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Effect of Cassava Varietal Differences and Fermentation Time on the Quality of *Agbelima*

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Abstract

The physico-chemical, functional, and other quality characteristics of some cassava products have been shown to be influenced by the cassava variety used for processing. The effects of varietal differences and fermentation time on the quality of *agbelima* - a fermented cassava product - was investigated with the objective of identifying the best cassava variety and the optimum fermentation time for *agbelima* production. Three improved cassava varieties - TMS 30572, TMS 50395, TMS 4(2)1425 - and two local varieties - *Bosomensia* and *Biafra* - were investigated in fermentation trials with sampling at fermentation times of 0 h, 24 h, 48 h and 72 h. Quality parameters assessed included total titratable acidity, pH, average particle size, and colour characteristics. All the parameters were significantly affected ($p<0.01$) by both varietal differences and fermentation time. The interaction between cassava variety and fermentation time were also highly significant ($p<0.01$) for all the parameters assessed. The overall best quality *agbelima* samples were from TMS 30572 at 72 h, TMS 50395 at 72 h, and TMS 30572 at 48 h fermentation times in descending order of quality. These findings would serve as a useful guide in selecting cassava varieties for processing and in controlling the fermentation time for *agbelima* production; thereby improving the general quality of the product.

Keywords: Cassava fermentation; agbelima; cassava variety; quality characteristics

Introduction

Cassava is grown widely in several parts of South and Central America, Central and West Africa and South East Asia, and it constitutes a significant proportion of the diet of the people in most of these regions (Kochhar, 1981). In Africa, it provides over 50% of the average daily calorific intake in some counties (Oyewole and Odunfa, 1992). Indigenous cassava varieties however tend to have very low yields and are most often highly susceptible to various diseases and pests (Silvestre, 1989). In an attempt to increase yield and resistance to diseases, a

number of regional programmes have been initiated to breed improved varieties of cassava.

These new cassava varieties have however received varying degrees of acceptability because of their differing responses to the traditional processing methods used in processing cassava into different products. Various studies have shown that the physico-chemical, functional and other quality characteristics of *fufu*, *gari,* cassava pellets and composite flours from cassava are significantly affected by varietal differences (Almazan, 1988; Sarfo-Kantanka and Owutu-Nipha 1992; Vitti *el al.*, 1978; Cabrera, 1986). However, Ampe *el al.*, (1994) comparing two cassava varieties showed that varietal difference did not significantly affect *fufu* quality.

Agbelima is a traditional fermented cassava product the production of which involves the use of an inoculum locally called *kudeme* (Sefa-Dedeh, 1989). Considering that attention is gradually being shifted to the improved varieties of cassava, there is the need to investigate the effect these varieties have on product quality in order to establish a basis for selecting varieties for processing. Investigations by Dziedzoave (1996) have shown that colour, cohesiveness, smoothness, aroma and sourness are the five most important sensory quality attributes consumers and producers associate with good quality *Agbelima*; and that average particle size, total acidity together with pH, and "metric chroma" (Minolta Chroma Meter) are the most adequate objective indicators of human evaluation of smoothness, sourness, and colour respectively.

It was the objective of this study therefore to investigate how the differences in five cassava cultivars and three fermentation times affect the smoothness, sourness and colour of *agbelima*. The varieties investigated were TMS 30572, TMS 50395, and TMS 4(2)1425 - all improved varieties; and *Bosome Nsia*, and *Biafra* -local varieties.

Materials and methods

Experimental design

A two-factor completely randomized design with two replications was used in this study. Studies on the colour characteristics, however, involved three replications. The five varieties constituted one factor whilst the fermentation time represented the other factor.

Agbelima preparation

The inoculum was first prepared as follows. Five hundred grams (500 g) of peeled cassava (from each variety of cassava) were cut into chunks and placed in boiling water for 10 min. The partially cooked chunks were removed and wrapped in a wet cheese cloth, and then in a polyethylene sheet, left in a basket at room temperature for four days; after which the resultant *kudeme* was ready for use. Fresh cassava tubers from each variety of cassava were then peeled, washed and grated into a mash. The grated mash from each variety was divided into four 1-kg batches which were inoculated with 30 g of their respective *kudeme*. The inoculated mashes were loaded into polypropylene sacks and left to drain and ferment for 0-3 days, without the application of any external pressure on the sacks. Fermentation was arrested by freezing after 0 h, 24 h, 48 h, and 72 h respectively for each of the four 1-kg batches in each variety.

Total titratable acidity

Total titratable acidity was determined by means of the Ghana Standards Board method for *gari* and cassava chips. Eighteen grams of *agbelima* were made into a slurry in 200 ml of distilled water in a flask. The flask which was loosely stoppered was placed in a water bath at 40°C and shaken for 1 h. The slurry was filtered through a dry filter paper (Whatman No.1). One hundred milliliters (100 ml) of the filtrate was titrated with 0.2 M NaOH using phenolphthalein as indicator. Total titratable acidity was calculated as percent lactic acid.

pH

A slurry of *Agbelima* was made by mixing 5 g of sample with 50 ml of distilled water in a beaker. The beaker was placed in a water bath at 40°C for 1 h with occasional shaking. The pH was then measured with the Corning pH meter (Model 240).

Colour

Sample colour was determined with the Minolta Chroma Meter (Model CR 200, Minolta Camera Co. Ltd.) using the L*C*H° colour system. The meter was calibrated with a white tile (L*=97.63, C*=2.17, H°=1.27).

Average particle size determination

A modification of the method proposed by Henderson and Perry (1979) for dry flours was used. The modification was made to suit the sample under investigation, which was a wet sample. One hundred grams (100g) of *Agbelima* was washed down a set of graded Tyler sieves with 10 litres of water. The aperture sizes of the sieves used were 1.00 mm, 0.50 mm, 0.25 mm and 0.125 mm. Fractions retained on each sieve were oven-dried at 120°C for two hours, cooled and weighed. The dry matter content of the cassava dough was determined and used to estimate the amount of the sample that would otherwise have collected in the pan. The results were used to calculate the fineness modulus from which the average particle size (D) in inches was calculated according to the method of Henderson and Perry (1979).

Statistical analysis

Analysis of variance (ANOVA) was performed on the data to determine significant differences between varieties, fermentation times and interactions between the two. Least significant differences (Lsd) were calculated to locate specific differences. Scoring on a scale of 4 to 1 according to the identified relative importance of colour, texture and sourness respectively was used to identify the cassava varieties and the fermentation times which gave the overall best quality *agbelima* samples.

Results

Parameter	Best variety with corresponding fermentation times*	Other comparable combinations
Total Titratable Acidity	Bosomensia (48 h) TMS 50395 (48 h) TMS 4(2)1425 (48 h)	TMS 30572 (48 h) Bosomensia (24 h)
pH	TMS 50395 (48 h) TMS 30572 (48 h) TMS 4(2)1425 (48 h)	TMS 30572 (72 h) TMS 30572 (24 h) Bosomensia (48 h) TMS 50395 (72 h)
Particle Size	TMS 4(2)1425 (72 h) Bosomensia (72 h) Bosomensia (48 h)	TMS 4(2)1425 (48 h)
Visual Lightness (L)	TMS 4(2)1425 (24 h) Bosomensia (48 h) Bosomensia (24 h)	TMS 4(2)1425 (72 h)
Metric Chroma (C)	Biafra (72 hrs) Biafra (48 hrs) TMS 30572 (72 h)	TMS 30572 (24 h) Biafra (24 h) TMS 30572 (48 h) TMS 50395 (72 h)
Metric Hue (H°)	TMS 30572 (72 h) Bosomensia (72 h) TMS 4(2(1425 (72 h)	Biafra (72 h) TMS 50395 (72 h)

Table1:
Summary of cassava varieties and corresponding fermentation times that give the best *agbelima* samples with respect to each of the parameters assessed

* For each parameter the list is in descending order of quality.

Fig. 1 - 6 show changes in the chemical, textural and colour characteristics with fermentation time for each cassava variety. Table 1 summarizes the cassava variety and fermentation time combinations which gave the best quality *agbelima* with respect to each of the quality characteristics assessed - the basis of selection being specifications proposed by Dziedzoave (1996).

In Table 2 the cassava varieties and the corresponding fermentation times which gave the overall best quality *agbelima* samples are presented. Highly significant differences ($p < 0.01$) were observed for all the varieties as well as the different fermentation times and the interactions between the two factors for each of the parameters assessed.

Table 2 :
Ranking of optimum cassava variety/fermentation time conbinations according to the overall quality of *agbelima* obtained from them

Cassava variety	Corresponding fermentation time (h)	Rank score	Rank order
TMS 30572	72	4	1
TMS 50395	72	4	2
TMS 30572	48	4	3
TMS 30572	24	4	4
Biafra	72	3	5
Biafra	48	3	6
Biafra	24	3	7
Bosomensia	48	3	8
TMS 4(2)1425	48	3	9
Bosomensia	72	2	10
TMS 4(2)1425	72	2	11
TMS 50395	48	1	12

Effect of varietal differences and fermentation time on total titratable acidity and pH

For all the varieties there was a rapid increase in total titratable acidity during the first 24 h of fermentation (Fig. 1). This increase continued during the second day of fermentation but at a slower rate. The third day saw a drop in acidity for all varieties. In all cases the drop in acidity resulted in an acidity level, lower than what was observed at 24 h fermentation. There was significant difference ($p < 0.01$) between the acidity at 0 h, and that at 24 h, 48 h and 72 h fermentation times.

The change in pH with fermentation time, as was to be expected, followed a directly opposite trend to that observed for the total acidity (Fig. 2). Unlike total acidity however, the final pH in comparison to the pH at 24 h did not show the same trend for all the varieties. Analysis of variance showed that *Bosomensia* and *Biafra* had significantly higher pH ($p < 0.01$) than TMS 50395 and TMS 30572. TMS 4(2)1425, even though significantly higher in pH ($p < 0.01$) than *Bosomensia* and TMS 30572, did not show significant difference from *Biafra* and TMS 50395. With respect to fermentation time, pH at 0 h, was significantly higher ($p < 0.01$) than pH at the other fermentation times. The pH at 24 h, 48 h, and 72 h fermentation were not significantly different from each other.

Effect of varietal differences and fermentation time on average particle size

Bosomensia and TMS 4 (2) 1425 showed a significantly lower average particle size ($p<0.01$) compared to *Biafra* and TMS 50395 varieties (Fig. 3). TMS 30572 although significantly different from *Bosomensia* and *Biafra* showed no difference from TMS 4(2)1425 and TMS 50395.

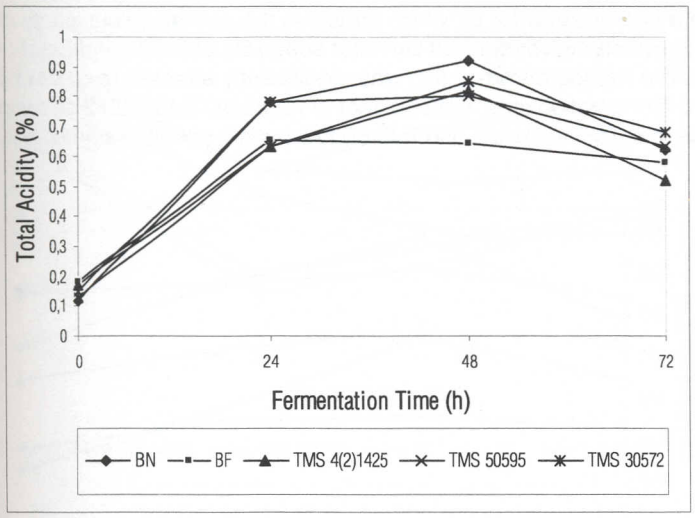


Fig. 1:
Change in total titratable acidity with fermentation time

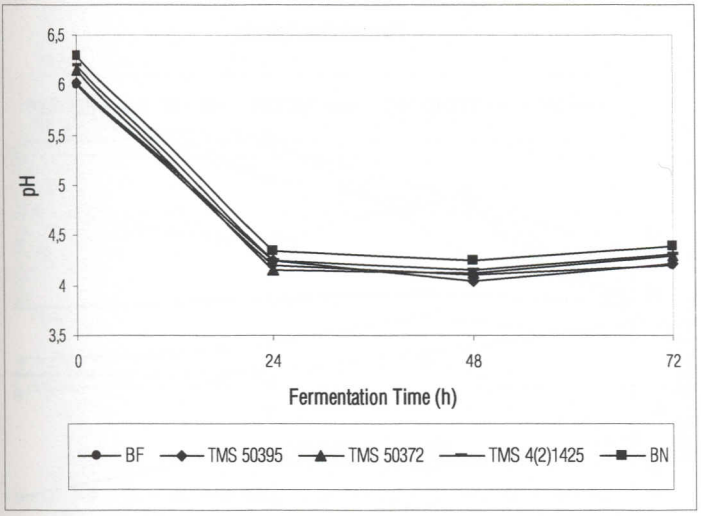


Fig. 2:
Change in pH with time during fermentation

Observed changes in particle size with time (Fig. 3) indicate identical trends for all the varieties. All the five varieties showed significant decrease in their particle sizes after the first day of fermentation. Even though particle size was significantly affected by fermentation time ($p < 0.01$), no difference was observed between the 0 h and 48 h fermented samples. However the 72 h fermented samples differed significantly from the 24 h and 48 h samples.

Effect of varietal differences and fermentation time on colour characteristics

The results indicate that *agbelima* colour is basically a blend of white, yellow and green in decreasing order of intensity. Fig. 4 shows the changes in the visual lightness (L*) of the samples with fermentation time. For all the five varieties the L* values decreased to a minimum after 72 h fermentation. Analysis of variance showed that the five varieties differed significantly ($p<0.01$) from each other in their L* values during the course of fermentation. TMS 50395 exhibited a significantly low L* value throughout the fermentation period. Fermentation time also did significantly affect ($p<0.01$) the L* values of the samples. On the whole the 72 h samples showed a significantly lower L* value.

The variations in "metric chroma" (C*) with fermentation time are shown in Fig. 5. All five cassava varieties exhibited a similar trend for C* which indicates the overall colour purity of the product. The C* colour parameter is considered the most adequate objective indicator of human evaluation of colour. The "metric chroma" (C*) was significantly affected ($p<0.01$) by both varietal differences and fermentation time. With respect to varieties, TMS 30572 showed a significantly higher C* value than TMS 4(2)1425 and TMS 50395; but did not differ significantly from the two local varieties.

Fig. 3:
Change in average particle size with time during fermentation

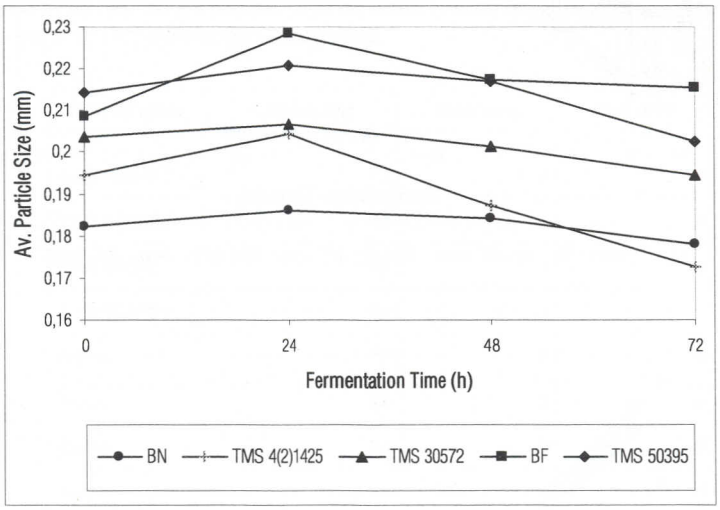
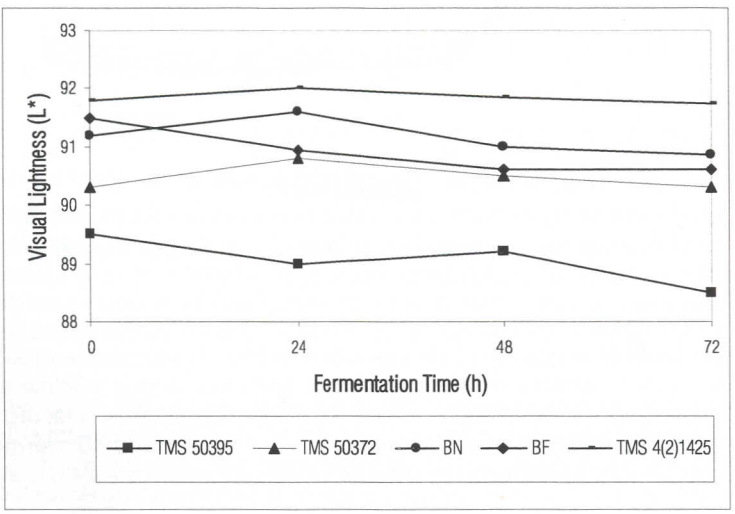


Fig 4:
Change in visual lightness (L*) with time during fermentation



"Metric hue values" (H°), showed the same trend for all the cassava varieties - decreasing throughout the fermentation period to a minimum after 72 h (Fig. 6) - except for *Bosomensia*. The *Bosomensia* variety showed an increase in "metric hue angle" during the second day of fermentation but this was followed by a rapid decrease to a minimum at the end of the 72 h. fermentation time. The *Bosomensia* variety differed significantly from all the other four varieties. Even though at 24 h fermentation the H° was not significantly different from that of the unfermented dough, the 48 h and 72 h fermented products differed significantly from each other and from the 0 h fermented samples.

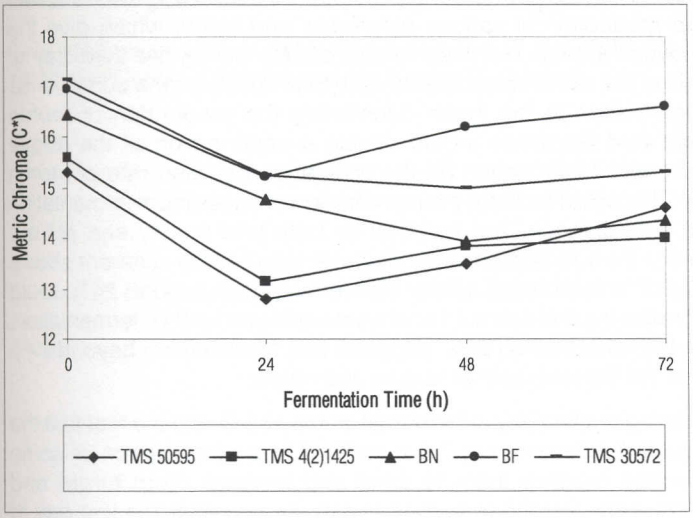


Fig. 5:
Change in metric chroma (C*) with time during fermentation

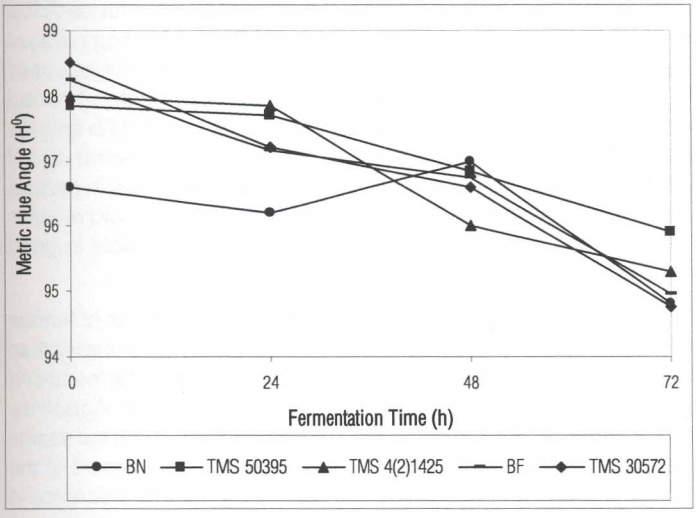


Fig. 6:
Change in metric hue angle (H) with time during fermentation

The summary presented in Table 1 indicates that whereas the *Biafra* variety and TMS 30572 seem to be good for producing *Agbelima* with a bright colour (C*), TMS 30572 and TMS 50395 appear to produce *Agbelima* with a relatively high acidity; whilst TMS 4(2)1425 and *Bosomensia* produce *Agbelima* with the best texture. Ranking the different *Agbelima* samples according to the relative importance of identified sensory quality attributes and the corresponding objective indicators of human evaluation (Table 2), the cassava varieties and the fermentation times which gave the overall best quality *Agbelima* were TMS 30572 at 72 h fermentation, TMS 4(2)1425 at 48 h fermentation, TMS 30572 at 48 h, TMS 4(2)1425 at 72 h fermentation time respectively in descending order of quality.

Discussion

The trends observed for the changes in pH and total titratable acidity with time, for all the varieties, are in consonance with observations made by Collard and Levi (1959) and Akinrele (1964), that cassava fermentation proceeds with the production of a variety of organic acids

leading to an increase in total acidity; and that during the course of fermentation some of these acids are used for the production of various aldehydes and esters which give the fermenting mash its characteristic aroma. The drop in total acidity during the third day of fermentation may be the result of the use of the acids formed, to produce aroma compounds thereby reducing their concentration in the mash. Monitoring the production of aroma compounds concurrently with acid depletion, would enable a confirmation of the above observation; and also provide useful information on the correlation between rate of aroma production and acid depletion. This would facilitate the identification of an optimum fermentation time for the best aroma and acid balance. The fact that for both total acidity and pH the observed changes after the first 24 h of fermentation were not significantly different shows that if the purpose of fermentation is to increase acidity then fermentation beyond 24 h would not be necessary. However considering that optimum acidity was achieved at 24 h fermentation, but texture was at its worst at this fermentation time, suggests that fermentation beyond 24 h is a necessary requirement for the improvement of texture and colour.

The increase in particle size during the first day of fermentation may be due to the fact that the large volume of exudate around the tissues may have resulted in a reabsorption of some water by the intact cells thereby causing them to swell and become more turgid and consequently increasing in size. However the reduction in particle size after the first day of fermentation could be attributable to the activity of tissue degrading enzymes in the fermenting mash. Some enzymes identified to be associated with the fermentation of cassava are amylases, pectin methyl esterase and cellulase (Oyewole and Odunfa, 1992). Studies by Amoa-Awua and Jakobsen (1995) have shown that the microflora of the inocula used for fermenting cassava into *agbelima* are dominated by *Bacillus spp.* which through the activities of their cellulase enzymes cause a breakdown of the texture of cassava dough during fermentation. The fact that the 72-h fermented samples had significantly lower particle sizes than both 24-h and 48-h fermented samples indicate that fermentation must necessarily be carried beyond 48 h if any significant improvement in smoothness is to be achieved. The overall decrease in particle size for all five varieties is of significant importance because such a decrease would result in an increased smoothness of the product - an effect confirmed to be very desirable in good quality *agbelima* (Dziedzoave, 1996).

Considering that the C* colour parameter is the most adequate objective indicator of human evaluation of colour, changes observed in C* must be considered more critical to quality than the changes in the L* and H°. The increase in metric chroma after the first day of fermentation indicates a brightening of the colour of the product, which is very desirable in *Agbelima*. Interestingly however the final C* values at 72 h fermentation were lower than the initial values at 0 h, meaning that the fermentation did not really result in any overall improvement in the brightness of the colour. The general decrease in metric hue indicates an overall decrease in the yellow-green colour of the product. This trend could be due to the isomerization of carotenoids at the onset of acid formation during the course of fermentation. Adewusi and Bradbury (1992) reported the identification of *b*-carotene, lutein, and other carotenoids in the tubers of some cassava cultivars. These are likely to be responsible for the colour of cassava. According to Eskin (1990), acids catalyze isomerization of carotenoids from the all-trans form to the corresponding cis-isomer. The change in shape associated with the cis-isomer reduces the resonance in the molecule as well as the colour intensity. The increase in acidity with fermentation time could therefore have caused increased isomerization of the carotenoids present, resulting in the observed reduction in the colour hue. The overall reduction in H° is a desirable effect, because in the production of *agbelima* the objective of adding *Kudeme* is to improve the whiteness and smoothness of the product (Budu, 1990; Sefa-Dedeh 1989); and a reduction in color hue would indirectly improve whiteness.

The major conclusions from this study are that cassava variety and fermentation time do significantly affect the quality of *Agbelima*; and the overall best performing cassava varieties are TMS 30572 at 72 h, TMS 50395 at 72 h, and TMS 30572 at 48 h fermentation time, respectively.

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