STUDIES ON MINIMIZING THE CAKING PHENOMENON IN *TATALE* MIX, A PLANTAIN PRODUCT.

BY

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SUMMARY

Studies were conducted on dehydrated tatale mix (a plantain product) to minimise caking phenomenon. The right level of ripeness of plantain samples for making tatale mix, the comparison of two methods for making the tatale mix as well as the use of anticaking agents for prevention of caking were studied. The moisture content, colour and caking behaviour of all the tatale mix samples were also determined fortnightly over the period. Calcium stearate and four starches (wheat, maize, potato, rice) were used as anticaking agents. The tatale mix samples were kept on the laboratory bench under room temperature conditions (29 $\pm$ 1°C and 75 $\pm$ 3% RH) as well as in the refrigerator over eight months period. The right level of ripeness was found to be 60 hours after hard ripe plantain. The method of drying cylindrically sliced ripe plantain followed by milling to obtain the dehydrated tatale mix did not work because of difficulty in milling out. There was significant gain in moisture (between 1.0% and 10.6%) by all samples kept on the laboratory bench at the end of the eight months period leading to non-enzymatic browning whilst there was no browning in all samples kept in the refrigerator. Also, there was no caking in all samples kept in the refrigerator over the eight months period. However, there was caking of between 0.5% and 6.8% in all samples kept on the laboratory bench over the eight months period.

1. INTRODUCTION:

Tatale is the Ghanaian name for a pancake made from soft ripe fruit of the plantain plant (*Musa paradisiaca*) and fermented wholemeal dough of maize (*Zea mays*). It is mostly seasoned with ginger, pepper, onion and salt. The paste formed from the ingredients above is fried in oil into tatale or *kaklo* (when the paste is made thicker) that may be served alone or with beans as a main meal, snack or desert.

Though tatale and kaklo are delicious, nutritious and highly acceptable, their preparation is cumbersome involving peeling, pounding, grinding, mixing, fermentation and frying (Dei-Tutu, 1975). A dehydrated convenience food, tatale mix, was developed by Dei-Tutu (1975) to remove most of the laborious aspects of tatale making and to indirectly preserve ripe plantain whose storage has been a problem in Ghana. One major problem that hindered the success of this goal was the caking of the dehydrated mix during the storage period due to its high hygroscopicity.

For high acceptability at the consumer level and proper handling in manufacturing operations, food powders must have good flow characteristics (Peleg *et al,* 1977). Many food powders however may undergo physical changes during their storage and handling that result in the loss of flowability and the formation of agglomerates. Though the physical mechanisms that may be involved are of diverse nature, the phenomenon as a whole is normally referred to as a caking problem (Cal-Vidal *et al*). High water sorption potential is a dominant factor for caking to occur (Cal-Vidal *et al*). Thus for a given type of food powder, an environment with high relative humidity may favour a high rate of adsorption and caking conditions afterwards. In the specific case of fruit and vegetable powders containing soluble components such as sugars, the adsorbed water may provoke their dissolution and the formation of liquid bridges after a subsequent dehydration, which results in caking. High temperatures may also favour the plasticity of sugar and fatty components with the formation of solid bridges following cooling. Caking tendency increases with temperature in the range of 15-35^{o}C (Notre *et al*, 1959).

The most successful method for caking inhibition in hygroscopic food powders is drying the powder to low moisture content (below 3%) followed by storage in a proper water impermeable package. Additional means like vacuum packaging, in package desiccation

(IPD) and refrigerated storage are also effective though in many cases their application is avoided for economic reasons (Peleg *et al,* 1977).

An economically feasible method for improving the situation is the application of flow conditioners also called anticaking agents. The use of anticaking agents has been investigated in several foods. These substances, effective at concentrations of 2% or lower, have several modes of action to prevent loss of flowability or caking of powders (Peleg *et al,* 1977). In general, if the conditioner is to be effective, its particle must adhere to the host powder particles, thus affecting their surface properties. The main food grade groups of these anticaking agents are silicates, stearic acid salts, phosphates and starches (Fennema, 1996).

Ripe plantain puree was mixed with fermented corn dough powder in formulating the tatale mix by Dei-Tutu (1975). The puree mix took comparatively long time before drying in the oven. This was due to the fact that the puree mix was forming thick and hard lumps that could not allow easy loss of moisture.

The overall objective of this work was therefore to minimise the caking behaviour that was encountered by Dei Tutu in his work. The following were the specific objectives;

1. To determine the right level of ripeness of plantain for dehydrated tatale mix making.
2. To compare a new method of dehydrated tatale mix production to that by Dei Tutu.
3. To investigate the effect of different anticaking agents (calcium stearate, wheat starch, potato starch, maize starch, rice starch) on the processing and shelf life of the tatale mix.

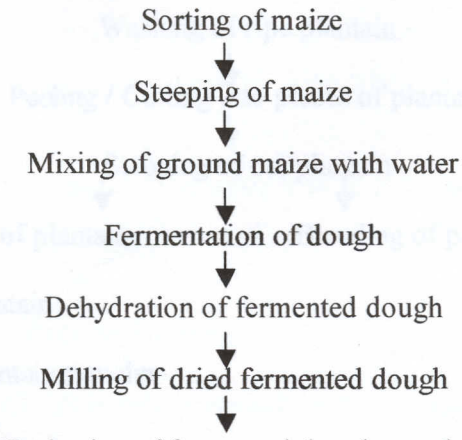
2.0 MATERIALS AND METHODS

Matured green plantain (Apentu variety) was bought at the Agbogbloshie market (Accra) for the studies. Maize was also obtained from the same source.

2.1 Preparation of fermented maize meal.

The maize bought was first sorted to remove mouldy grains, broken cobs and any other foreign matter. The good-looking grains was properly washed under clean running tap water and steeped for sixteen (16) hours. The grains were then removed from the water and milled. Reasonable amount of clean water was then added to the powder and mixed to form dough. The dough was left to ferment for additional 12 hours. It was spread thinly on stainless steel trays after fermentation and dried in the apex dryer at 50°C for 4 hours. The dried dough was milled into powder and packaged in rubber bags. The fermented meal was subsequently added to ripe plantain pulp to form the tatale mix

Flow diagram for production of fermented maize powder.



2.2 Determination of right level of ripeness of plantain for making tatale mix.

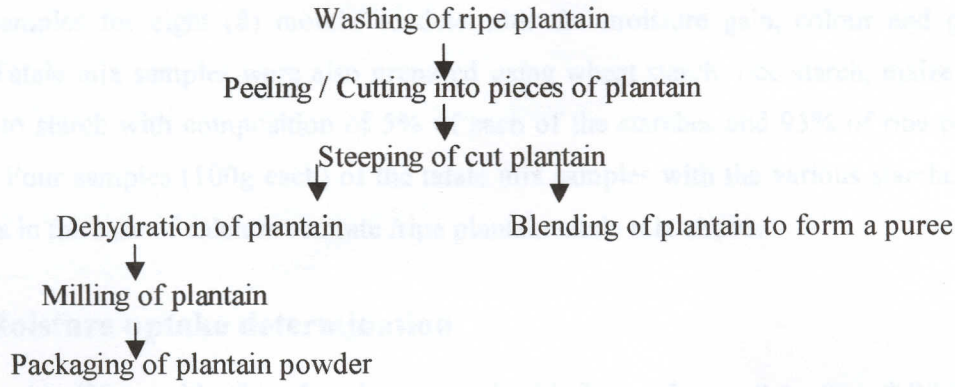
Plantain, which was bought at the mature green stage was allowed to ripe. Uniformly ripened plantain in the firm ripe state was processed in twelve-hour intervals (12,24,36,48,60,72, 84) to determine the right level of ripeness for tatale mix making. Twenty-five fingers of plantain were peeled and cut into pieces at each stage of ripeness. The pieces were immediately steeped in a 0.3% solution of sodium metabisulphate for 3min, drained and pulped into a

puree in a pulping machine. Fermented maize meal was then added to the pulped ripe plantain in the ratio of 1:20 respectively. This was then thoroughly mixed and spread thinly on stainless steel trays for drying. The dried mix was milled into powder, reconstituted with water in the ratio 2:3 respectively. The mixture was beaten well for twenty minutes and fried in palm oil. The tatale samples were then tasted by a panel of five and results compared to samples made from the traditional method.

2.3 Preparation of tatale mix.

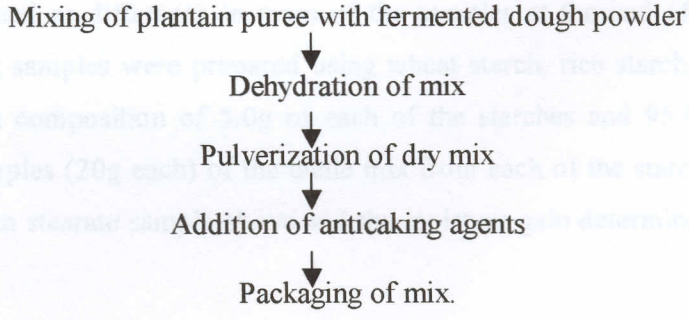
The green plantain was left to ripe for 60 hours after firm ripeness. It was then washed under running tap water and peeled. The peeled plantain was then cut into small cylindrical bits and steeped in 0.3% metabisulphite for 3 minutes. It was then removed, drained and one part pulped in a pulping machine. Fermented maize meal was then added to the pulped ripe plantain in the ratio of 1:20 respectively. This was then thoroughly mixed and spread thinly on stainless steel trays for drying. The other part was dried without pulping in the apex dryer.

Flow diagram for production of plantain puree / powder.



Flow diagram for production of tatale mix.

Method 1.



Method 2.

Mixing of plantain powder with fermented dough powder

↓

Addition of anticaking agents

↓

Packaging of mix.

2.4 Drying and milling of tatale mix.

The thinly spread tatale mix was placed in the Apex dryer and dried at 60°C for 4 hours after which it was removed, turned over and placed in the dryer for another 4 hours at 50°C. The sample was then removed into plastic containers and quickly placed in the dessicator to cool down. The cooled sample was then milled and packaged in polythene bags.

2.5 Shelf life studies

Four samples (100g each) of tatale mix, composed of 2% calcium stearate and 98% ripe plantain powder were prepared and packaged in polythene pouches. Two of the samples were stored on the shelf in the laboratory under room temperature conditions (29 $\pm$ 1 °C and 75 $\pm$ 3 % RH). The two other samples were kept in the refrigerator. Monthly tests were conducted on the samples for eight (8) months to determine the moisture gain, colour and percent caking. Tatale mix samples were also prepared using wheat starch, rice starch, maize starch and potato starch with composition of 5% of each of the starches and 95% of ripe plantain powder. Four samples (100g each) of the tatale mix samples with the various starches were treated as in the case of calcium stearate /ripe plantain tatale mix above.

2.5.1 Moisture uptake determination

Two samples (20g each) of tatale mix prepared with 2.0g calcium stearate and 98.0g ripe plantain powder was packaged into 4cm square polythene pouches. The samples were placed on the shelf in the laboratory under room temperature conditions (29 $\pm$ 1 °C and 75 $\pm$ 3 % RH). The mass of the samples were determined weekly for eight (8) months. The moisture gain was determined as difference in mass of the samples at the end of every two weeks. Similar tatale mix samples were prepared using wheat starch, rice starch, potato starch and maize starch with composition of 5.0g of each of the starches and 95.0g of ripe plantain powder. Two samples (20g each) of the tatale mix from each of the starch was treated as in the case of calcium stearate sample above and the moisture gain determined weekly for eight (8) months.

2.5.2 Colour measurements

The colour of each of the tatale mix samples with various antcaking agents was determined using the Minolta Chromameter CR310. The powdered samples were placed in a cylindrical container with depth of 2cm. The measurement was taken with the measuring head centrally placed on the cylindrical container. The CIELAB colour parameter L*, a* and b* were determined. The reading was taken in triplicates for each sample with thorough mixing of the samples after each reading. The mean of the three readings was then noted. The hue angles, h*, representing the degree of yellowness was calculated using the equation $h^* = \tan^{-1} (b^*/ a^*)$ (MacDougall, 1988). This was repeated at monthly intervals for eight (8) months.

2.5.3 Percentage caking measurement

The tatale mix samples prepared with the anticaking agents for shelf life studies were sieved through a sieve of mesh size 6 (Newark Wire Cloth Company, New York) after first day of preparation. The mass of the samples that went through the sieve were recorded as 0% caking behaviour. These samples were packaged into polythene bags and stored in the refrigerator and on the laboratory bench for shelf life studies. Sieving of the samples was repeated at monthly intervals and the percentage caking behaviour was recorded using the formula below:

Mass of sample that went through sieve = X

Mass of sample that was retained by sieve = Y

$$\text{Percentage caking} = \frac{Y * 100}{X + Y}$$

3.0 RESULTS AND DISCUSSION

3.1 Right level of ripeness of plantain for making tatale mix.

Comparing the different levels of ripeness of plantain used in making tatale to the tatale made from the traditional method, it was observed that the texture, appearance and mouth feel of plantain held for 60hours after firm ripe plantain had the best characteristics. The tatale made from plantains held between firm ripe stage and 60hours were very hard on feeling though they dried and milled out easily. Tatale made from plantain samples that were held more than 60hours after firm ripe had problem with drying out and milling. The samples that milled out were even difficult to reconstitute but once well mixed, they fried out with characteristics similar to those made traditionally. This conforms to the finding of Dei Tutu (1975).

3.2 Different methods of making tatale mix.

The method by which the pieces of plantain are dried before milling into dehydrated tatale mix did not work out. This was due to shrinking of the ripe plantain samples and poor moisture loss with time of drying which did not allow for easy milling into powder. However, the method of pulping the ripe plantain and mixing with fermented maize flour followed by drying and milling out worked perfectly. This method was therefore used for tatale mix making for the rest of the studies.

3.3 Moisture uptake

Fig 1 gives the trend of moisture gain by tatale mix samples over the eight months period. It was observed that there was an increase in uptake of moisture with time by all tatale mix samples kept on the laboratory bench. Fig. 2 shows the percent moisture gain by the tatale mix samples at the end of the eight (8) months period of studies. The percent moisture gain by the tatale mix samples at the end of the eighth month ranged from 1.0 to 10.6 with the lowest being the potato starch sample and the highest being the wheat starch sample.

3.4 The degree of yellowness

Fig 3. shows the degree of yellowness of tatale mix samples stored on the laboratory bench and in the refrigerator over eight months period. It was observed that the tatale mix samples stored on the laboratory bench became less yellow, more red and slightly darker than the freshly prepared samples as well as those stored in the refrigerator as storage progressed.

There was 4.0% to 11.8% decline in degree of yellowness of the samples stored on the laboratory bench at the end of the eight months period. The change in colour is most probably due to non-enzymatic browning. Non-enzymatic browning in dehydrated foods is caused mainly by Maillard reaction, which is a series of condensation reactions involving reducing sugars and amino group (O'Brien & Morrisey, 1989). The moisture level of the samples most probably influenced the observed trend because the rate of moisture gain by the dehydrated tatale mix followed the same trend (Fig 1). Thus the rates of moisture gain and the extent of non-enzymatic browning are directly correlated.

3.5 Caking behaviour

Fig. 4 shows the level of caking in dehydrated tatale mix samples kept on the laboratory bench over eight months period. It was observed that there was caking behaviour of between 0.5% and 6.8% in the samples at the end of the eighth month. The tatale mix sample with no anticaking agent had significantly higher level of caking compared to tatale mix samples with calcium stearate and starches as anticaking agents. It can therefore be said that the starches as well as the calcium stearate prevented some caking in the samples. Comparing the caking behaviour in the four starches used, it was observed that the potato starch sample had the least caking behaviour and the wheat starch sample had the most caking behaviour. It can therefore be said that potato starch is a better anticaking agent than rice, maize and wheat starches.

Comparing all samples with anticaking agents, it was observed that the sample with calcium stearate had the least caking behaviour and that of wheat starch had the highest caking behaviour. Since the sample with the calcium stearate had only 2% of calcium stearate and all starch samples had 5% starch as anticaking agent, it can be said that Calcium Stearate is a better anticaking agent compared to the starches. However, the use of calcium stearate can be avoided for the economic reasons as well as consumers' perception about food additives.

It was observed that all the tatale mix samples kept in the refrigerator had 0% caking behaviour throughout the eight (8) months period of storage. Since the temperature in the refrigerator was low (4°C), it can be said that the relatively high temperature in the laboratory contributed so much for the caking in the samples kept on the laboratory bench (Peleg et al, 1977).

Fig 1. Moisture uptake by tatale mix samples

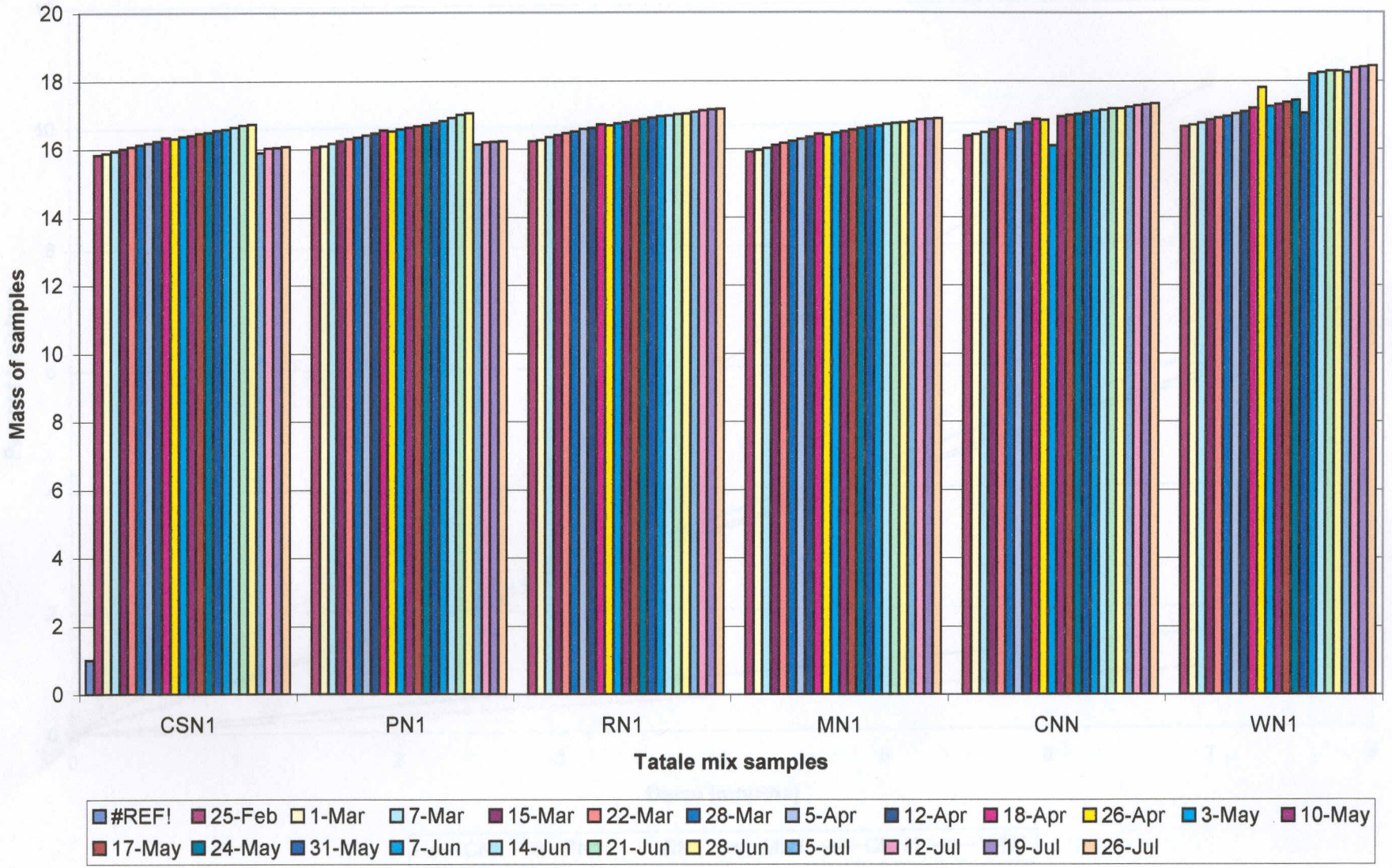


Fig 2. Percentage moisture gain by tatale mix samples

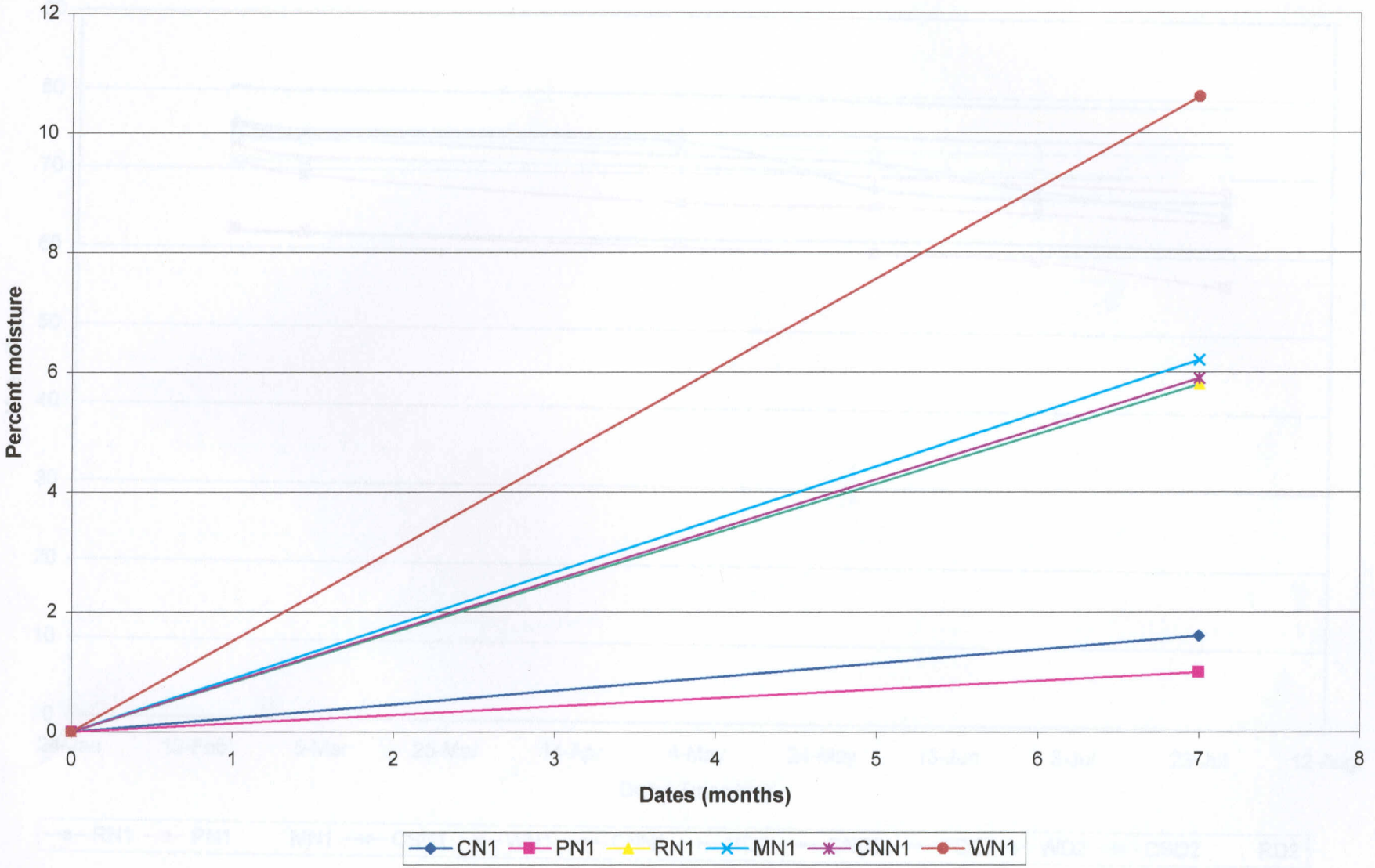


Fig 3. Degree of yellowness in tatale mix samples

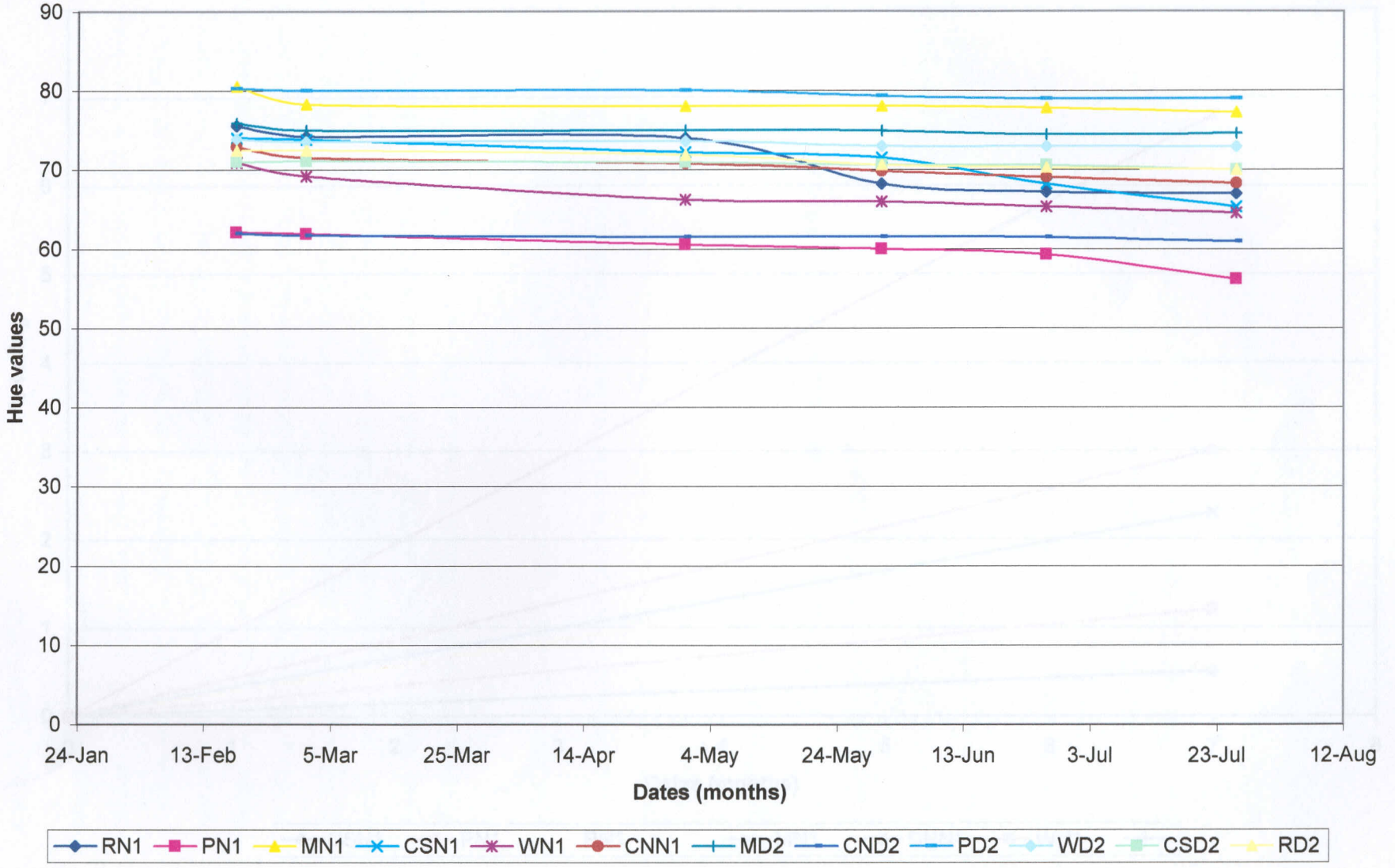
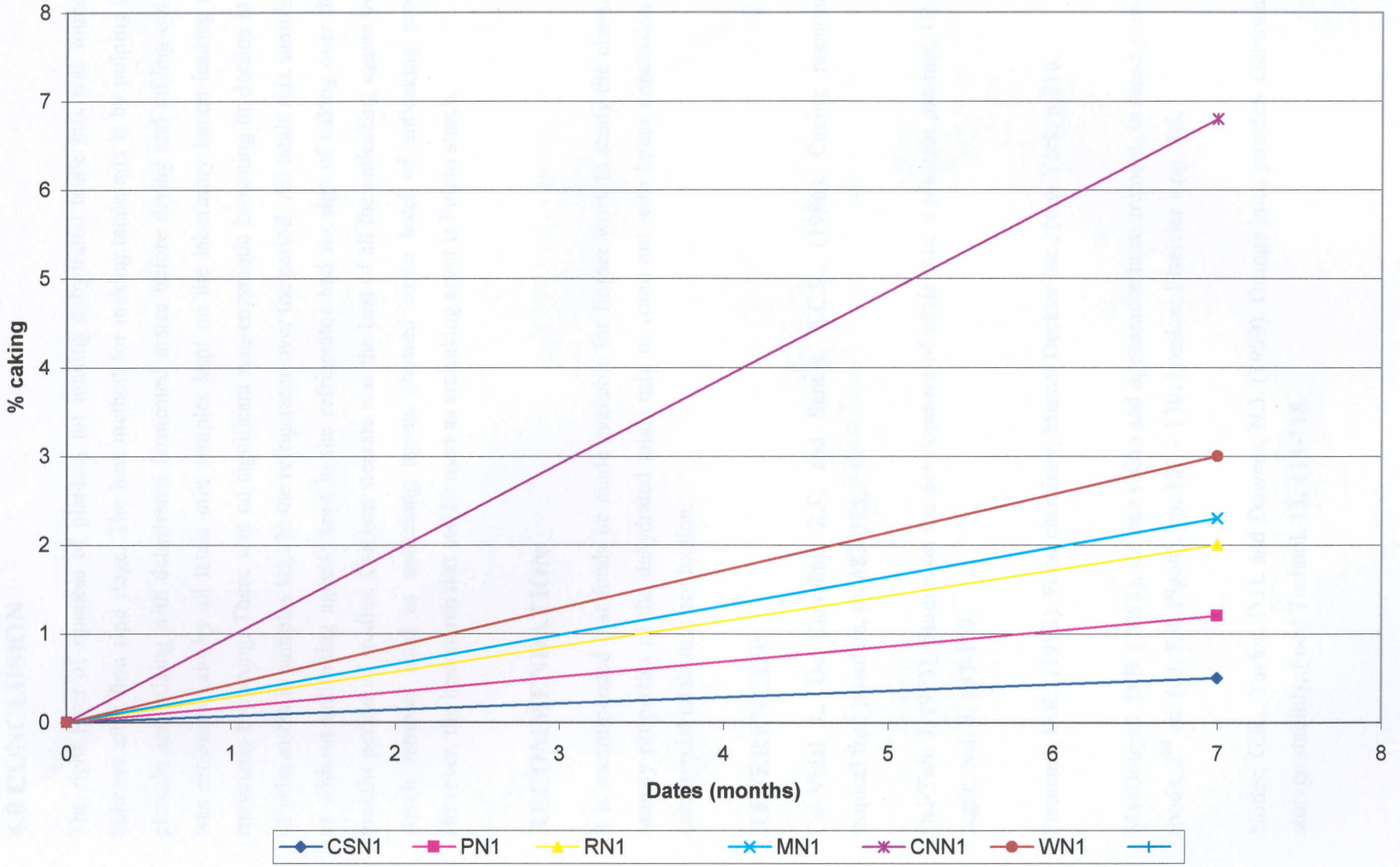


Fig 4. Percentage caking in tatale mix samples



4.0 CONCLUSION

The right level of ripeness of plantain for making dehydrated tatale mix was found to be 60hours after firm ripe stage. The best method for making tatale mix is by pulping the ripe plantain and mixing with dehydrated fermented maize before drying and milling out. There was moisture gain by all tatale mix samples kept on the laboratory bench leading to non-enzymatic browning. There was no significant non-enzymatic browning or decline in degree of yellowness in samples kept in the refrigerator over the period. All tatale mix samples (with or without anticaking agents) kept in the refrigerator had no sign of caking over the eight months period of studies. Calcium stearate was the best of all the anticaking agents used. All starch samples used as anticaking agents showed some level of anticaking properties. However, the best starch that can be used as anticaking agent is Potato starch.

RECOMMENDATION

It is recommended that funds be made available for further work to study the chemical and sensory properties of the dehydrated tatale mix to come out with better conclusion for the commercial tatale mix production.

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Meaning of symbols used

CNN1 – Tatale mix sample kept on laboratory bench with no anticaking agent.

CSN1 - Tatale mix sample kept on laboratory bench with calcium stearate as anticaking agent.

MN1 - Tatale mix sample kept on laboratory bench with maize starch as anticaking agent.

WN1 - Tatale mix sample kept on laboratory bench with wheat starch as anticaking agent.

PN1 - Tatale mix sample kept on laboratory bench with potato starch as anticaking agent.

RN1 - Tatale mix sample kept on laboratory bench with rice starch as anticaking agent.

CND2 - Tatale mix sample kept in the refrigerator with no anticaking agent.

CSD2 - Tatale mix sample kept in the refrigerator with calcium stearate as anticaking agent.

MND2 - Tatale mix sample kept in the refrigerator with maize starch as anticaking agent.

WND2 - Tatale mix sample kept in the refrigerator with wheat starch as anticaking agent

PND2 - Tatale mix sample kept in the refrigerator with potato starch as anticaking agent

RND2 - Tatale mix sample kept in the refrigerator with rice starch as anticaking agent