during pawpaw wine fermentation.

Parameter		Color	Taste	Others
A	24 h	Pawpaw	Slightly sweet	Foamy with whitish suspension.
	48 h	Pawpaw	Sour	Frosty.
	72 h	Pawpaw	Sour	Flocs.
	144 h	Pawpaw	Sour	Flocs.
B	24 h	Pawpaw	Sweet	Foamy with more whitish suspension than A.
	48 h	Pawpaw	Sour	Frosty.
	72 h	Pawpaw	Sour	Flocs.
	144 h	Pawpaw	Sour	Flocs.
C	24 h	Pawpaw	Sweet	Frosty suspension.
	48 h	Pawpaw	Sour	Sediments.
	72 h	Pawpaw	Sour	Flocs.
	144 h	Pawpaw	Sour	Flocs.
D	24 h	Whitish	Sweet	Highly foamy.
	48 h	Whitish	Sour	Foamy.
	72 h	Whitish	Sour	Flocs.
	144 h	Whitish	Sour	Flocs with clear suspension.

reports of Okafor (2007).

The Observed changes during pawpaw wine fermentation in the pawpaw wines during fermentation are presented in Table 4. The pawpaw wines produced with Recipes A – C decreased in color and taste with period of fermentation and had sediments/ flocculation of yeast cells after 72 h of fermentation but generally did not differ considerably while the wine produced with Recipe D had similar taste, color and frothing characteristics with natural palm wine. These results agree with the reports of previous workers (Robinson, 2006; Anon, 2007, 2008a, b).

Conclusions

Pawpaw wines were produced, for immediate consumption or storage by refrigeration, by fermenting for 72 h using any of the Recipes A – C. A wine with similar taste and characteristics with palm wine was produced by using Recipe D. Malo-lactic fermentation was evident after 48 h of fermentation in all the wines. All the pawpaw wines did not require chemical preservation. There were no statistical differences in tested parameters between the pawpaw wines produced at 95% confidence level. However, more research is still required to determine the shelf stability of these wines. Production of pawpaw wine could be carried out using the flow chart.

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