USE OF FRESH CASSAVA AND SWEET POTATO ROOT PULPS IN CAKE MAKING

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A THESIS

Submitted in partial fulfilment for the degree of MASTER OF SCIENCE of the University of Nairobi.

Department of Food Technology and Nutrition.

1996

DECLARATION:

This thesis is my original work and has not been presented for a Degree in any other University:

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DEDICATION:

Specially dedicated to my dear husband, Julius, for his love,care and understanding, my children, Sela, Rachel, Miriam, Naomi and Luka for their sacrifice and endurance during my absence from home, and my parents, Erastus and Rispa Simiyu for their timely support and encouragement to pursue further education.

ACKNOWLEDGEMENTS:

I wish to express my most sincere gratitude to my Supervisors Dr. E.L. Keya and Dr. E.G. Karuri, both of the Department of Food Technology and Nutrition, University of Nairobi for their tremendous patience, understanding and guidance during my research and preparation of this thesis. Dr. Keya's valuable guidance and suggestions leave me determined to pursue further Research in this subject.

I also sincerely extend my thanks to the Kenya Agricultural Research Institute for Msc. scholarship funding through which this work was done.

I further extend my thanks to J.N. Nasila and J.M. Ng'eny, both of the National Agricultural Research Centre, Kitale, for their assistance in statistical analysis and graphical presentation of the data, and also to Mrs. R. Nkonge and I.O. Otori for swiftly typing this document.

To those members of the Department of Food Technology and Nutrition, University of Nairobi, who participated in the organoleptic evaluation of the cakes and many friends who assisted in any way, I say "THANK YOU VERY MUCH".

ABSTRACT:

Fresh pulps of three cassava cultivars (cv. Serere, cv. Dorika, cv. Namba munana) and two sweet potato cultivars (cv. Maseno 14, cv. Bisale), were characterised for their physico-chemical properties and related to those of commercial home baking wheat flour in order to assess the possible use of the root pulps for cake production.

The moisture content ranged between 63.70 and 64.87% for Cassava, 68.30 and 70.18% for sweet potato and 14.50% for wheat. The crude protein ranged between 0.89 and 1.20% for cassava, 1.29 to 1.53% for sweet potato and was 10.60% for wheat flour. The total sugar content ranged between 3.03 to 4.07% for cassava, 5.73 to 6.13% sweet potato and was 5.04% for wheat flour, while the starch content ranged between 24.01 and 25.33% for cassava, 16.56 and 20.20% for sweet potato and was 63.82% for wheat flour. Root pulps were generally low in crude fat, and ash content but higher in crude fibre than wheat flour.

The α- amylase activity was 1.32 and 26.85 Sweet Potato Dextinising Units (SDU) for the two sweet potato cultivars, and 1.02 (SDU) for wheat flour. ß-amylase ctivity was 3.2 and

1.95mg/maltose/ml/min for the sweet potato cultivars and 0.91mg/maltose/ml/min for wheat flour. No significant diastase activity was observed in the cassava cultivars used.

The peak viscosity of cassava pulps ranged between 2400 and 2660 Brabender Units (BU), while that for sweet potato pulps was between 360 and 520 BU and was 740 BU for wheat flour.

In developing a suitable processing technique, it was found necessary for the pulp to have fine particles of average size of 500μm in order for the texture of the pulpy cakes to be acceptable. 0.5% sodium metabisulphite and 0.5% citric acid were both effective in controlling enzymatic browning which was more prevalent in sweet potato than in cassava pulp. Citric acid was more recommended as it had the additional effect of lowering pulp pH and hence improving cake keeping quality.

For maximum reduction of cyanide content in cassava cakes, pulps had to be stored at room temperature for about 0.5, 2 and over 6hrs for the low, medium and high cyanide cultivars respectively before baking.

To evaluate the pulps performance in cake making, cakes were made from pure pulps without wheat flour added, 80% pulp with 20% wheat flour added and 50% pulp with 50% wheat flour following recipes formulated during the study. A pure wheat flour cake was used as a control. Less sugar and shortening were required in order to produce acceptable cassava and sweet potato pulp cakes in comparison to the wheat flour cake.

Sensoric quality evaluation of the cakes showed that significant differences existed in the colour, flavour, texture, and overall acceptance of the different type of cakes at both 95 and 99% levels of significance. Although pure pulp cakes generally had lower mean scores than the wheat flour cake, they were still acceptable to consumers and could be used as cheaper substitutes for the costly wheat flour cake.

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1. INTRODUCTION:

Traditionally, cakes are made from wheat flour because of its suitable quality characteristics (Pomeranz, 1971; Sultan, 1986). Over the last few years, there has been a tremendous increase in the demand for wheat based products such as cakes and this has been due to several factors including, rapid population growth, increased rural to urban migration, rising average income, and changing life styles which have encouraged increased use of these highly prestigious foods (Numfor and Lyonga, 1986).

Despite this increasing demand, wheat production in many developing countries including Kenya is very limited due to scarcity of suitable environmental resources. It is estimated that although Africa occupies about 22.7 per cent of the world's land area, it contributes only about 1.8 per cent of the world's wheat production (FAO, 1984). Most countries deficient in wheat production have had to import wheat involving a lot of foreign exchange.

Over the last 20 years, a lot of research has been done on the possible use of non-wheat flours in baking technology in order to extend the utilization of the limited wheat supplies, and the researchers have reported their findings in this area

(Dendy and Kasasian, 1979; Crabtree and James, 1982; Chandrashekara and Shurpaleka, 1983; Keya, 1985).

Cassava and sweet potatoes have been used in composite flours for making cakes after drying and milling of the roots into flour (Osei-Opare, 1986). However, it appears illogical, unless shelf-life or transportation is a consideration, to dry material and then add water to the dough that is being prepared. The drying process has many problems related to it besides being an added cost. These problems could be avoided if cakes were made directly from fresh root/tuber pulps.

The major limitations to the use of fresh pulps of cassava and sweet potatoes include the presence of cyanogenic glucocides in cassava which produce the highly toxic hydrogen cyanide on hydrolysis, while sweet potato undergoes enzymatic browning on comminution, making the colour of the processed products undesirable. Therefore any processing technique utilizing the fresh pulps of the two root crops has to take into consideration these limitations.

The current food crisis in sub-saharan Africa is a major concern worldwide and this has necessitated the launching of programmes to boost production and utilization of particularly drought resistant crops such as cassava and sweet potato which also have the added advantage of being sources of nutrients and calories (Bede, 1986; FAO, 1986). However, the key to the expanded growth and utilization of these crops lies in the development of good quality processed products that meet the demand by both rural and urban consumers for variety, preference, nutrition, and low cost.

3. LITERATURE REVIEW.

3.1 Production and Utilization of Cassava:

Cassava (Manihot esculeta crantz) is the most important root crop grown in the tropics and accounts for approximately a third of the total staples produced in sub-saharan Africa (FAO, 1986). Out of the estimated global production of 153 million tonnes in 1991, 68 million tonnes were produced in Africa with four African countries (Ghana, Nigeria, Tanzania and Zaire) being among the largest producers (FAO,1991). Tables 1a and 1b show the production figures for the world and the major producers of cassava in Africa respectively, as obtained from the FAO production Year Book (1991).

In Kenya, reasonable amounts of cassava are produced mainly at the coast and in the western parts of the country. However, production and utilization of this crop is limited due to several reasons and in particular the fact that cassava is traditionally a crop used by low income people and not particularly attractive to the sophisticated urban population. In addition cassava varieties contain varying levels of toxic cyanogenic glucosides which have to be reduced by processing before consumption (Oke, 1973; Cooke, 1978; Mahungu et al, 1987).

Table 1a: World production figures for cassava in 1991 (FAO production year book 1991).

	Area (1000 Ha)	Yield (Kg/Ha)	Production (1000 MT)
World	15,671	9,808	153,689
Africa	8,922	7,726	68,931
North Central. America	188	5,056	951
South America	2,593	12,401	32,155
Asia	3,950	13,027	51,460
Oceania	17	11,060	191

Table 1b. Production figures for the major producers of cassava in Africa in 1991 (FAO Production Year Book 1991).

	Area (1000 Ha)	Yield (Kg/Ha)	Production (1000 MT)
Africa	8,922	7,726	68,931
Cameroon	92	13,370	1,230
Angola	500	3,700	1,850
Ghana	535	6,733	3,600
Nigeria	1,700	11,765	20,000
Tanzania	604	10,370	6,266
Uganda	380	8,816	3,350
Zaire	2,388	7,631	18,227
Kenya	67	9,701	650

Cassava roots are consumed as home prepared dishes by methods varying from region to region, and also depending on whether they are sweet (low cyanide) or bitter (high cyanide varieties) (Hahn et al,1986). The sweet varieties are either eaten raw as a snack, boiled or roasted (Philips,1982). The tubers are peeled, dried after removing the core and ground into flour and used to prepare various dishes such as "Uji" (Porridge) and "Ugali" in combination with cereal flours such as maize, sorghum or fingermillet (Onyango et al. 1993). The roots may be stewed in coconut milk together with vegetables as is done at the Kenyan coast (Imungi, 1986). Crisps and chips are also made from cassava. The bitter varieties have to undergo special methods of processing in order to make them safe for consumption. These processes mainly involve the production of flour which is then utilized in various ways just like flour from the sweet varieties. In recent times, cassava flour has been composited with wheat flour for baking purposes.

Due to its tolerance to extreme conditions, its biological efficiency in the production of food energy, its low production requirements, and its suitability for farming systems in Africa, cassava is capable of alleviating the current food crisis (Hahn et al. 1986; Bede,1986).

3.2. Production and Utilization of Sweet Potato.

Sweet potato (Ipomea batatas) like cassava is also an important root crop in many parts of the world. According to FAO statistics, total world production in 1991 averaged 126 million tonnes out of which 6.4 million tonnes were produced in Africa (Table 2a). Uganda, Kenya, and Burundi are among the major producers in Africa (Table 2b). In Kenya, over twenty cultivars are grown in many areas running from the Western to the Coastal parts of the country. Just like cassava, the sweet potato plays a vital role as a food security crop because of its resistance to drought and also has tremendous potential to be an efficient and economic source of food energy and nutrients such as Vitamin B_1, Vitamin C, Provitamin A, Calcium and Iron (FAO, 1986; Alvarez, 1986).

Preparation practices of sweet potato for food vary according to location. In East Africa, roots are boiled, roasted in the hot ashes of a fire or boiled and mashed and eaten with or without vegetable sauces. More sophisticated products such as chips are also made from peeled and diced sweet potato. Sweet potato flour has been used in composite flours to make highly acceptable products such as bread and cakes (Osei-Opare, 1986).

Table 2a: World production figures for sweet potato in 1991. (FAO Production Year Book 1991).

	Area (1000 Ha)	Yield (Kg/Ha)	Production (1000 MT)
World	9,260	13,628	126,187
Africa	1,342	4,825	6,473
North & Central America	185	7,028	1,300
South America	140	10,436	1,457
Asia	7,469	15,570	116,291
Europe	7	13,832	97
Oceania	118	4,841	570

Table 2b: Production figures for the major producers of sweet potato in Africa In 1991 (FAO Production Year Book 1991).

	Area (1000 Ha)	Yield (Kg/Ha)	Production (1000 MT)
Africa	1,342	4,825	6,473
Nigeria	20	13,000	260
Zaire	75	50,600	377
Tanzania	232	1,253	291
Uganda	420	4,286	1,800
Mozambique	9	6,471	55
Burundi	97	7,010	680
Kenya	61	9,836	600

3.3. The use of cassava and sweet potato in composite flours.

The increasing demand for wheat based baked products in many developing countries despite their inability to produce enough wheat has aroused interest in composite flour technology aimed at utilizing local starchy flours and oil seed flours in order to extend the use of the available wheat (Faure and Chatelanat, 1974; Dendy et al. 1975; UNECA, 1985).

Cassava and sweet potato have been used extensively in studies involving composite flours and the results have been encouraging. Sammy (1970) reported that a 20% substitution of wheat flour with sweet potato flour in bread gave acceptable quality. Osei-Opore (1986) reported that doughnuts made from a blend of pre-cooked sweet potato and wheat flour at substitution levels of 25 and 40% for cake and yeast types respectively, were highly acceptable to consumers. Sweet potatoes gave the products a rich soft texture and good colour Onyango (1990) also reported that up to 50% cassava flour was acceptable in "Mandazi" recipes.

There have been some attempts by researchers to incorporate fresh cassava into bread. Crabtree et al. (1978) reported that quite acceptable loaves could be made when upto 30% of fresh cassava was added to wheat flour. Other attempts to make cakes from fresh pulps of cassava and sweet potato have been reported but no scientific data on the quality of such cakes is available (WWB, 1990).

Despite the encouraging results from research, national programmes in composite flour technology in many developing countries have not succeeded in reducing wheat imports. This lack of success is attributed to several factors including the lack of supply of low cost high quality non-wheat flours, lack of incentives to wheat millers and bakers to participate, and impaired baking quality among others (Dendy and Trotter, 1986; Fellers and Bean, 1988). In some developed countries however, composite flours are part of the everyday life and such flours find their greatest use or role in providing variety and better nutrition to the diet.

The advantages of adopting composite flour technology are numerous, some of which include the possible saving in foreign exchange by the countries which import wheat and increasing production of local food crops by providing a market for their products. The technology also improves food security by increasing production of drought resistant crops (Dendy and Trotter, 1986).

3.4. Physico-chemical Properties of Cassava, Sweet potato and Wheat Flour.

The physico-chemical properties of cassava and sweet potato pulp that may affect their cake making performance include the chemical composition and gelatinization properties among others.

3.4.1. Chemical composition of cassava root.

The edible fleshy portion of a cassava root is composed of about 62% water, 25% carbohydrates, 1-2% protein, 0.3% fat, 1-2% fibre, and 1.0% mineral matter. Most of the carbohydrates fraction is starch which makes up to 20-25% of the flesh (Onwueme, 1978). The protein of cassava is not only very low in quantity but is also poor in quality. According to Martin (1975) there seems to be a relatively large amount of non-protein nitrogen in the root such that the protein content as estimated from nitrogen analysis is higher than that estimated from amino acids.

The chemical and nutrient composition of cassava has been found to vary greatly depending on the soil conditions, weather, stage of maturity, and variety. The composition may also differ between roots of the same plant (Onwueme, 1978).

3.4.2. Chemical composition of the sweet potato tuber.

The fresh root of sweet potato is composed of about 70% water, 20% carbohydrates, 0.9-2.4% protein and 0.8-1.8% minerals (Bradbury and Holloway, 1988). Sweet potato has also been found to be rich in Carotene and Ascorbic acid each constituting about 1.8 to 16mg/100gm, and 20 to 55mg/100gm fresh weight respectively.

Just like cassava, there is great variability in the composition of sweet potato depending on growing conditions and cultivar among other factors.

3.4.3. Chemical composition of wheat flour.

The chemical composition of wheat flour also varies over fairly wide limits depending on the wheat variety and growing conditions. Wheat flour.is characterized by a high carbohydrate content ranging from about 74.0 to 77.0%,a protein content ranging from 9.0 to 16%, fat of about 1.0% , fiber 0.4%, and Ash 1.7% (Pomeranz, 1971; Pyler,1979).

The carbohydrates of wheat are chiefly starch and cellulose, with small amounts of sugar and pentosans. The protein includes glutenins, gliadins, globulins, albumins and proteoses of which the first two predominate and account for the characteristic gluten formation (Pyler, 1979).

3.4.4. Changes in the chemical composition of cassava and sweet potato on baking.

Changes in the chemical composition of cassava and sweet potato roots on baking have been extensively studied and among the important changes observed is the conversion of a large portion of the starch to dextrins and sugars mainly maltose (Walter et al., 1975; Bradbury and Holloway, 1988). The degree of starch conversion depends upon cultivar.

In sweet potato, starch conversion to dextrins and sugars has also been associated with the presence of an active diastase (Ikemiya and Deobald, 1966; Walter and Purcell, 1973; Shen, 1981). Balls et al. (1948) crystallized the diastatic enzymes from sweet potato and observed that the amylolytic activity was almost entirely due to ß-amylase. However, other reports show that α-amylase also plays an important role (Walter et al., 1975; Hastings et al., 1975).

3.4.4. Cassava, sweet potato and wheat starch gelatinization properties.

As indicated under review on composition, starch is the largest constituent of the fleshy portion of cassava or sweet potato roots. Starch also constitutes some 67% of wheat flour (Pomeranz, 1971). Just like protein, starch plays a very important role in baking which will be discussed later.

The baking quality of wheat and tuber starches has been found to be a function of their physico-chemical properties, the most important being the gelatinization and pasting properties (Ciacco and D'Appolonia, 1977). Earlier studies with wheat starches showed that wheats of widely varying baking quality differed in their paste viscosity with wheats of superior baking quality having higher viscosities than wheats of inferior quality (Pyler, 1979).

When a slurry of starch in water is heated beyond a critical temperature, the granules swell irreversibly to many times their original size increasing the viscosity of the slurry. This process is referred to as *Gelatinization* (Wurzburg,1968; Whistler,1965; Pyler, 1970). The temperature at which the viscosity begins to rise is termed as the *Gelatinization Temperature*. This temperature is affected by the amount of free water between the granules and is therefore inversely related to starch concentration (Leach, 1965). In any given species of starch, individual granules do not all commence to swell at the same temperature but over a range termed *Gelatinization temperature range*. Maximum viscosity is obtained when the increase in slurry viscosity caused by swollen starch aggregates is counter balanced by the decrease in viscosity resulting from disintegration (especially if stirred) and solubilization of the starch granules. The latter effect predominates as heating is continued and consequently the viscosity decreases gradually.

A popular instrument for measuring starch gelatinization properties is the Brabender Amylograph. Brabender viscosity curves are characteristic and different for each starch. Gelatinization properties of starch depend upon numerous factors and plant origin is one of the most important (Whistler, 1965). It has been shown that root or pith starches not only gelatinize at temperature lower than most cereal starches but they also swell faster to a greater extent and at a more uniform rate (Leach, 1965). Although all starches consist basically of amylose, a linear polysaccharide with α-1-4,D-glucose molecules and amylopectin, another polysaccharide of branched chain α-1-4, D-glucose molecules, with α-1-6 glycosidic linkages at the branching points, they do not have the same physico-chemical properties. Root and tubers starches are higher in amylopectin content and tend to swell more and develop thicker paste viscosities than high amylose cereal starches (Leach and Schoch, 1961).

When a slurry of cooked starch is cooled, the linear molecules gradually line up and form hydrogen bonds between hydroxyl groups on the glucose units of adjacent linear chains. This is called *retrogradation* (Leach, 1965). In more concentrated systems like cake mixtures, the linear molecules do not orient completely but associate randomly to give the rigid network of a gel. The branched starch fraction is not prone to retrogradation since its structure is not conducive to side by side alignment of molecules (Whistler and Pascall, 1965). Therefore cereal starches are more prone to retrogradation than root or tuber starches. Retrogradation of starch in baked foods such as cakes is organoleptically undesirable due to the firming influence it contributes.

Extensive work has been done to evaluate the gelatinization properties of starches of wheat, cassava and sweet potato (Keya, 1985; Keya and Hadziyev, 1985; Shiotam et al., 1991). Work done by

Keya (1985) showed that cassava starch and sweet potato starch had gelatinization properties close to wheat starch. However, the hot paste viscosities differed significantly with cassava starch having the highest viscosity followed by sweet potato starch and lastly wheat starch. This therefore shows that it is possible to substitute part of the wheat flour with either cassava or sweet potato pulp in a cake recipe since the pulps are predominantly starch. However, cake tenderness might decrease in the presence of cassava or sweet potato. Studies on the retrogradation tendencies of the three types of starches show that wheat starch retrogrades faster than either sweet potato or cassava starch (Whistler and Pascall, 1965; Matsunaga and Kainuma, 1986). Therefore a firmer cake may result from wheat flour than either cassava or sweet potato on cooling.

3.5. Cassava cyanide toxicity and mode of detoxification.

In addition to the chemical constituents shown in the review on composition, cassava cultivars contain small but significant amounts of cyanogenic glucosides (linamarin and lotaustralin). On the basis of the cyanide contents, the cultivars have been classified as either "sweet" or "bitter". This classification is not rigid as there is a great variation in the cyanide content depending on the growing conditions (DeBruijin, 1973; Coursey, 1973). The sweet varieties are less toxic than the bitter varieties. According to DeBruijin (1973), cultivars with less than 50mg/kg are less poisonours, between 50 and 100mg/kg are moderately poisonous and those with over 100mg/kg are dangerously poisonous.

Cassava also contains linamarase, an enzyme capable of facilitating hydrolysis of cyanogenic glucosides to the intermdiates cyanohydrin and glucose (Figure 1.). Cyanohydrin further dissociates to form hydrocyanic (HCN) acid and acetone. This reaction, which can occur non enzymatically or can be catalysed by the enzyme hydroxynitrile lyase also present in the root, is pH dependent.It has been shown that the reaction is faster when the pH is greater than 5 (Cooke, 1978).

Studies on the toxic effects of hydrocyanic acid have shown that cassava has a definite antithyroid action in humans resulting in the development of goitre and cretinism especially when iodine intake is low (Ekpechi, 1973; Ermans, et al., 1982; Delange et al., 1982). Extremely high levels of HCN may be lethal (Rosling, 1986).

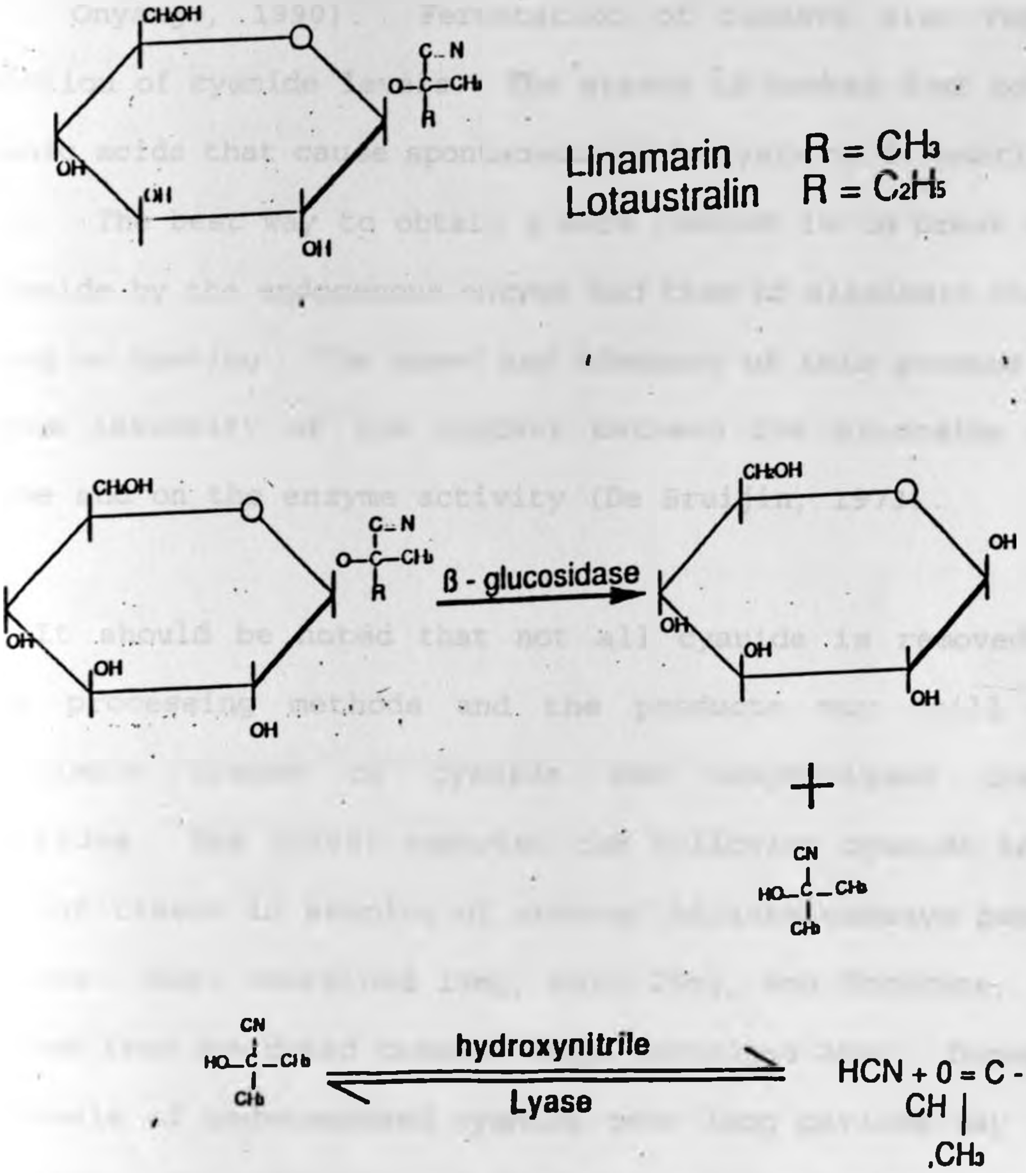


Fig. 1. The mechanism of enzymatic decomposition of cyanogenic glucocides of cassava.

Many processing methods for eliminating toxicity in cassava are known. Such methods include boiling, steaming, baking, drying, roasting or soaking in water (Cooke, 1978; Maduagwu, 1980; Mahungu, 1987; Onyango, 1990). Fermetation of cassava also results in reduction of cyanide levels. The starch is broken down to produce organic acids that cause spontaneous hydrolysis of linamarin (Hahn, 1982). The best way to obtain a safe product is to break down the glucoside by the endogenous enzyme and then to eliminate the HCN by drying or heating. The speed and adequacy of this process depends on the intensity of the contact between the glucoside and the enzyme and on the enzyme activity (De Bruijin, 1973).

It should be noted that not all cyanide is removed by the above processing methods and the products may still contain appreciable traces of cyanide and unhydrolysed cyanogenic glucosides. Oke (1982) reported the following cyanide levels in mg/Kg of tissue in samples of several African cassava based food products:- Gari contained 19mg, Fufu 25mg, and Konkonte, a flour prepared from sun dried cassava chips contained 20mg. Ingestion of low levels of undecomposed cyanide over long periods may lead to poisoning. The undecomposed glucoside can be broken down by the enzymes of the digestive juice in the gut releasing free cyanide and causing poisoning (Odigboh, 1983).

3.6. The role of cake recipe components.

The essential components of a plain cake recipe are flour, fat or shortening, eggs, sugar, a leavening agent,and a moistener which is usually milk or water. Each of these ingredients performs a particular function and a good balance between these ingredients coupled with the use of an appropriate mixing method results in the production of a cake with desirable color, grain, good volume, and tender texture characterized by a multitude of evenly distributed minute gas cells without any large holes (Pomeranz, 1971; Sultan, 1986).

3.6.1. Flour.

Flour is the basic ingredient of a cake recipe which provides strength and structure to the cake. Generally, cake flour is a weak flour with less protein content hence less gluten content. When water is added to wheat flour and mixed, the proteins, gliadin and glutenin become hydrated forming gluten which provides the background matrix in which starch is embedded (Pyler, 1979; Pomeranz, 1971). The gluten must be just enough to hold the cake together. The formation of gluten in wheat flour accounts for the superiority of wheat flour over flour from other cereals or root crops in the processing of leavened products. Although protein was first suspected as the quality determining factor of wheat flour, several researchers have demonstrated that the starch of flour also plays a very important role (Sandstedt, 1961; Schoch, 1965). Investigations have shown that this major constituent of flour performs several functions. It dilutes the gluten to a desirable consistency and provides an active surface for gluten to adhere to during the baking process. This is due to the exposure of a maximum number of hydrophilic sites for binding with gluten. Starch permits the stretching of the gas cell wall during baking by becoming flexible but not disintegrating as it gelatinizes in a deficiency of water. Also during gelatinization, the starch granules swell and absorb water from the gluten matrix in which they are embedded and cause it to set hence providing support for the whole crumb structure (Pyler, 1979). However, dehydration and denaturation of gluten during baking reduces its affinity for gelatinized starch due to reduced hydrophilicity (Dennet and Starling, 1979) and this has the advantage of resulting in a softer and more flexible crumb.

The functionality of starch in baking therefore depends on its swelling and gelatinization properties and factors affecting starch gelatinization will affect its function in baking. Miller and

Trimbo (1965) found that changes in the gelatinization temperature of starch altered the consistency of white cake batters and the quality of the resulting cake. The extent of starch gelatinization has been found to greatly influence the textural quality and shelf-life of baked products (Lineback and Wongsrikasem, 1980). Studies done to evaluate the extent of starch gelatinization in various baked products have shown it to depend on the baking temperature and time, water content of dough or batter, and the presence of some recipe components mainly sugar and shortening (Lineback and Wongsrikasem, 1980; Wootton and Chaundry, 1980).

3.6.2. Fat or Shortening.

Fat or Shortening is used in cake making for several reasons. According to Sultan (1986) fat imparts richness and tenderness to the cake. It also promotes desirable grain and texture of the cake crumb. The effect of fat is assumed to result from its adbsorption on the surface of the starch granules thereby weakening the binding forces between the starch granules and the gluten. Hence the granules do not become closely pressed together thereby reducing the firmness of the cake crumb (Pyler, 1979). In addition to the tenderizing effect, fat also provides for aeration of the cake mixture by allowing the incorporation of air during the creaming process, and hence assists in the leavening of the cake.

Fat is not soluble in water but during mixing, particles of fat are dispersed throughout the mix and exist in either a water in fat emulsion or air in fat foam if the mix is well creamed. The distribution of these particles contributes largely to the tenderness of the cake crumb (Sultan, 1986).

3.6.3. Eggs.

Eggs are a very important but costly ingredient of bakery products especially cakes. They represent 50% or more of the cost of the ingredients. Eggs serve several major purposes. These include moistening due to the large amount of moisture present and leavening due to the ability to form a foam when whisked which entangles large quantities of air. Egg proteins such as albumen act as binding agents with starch granules and also coagulate on heating and hence provide structure and strength to the cake.

The yolk of the egg provides the desirable yellow color which gives the cake a rich appearance. Eggs also have an emulsifying effect due to the presence of Lecithin in the yolk. As a food, eggs have great nutritional value due to the high protein in the whites and the high proportion of fat in the yolk (Bennion, 1973; Sultan, 1986).

3.6.4. Sugar.

Granulated Sugar or sucrose is the principal sugar used in cake production. Sugar provides the necessary sweetness to the cakes and assists in the creaming and whipping process. Sugar absorbs moisture and makes the batter less fluid.

Sugar also acts as a tenderizer by exerting an inhibitory action on the swelling of starch granules (Wurzberg, 1968). Sugar and similar hydroxylated compounds tend to stabilize starch pastes and decrease their tendency to set back or retrograde. Hence sugar aids in retention of moisture and prolongs freshness. Sugar also promotes good crust color and adds nutritional value to the cake (Bennion, 1973; Sultan, 1986). It has been proposed that sucrose delays the start of gelatinization by lowering the amount of water available to the starch granules and also by interacting with starch chains to stabilize the armophous regions of the granule, thus increasing the energy required for gelatinization (Miller and Trimbo,1965; Bean and Yamazaki,1978).

3.6.5. Baking powder.

Baking powder is used in cake mixes to aerate the mixture such that the resulting baked product is light, porous, tender and has good volume. It is composed of acid reacting materials and bicarbonate of soda which react to release carbondioxide gas (Sultan,1986).

Carbondioxide production is not the only means of leavening. The creaming of shortening and sugar, the whipping of eggs and the mixing of the ingredients are equally important. Excessive baking powder makes cakes to have an open grain and crumbly texture, or fall during baking while small volume, dense structure and shrinkage may be attributed to inadequate leavening agent.

3.6.6. Liquid

Milk is the main liquid used in cake mixtures although other recipes use water. Milk has a strengthening effect and also gives the cake better bloom and crust color. Powdered milk is also sometimes used although not as a moistening agent but to aid in absorbing excess moisture. The emulsified butterfat present in powdered milk solids aids in creaming and improves cell structure hence improving the texture of the cake. Milk also gives richness to the cakes because of its fat, protein and natural sugar in the form of lactose. Recipes using milk powder also use much more water than normal recipes.

3.6.7. Additives.

Colour changes caused by enzymatic browning is one of the major problems encountered in processing of many fruits and vegetables. Sweet potato is one such crop which develops a dark coloring when the roots are peeled resulting in undesirable processed products. This darkening is due to enzymatic oxidation of phenolic compounds, (mainly by the enzyme polyphenol oxidases to quinones) followed by the non-enzymatic polymerization of the quinones to melanin like compounds which turn black in the presence of iron (Scott, 1985).

Many methods have been used to inhibit enzymatic browning and these include pre-heating of the material before further processing, or the use of chemical additives such as citric acid or sodium metabisulphite.

For any processed product, shelf-life is one of the most important factors that contribute to its quality. The shelf-life of a product may be reduced due to contamination by spoilage organisms before or during processing. Contamination from vegetative type of micro-organisms is usually accompanied by their spores (Post et al., 1985). Spores are known to be highly heat resistant and during sterilization, only a portion of the spore population may be killed by the heat thus permitting growth of the organisms during storage. However, most types of spores are prevented from germinating by the presence of acid (Reiss, 1976; Doores, 1983).

3.6.7.1. Citric Acid.

Citric acid is a tricarboxylic acid having a pleasant taste and occurs naturally in a variety of foods and in fruits especially lemon and lime. It is highly soluble in water and has the important property of being a powerful sequestrant of heavy metals which can act as pro-oxidant catalysts. Hence its great value in inhibiting flavour and color deterioration in a wide range of foods (Arnold, 1975).

In addition, citric acid used as an acidulant acts as a preservative in preventing growth of micro-organisms and the germination of spores which can lead to spoilage of food or cause food poisoning (Gardner, 1968; Post et al., 1985).

Although citric acid is not used directly as an anti microbial, it has been shown to posses activity against some moulds and bacteria. Reiss (1976) found that 0.75% citric acid slightly reduced growth and greatly reduced toxin production by Aspergillus parasiticus and Aspergillus versicolor. The mechanism of inhibition by citrate has been theorized to be related to its ability to chelate metal ions (Brannen, 1990). It has also been proposed that the undissociated acid penetrates the interior of the bacterial cell and dissociates owing to a pH differential, thus causing general protein denaturation (Doores, 1983).

3.6.7.2. Sodium Metabisulphite.

Sodium metabisulphite is used greatly as a food additive because of its antimicrobial action and other preservative effects including prevention of enzymatic and non-enzymatic discolouration, of some foods (Wedzicha, 1981; Ough, 1983). When dissolved in water sodium metabisulphite forms sulphurous acid (H_2SO_3), bisulphite ion (HSO^-_3) and sulphite ion (SO_3^{2-}). The relative proportions of each form depends on the pH of the solution. There is evidence that the un-dessociated acid is the most effective in controlling a large number of bacteria, yeasts, and moulds (Chichester, 1968). However, the pH level strongly influences the growth inhibiting powers of sulphurous acid. It is believed to be most effective at pH less than 4 (Brannen and Davidson, 1983). Increased effectiveness at low pH may result from un ionized sulphurous acid penetrating the microbial cell more rapidly than ionic species. Cell damage may result from interaction with SH groups in structural proteins and interactions with enzymes. Enzyme inhibition takes place mainly as a result of a reaction with disulphide groups of proteins leading to a modification of the tertiary structure which is important in protein function (Wedzicha, 1981).

4. MATERIALS AND METHODS:

4.1. Materials.

4.1.1 Cassava roots.

Fresh roots of two cassava cultivars, Dorika and Serere were obtained from the National Agricultural Research Centre, Kitale, while a third variety Namba munana was obtained from the National Agricultural Research Centre, Kakamega. Selection of these cultivars was based on their cyanide contents. Generally, Serere is a sweet variety with a low cyanide content, Dorika is a medium cyanide cultivar and Namba munana is a high cyanide cultivar. The plants from which the roots were obtained were about 18 months old. Before processing or analysis, the roots were stored for 24 hrs or less at +4°C.

4.1.2. Sweet Potato Roots.

Fresh roots of two cultivars, Maseno 14 and Bisale selected on the basis of their starch content were obtained from the National Agricultural Research Centre, Kitale. The plants were about 10 months old. The roots were stored at +4°C for 24 hours or less, before processing or analysis.

4.1.3. Wheat Flour.

Finely ground and sifted wheat flour recommeded for home baking (Unga Limited, Nairobi) was used.

4.1.4. Baking Fat.

Kasuku shortening (Kapa oil Refineries Limited, Nairobi) containing vegetable fat and oil was used. This type was choosen because of its bland taste and white colour unlike butter or margarine which have a salty taste and yellow colour.

4.1.5. Milk Powder.

Skimmed milk powder (Kenya Co-operative Creameries) was used because of its low fat content.

4.1.6. Fresh Milk.

Pasteurized milk (butter fat 3.3%) was obtained from the University of Nairobi, Department of Food Technology and Nutrition pilot plant.

4.1.7. Sugar.

Commercial food grade granulated sugar was used.

4.1.8. Eggs.

Fresh eggs were locally obtained.

4.1.9. Baking Powder.

Baking powder (Zesta brand, Trufoods Limited, Nairobi) was used.

4.1.10. Chemicals and Reagents.

All chemicals and reagents used in this study were of analytical grade and were obtained from Kobian (K) Limited Nairobi and E.T. Monks (K) Limited, Nairobi except for chemical reagents for cyanide determination which were specially obtained through the Department of Food Technology and Nutrition of the University of Nairobi.

4.2. Methods.

4.2.1. Preparation of Roots For Comminution.

Fresh cassava and sweet potato tubers were washed in running water to remove any adhering soil. The tubers were then hand peeled using a kitchen knife and washed in cold water before dicing into small pieces using the Lips Kitchen machine (IR.B Jacob Lips, Urdof, Switzerland).

The middle fibrous portion of the cassava tuber was removed before dicing.

4.2.2. Pulp Preparation.

Before comminution diced pieces were subjected to three treatments as described in 4.2.2.1. to 4.2.2.3. for the purpose of controlling enzymatic browning and improvement of cake shelf-life.

The diced pieces were comminuted using the Bowl Cutter machine (Kilia, Fleishereimachienfabrik, type TK 20 LTR, Kiel). The moisture contents of the pulps were determined.

4.2.2.1. Treatment With Sodium Metabisulphite.

0.5% Sodium metabisulphite (based on root fresh weight) was sprinkled onto the diced pieces before comminution.

4.2.2.2. Treatment With Citric Acid.

0.5% Citric Acid (based on root fresh weight) was sprinkled onto the diced pieces before comminution.

4.2.2.3. Precooking.

Diced pieces were precooked in water for 10 minutes at a temperature of 70°C. and then mashed before incorporation into the recipes.

4.2.3. Determination Of Optimum Pulp Particle Size.

In order to determine the most appropriate pulp particle size that could give cakes of good texture, cakes were made from pure pulps of coarse, medium and fine particles obtained by comminuting the roots for 3, 6, and 9 minutes respectively. The acceptability of the texture of the cakes was assessed by carrying out Ranking in a Preference Test using 15 trained panelists. The panelists were asked to give a rank to each of the 3 samples offered simultaneously with the most preferred sample being ranked 1 while the least preferred sample ranked 3. Significant differences between samples were tested using the Friedman Test (Watts et al., 1989) at 5% level of significance.

4.2.4. Determination Of Cassava Pulp Holding Time Before Baking.

The holding time required for maximum reduction of cyanide in cassava cakes was determined by storing pulps at room temperature for 0, 0.5, 2 and 6 hours before baking and determining the cake's total and free cyanide contents.

4.2.5. Cake Making.

4.2.5.1. Formulations.

The baking formulae and procedures for pulpy cakes were developed following guidelines on cake formula balancing by Sultan (1986). The basic wheat cake recipe was used as a starting point. Preliminary baking trials showed that the basic cake recipe was not suitable for pulp cakes as the cakes were too sweet,and the crumb was oily, too tender and had poor volume with no gas cells. Since sugar and fat are the main ingredients affecting affecting crumb texture, their amounts were reduced and minimum levels for good quality cakes were identified using taste panels and by qualitative evaluation of crumb characteristics including crumb texture, volume, grain, and size, uniformity and number of gas cells. To evaluate the perfomance of fresh pulps in cake making, cakes were made as follows:-

Cake I - 100% pulp + No wheat flour

Cake II - 80% pulp + 20% wheat flour

Cake III - 50% pulp + 50% wheat flour.

A pure wheat flour cake was used as a standard. Roots were treated with 0.5% Citric acid before comminution. Table 3. shows ingredient proportions for making acceptable cassava and sweet potato pulp cakes in comparison with a wheat flour cake. For pulp based cakes, milk powder was used instead of liquid milk to arbsorb excess moisture.

4.2.5.2. Baking Procedure.

The creaming method was adopted because of the wet nature of the pulps. Several trials were run to determine the optimum mixing time for pulpy cakes. Longer mixing time (over 2 minutes) caused the cake mixture to separate. Half of the mixing time for a pure wheat flour cake was therefore found suitable. For pure wheat flour cakes sugar and fat were creamed in a mixer at high speed until the mixture was light and fluffy. Eggs previously well beaten were stirred in well. Liquid milk was added to the mixture in small quantities at a time while mixing at a slow speed. Wheat flour sieved together with baking powder was then added also in small amounts as the mixing continued gently until all the flour had been added. The mixer was then run for 2 minutes at medium speed.

Table 3. Ingredient proportions for cassava and sweet potato pulp cakes in comparison with a wheat flour cake (gm).

Ingredient	Cassava Pulp			Sweet Potato Pulp			Pure Wheat Flour
	Pure Cassava	80% Cassava 20% Wheat	50% Cassava 50% Wheat	Pure Sweet Potato	80% Sweet Potato 20% Wheat	50% S. Potato 50% Wheat	
Pulp	300.0	240.0	150.0	300.0	240.0	150.0	-
Sugar	67.5	94.2	134.3	54.9	81.6	121.9	201.0
Shortening	65.0	82.0	107.5	52.7	70.0	90.3	150.0
Wheat Flour*	-	60.0	150.0	-	60.0	150.0	300.0
Eggs	135.0	135.0	135.0	135.0	135.0	135.0	135.0
Milk Powder**	12.5	10.0	6.3	13.8	11.3	7.6	-
Liquid Milk	-	-	-	-	-	-	101.0
Baking Powder	9.0	9.0	9.0	9.0	9.0	9.0	9.0

Average moisture content for cassava pulp - 63.4%

Average moisture content for sweet potato pulp - 70.3%

* Amount based on pulp's fresh weight

** Amount based on pulp's moisture content.

When 100% pulp instead of wheat flour was used, fat and sugar wer creamed and eggs added as in the case of wheat flour cake. Milk powde replaced liquid milk and this was first sieved with baking powder and added to the creamed mixture of sugar and fat before addition of well beaten eggs. Gentle mixing was continued for 1 minute before additior of pulp. Further mixing was done at medium speed for 1 minute.

For cakes in which 20 or 50% of the pulp had been substituted with wheat flour, sugar and fat were creamed as above and well beaten eggs added before addition of wheat flour sieved together with milk powder and baking powder. Mixing was done for about 2 minutes or until the mixture was uniform. The pulp was then added and mixing done for 1 minute.

For each type of cake 300gms of batter was scaled into 500gm baking tins and baked at 190.5°C (375°C) in a Rotary Test Baking Oven (Henry Simon Limited, Serial No. 16 2546, England) until the cake was done and had a golden brown crust color. To test whether the cake was done, a knife was pricked into the centre of the cake and if it came out clean, the cake was done.

4.2.6. **Analytical Methods.**

4.2.6.1. **Determination Of Moisture Content.**

Moisture contents of fresh pulps and cakes were determined by drying at 60°C. in an air oven to constant weight.

4.2.6.2. Determination Of Crude Protein.

Crude protein contents of fresh pulps and cakes were determined as total nitrogen by Kjeldahl method (AOAC method 2.056,1984). The percentage of nitrogen was multiplied by 6.25 to obtain the percentage of protein.

4.2.6.3. Determination Of Crude Fibre.

Crude fiber contents of pulp and cake were determined following the AOAC method 7.066-7.070 (1984).

4.2.6.4. Determination Of Fat Content.

The crude fat was determined by extracting a 10gm sample with petroleum ether (B.pt range 60-80°C), for 6 hrs. in a Soxhlet extractor. The residue after evaporation of ether was weighed as crude fat.

4.2.6.5. Determination Of Starch Content.

The starch content of fresh pulp and cakes were determined by slightly modifying the method of Hart and Fisher (1971). Starch was hydrolysed to glucose with 52% perchloric acid. The standard curve used for this determination is shown in figure 2. The amount of glucose in the sample was calcuated from the curve and converted to starch content using the formula:- Starch = glucose x 0.9.

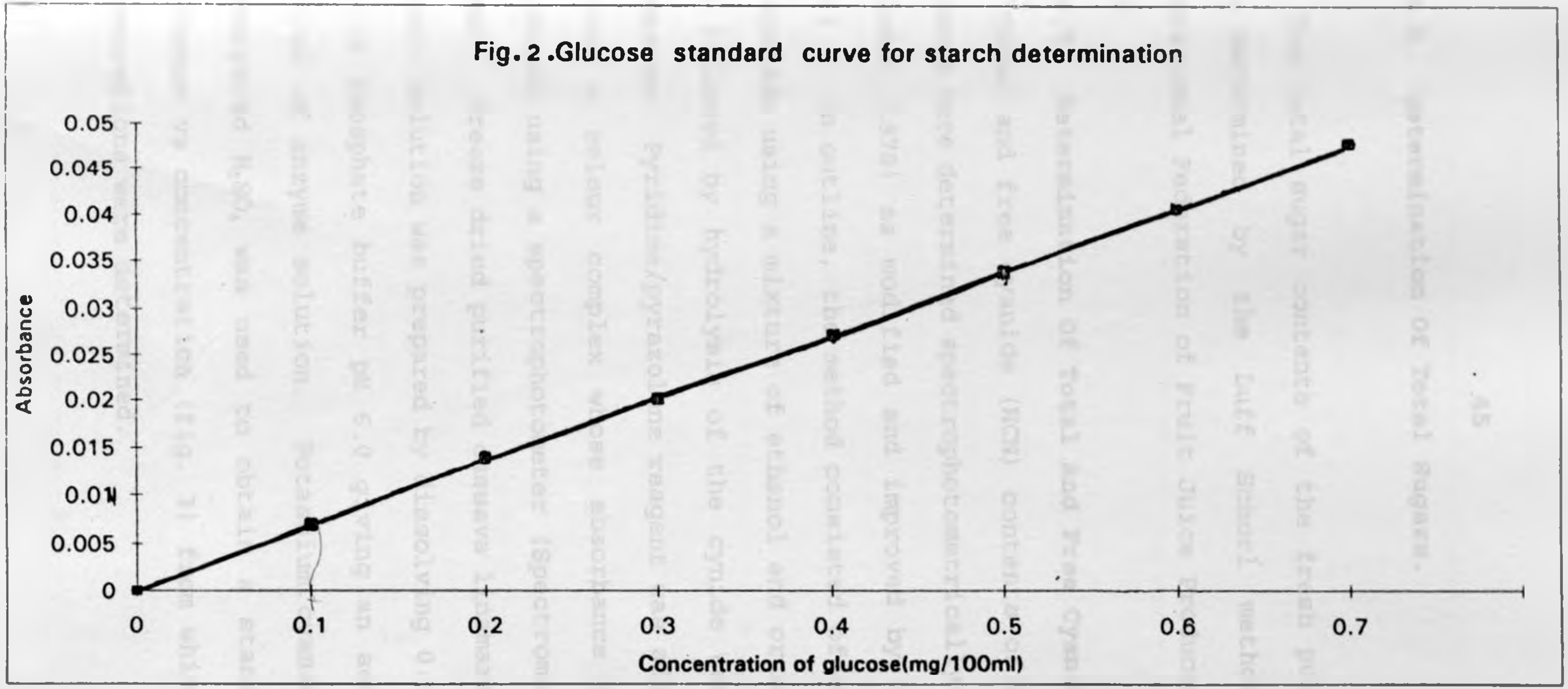


Fig. 2 .Glucose standard curve for starch determination
Absorbance
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Concentration of glucose(mg/100ml)

4.2.6.6. Determination Of Total Sugars.

The total sugar contents of the fresh pulps and cakes were determined by the Luff Schorl method 4 of the International Federation of Fruit Juice Producers (IFFJP, 1968).

4.2.6.7. Determination Of Total And Free Cyanide.

Total and free cyanide (HCN) contents of cassava pulps and cakes were determined spectrophotometrically by the method of Cooke (1978) as modified and improved by O'Brien et al (1991) . In outline, the method consisted of extraction of the cyanide using a mixture of ethanol and orthophosphoric acid followed by hydrolysis of the cynide using exogenous linamarase. Pyridine/pyrazolone reagent was added to mixture to form a colour complex whose absorbance at 620nm was determined using a spectrophotometer (Spectrometer 20, Baush & Lomb). Freeze dried purified cassava linamarase (BDH Ltd., England) solution was prepared by dissolving 0.005gm in 100ml of 0.1m phosphate buffer pH 6.0 giving an activity of 0.3 units/ml of enzyme solution. Potassium cyanide dried over concentrated H_2SO_4 was used to obtain a standard curve of absorbance vs concentration (fig. 3) from which the cyanide concentrations were determined.

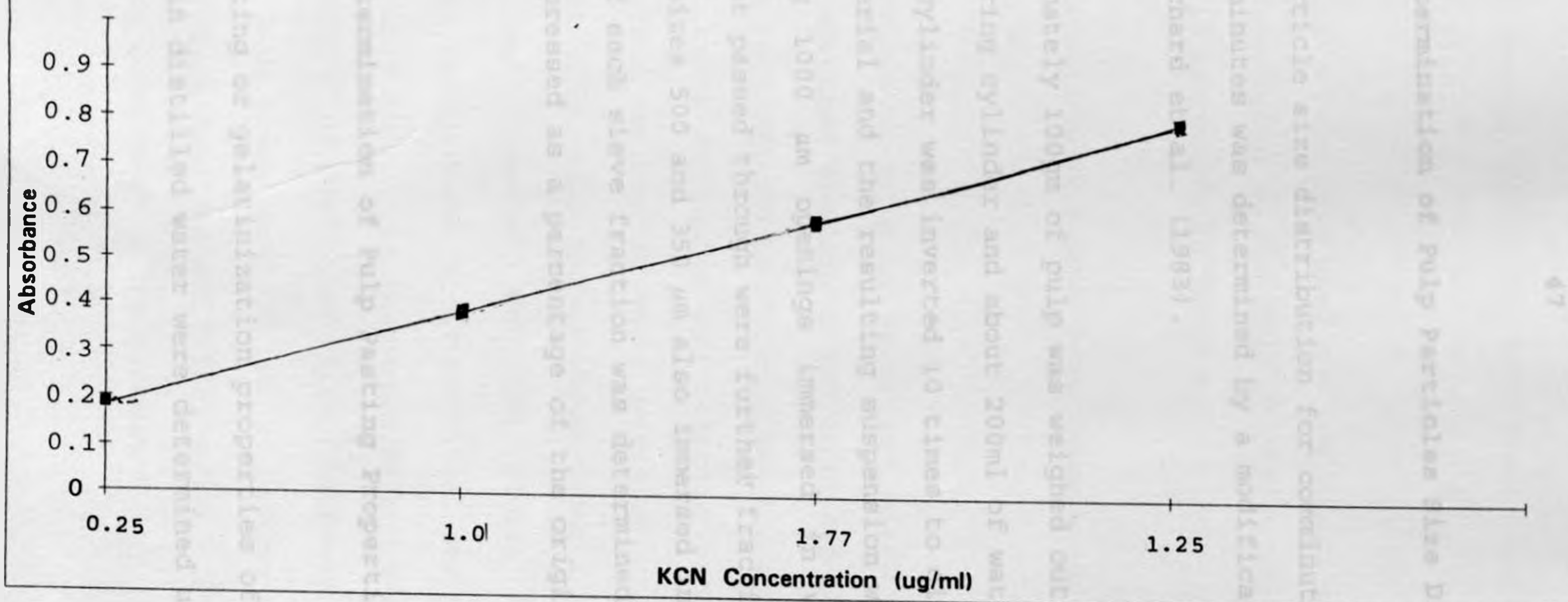


Fig.3. Standard curve for cyanide determination

4.2.6.8. Determination of Pulp Particles Size Distribution.

Pulp particle size distribution for comminution times of 3, 6, and 9 minutes was determined by a modification of the method by Richard et al. (1983).

Approximately 100gm of pulp was weighed out accurately into a measuring cylinder and about 200ml of water at 25°C. added. The cylinder was inverted 10 times to dissociate all the free material and the resulting suspension washed into a sieve having 1000 μm openings immersed in water. The particles that passed through were further fractionated using 2 sieves of sizes 500 and 350 μm also immersed in water. The dry weight of each sieve fraction was determined and the fractions expressed as a percentage of the original pulp dry weight.

4.2.6.9. Determination of Pulp Pasting Properties.

The pasting or gelatinization properties of fresh pulp suspensions in distilled water were determined using the

Brabender Amylograph (model No. 8001/8002), according to AACC method 22.10 (1982).

The weight of the pulp used and the amount of water added in order to correspond to the 80gm specified for flour on 14% moisture basis are shown in Table 4.

4.2.6.10. Extraction Of Starch from Cassava and Sweet Potato Pulps.

A suspension of pulp in water was mixed in a warring blender and screened through a 100 mesh nylon cloth. The filtrate was retained and to the residue, the above procedure was repeated twice retaining the filtrate each time. The combined filtrate was then screened once more in a clean piece of nylon cloth (100 mesh) and sedimented for 1 - 2 hrs. The supernatant was decanted and the slurry of sediment centrifuged at 3000 r.p.m. The supernatant was discarded and the scum scraped away. The recovered starch was purified by washing with 300ml of distilled water, followed by 300ml of 95% ethanol and 300ml Acetone in a Buchner funnel with aspiration through No.1 Watman filter paper. The starch was left to dry at room temperature overnight.

Table 4. Proportions of pulp and water for determination of cassava and sweet potato pulp pasting properties.

Pulp Type	Cultivar	% Moisture	Pulp wt(gm)	Water (ml)
Cassava	Serere	64.6	194.1	313.6
Cassava	Dorika	63.7	189.5	318.1
Cassava	Namba Munane	61.8	180.1	327.6
Sweet Potato	Maseno 14	68.3	217.0	290.6
	Bisale	72.2	247.5	260.2

4.2.6.11. Determination of Starch Swelling Power.

Starch swelling power was determined following the method described by Schoch (1964). The swelling power (SP) was expressed as grams of starch paste per gram of starch on dry weight basis and was calculated as follows:-

$$SP = \frac{\text{gm. starch paste} \times 100}{\text{wt. of sample} \times (100\text{-}\%\ \text{soluble, db})}$$

4.2.6.12. Determination of α-Amylase Activity.

The α-amylase activity of sweet potato was determined by the method of Hastings et al. (1973) as follows:-

About 400gm of ground fresh sweet potato was weighed into a tared 400ml beaker with a double thickness of thin nylon cloth and about 1/3 of the weight of juice squeezed out from the pulp. One hundred millitres of crude juice was poured into 250ml beaker and 6 drops of 30% $CaCl_2$ added for stabilization of α-amylase. The beaker was immersed into boiling water in 400ml beaker acting as a water bath. The juice was stirred constantly until the temperature reached 71°C. The heated juice was allowed to stand for 5 minutes for starch and other solids to settle to the bottom, and about

10ml of the supernatant drawn off. Again using a beaker as a water bath, 10ml of a 2% solution of gelatinized starch (substrate) was heated to 70°C and while maintaining that temperature, 2ml of heated juice was pipetted into the substrate starting a stop watch. The time taken to match the color of 0.1cc of this substrate in 1cc of diluted iodine to the color of ß-limit dextrin in a spotting dish was measured.

The activity was calculated as (12/Time x ml of juice) and expressed as sweet potato Dextrinizing Units (SDU).

4.2.6.13. Determination of ß-Amylase Activity.

The activity of ß-amylase in sweet potato was determined using Lintner starch as the substrate (Walter et al. 1975). A 10ml sample of juice was added to 15.0ml of substrate (2%) at room temperature. The reaction was continued for 5 minutes and then stopped with 0.2 N NaoH.

The amount of reducing sugar produced was determined as maltose by AOAC method (1984) and expressed as mg of maltose per ml of juice per minute.

4.2.6.14. Determination of Total Microbial Counts.

Total microbial counts of cakes were determined according to standard procedures for microbiological examination of foods as outlined by Speck (1982).

4.2.7. Cake Quality Evaluation.

4.2.7.1. Sensoric Quality Evaluation.

The acceptability of the cakes was evaluated using a 9 point Hedonic Scale (Appendix I) by a sensory panel of 15 members from the Department of Food Technology and Nutrition. The results were subjected to analysis of variance and the means compared by the Duncan's Multiple Range Test (Watts et al., 1989).

4.2.7.2. Determination Of Cake Volume.

The volume of cakes cooled for 30 minutes in the pans was determined using the Layer cake measuring template according to the AACC Method 10.91 (1969).

4.2.7.3. Determination of cake crumb microstructure by Scanning Electron Microscopy (SEM)

Small pieces of dried cake samples were attached to specimen stubs using two sided adhesive tape. The pieces were then coated in vacuo with approximately 500 Å of gold in 5 minutes using the Jeol Fine Coat Ion Sputter (JFC-1100) operating at 1KV accelerating voltage. Samples were viewed with the Jeol Scanning Electron Microscope (JSM-T100) and images were photographed on Ilford PAN 400 black and white film at magnifications of x 500 and x 1000.

4.2.7.4. Determination of Cake Crumb Penetration Resistance.

A penetrometer (model FT 011) was used to determine the crumb resistance to penetration by a standard probe and this was as an indication of cake crumb tenderness or firmness at ½ hr. after baking, and after storage for 1, 3, 5, and 7 days at room temperature.

4.2.7.5. Determination of Extent Of Starch Gelatinization.

The extent of starch gelatinization in the cakes was determined by the method of Wooton and Chaundry (1980) as follows:- 2 gm of defatted cake crumb was macerated with 100ml water in a warring blender for 1 minute. The suspension was then centrifuged at 2000 r.p.m. for 10 minutes at room temperature. Duplicate aliquots (1ml) were diluted to 10ml with water and 0.1ml iodine solution (4% KI, 1% I_2) added. Absorbance (A_1) at 600nm in 10mm cells was then measured against a reagent blank. A further suspension of defatted sample (2g) in water (95ml) was prepared as described above. To this suspension was added KOH solution (10m, 5ml) and the mixture allowed to stand for 5 minutes with gentle agitation. The alkaline suspension was then centrifuged. Duplicate aliquots (1ml) were then mixed with HCL (0.5 ml, 1ml) and diluted to 10ml with water. 0.1gm of crystalline potassium tatrate was added to stabilize the pH. Iodine solution (0.1ml) was then added and absorbance (A_2) at 600nm determined as described above. Extent of gelatinization was calculated as :- (A_1/A_2 x 100)%.

4.2.7.6. Evaluation of Cake Storage Stability.

Cakes made from pure pulps treated with 0.5% citric acid and wrapped in polythene paper bags were stored under 3 different storage conditions as follows:- Room Temperature, (28-29°C) Refrigeration (+4°C) and Deep Freezing. The microbial load of the cakes was determined after 2, 4, 6, 8, 10, 12, and 14 days of storage. The number of days before signs of spoilage were observed was noted and the types of spoilage.

5. RESULTS AND DISCUSSION

5.1. Physico-chemical Properties of cassava and sweet potato pulps in comparison with wheat flour.

5.1.1 Chemical Composition:

Table 5 shows the chemical composition of cassava and that of sweet potato root pulps in comparison with wheat flour while Table 6 shows the total cyanide contents of the three cassava cultivars used in the study.

Although the composition of the pulps was within reported limits, there was considerable variation among the cultivars, which could be attributed to genetic differences between cultivars, soil conditions, and age of the root at harvesting since some roots mature earlier than others (Onwueme 1978; Bradbury and Holloway, 1989).

As expected the root pulps had considerably higher moisture and hence less dry matter than wheat flour. Of the two root crops, sweet potato cultivars had generally higher moisture contents than cassava cultivars, with cv. Bisale having the highest moisture content.

Table 5: The chemical composition of pulps of some cultivars of cassava and sweet potato roots in comparison with wheat flour (%)[M]

	Moisture	Crude protein	Crude fat	Total sugar	Crude fibre	Ash	Starch
Cassava:							
cv. Serere	63.70 ±2.26	0.89 ±1.13	0.34 ±0.19	4.07 ±0.96	1.04 ±0.22	0.32 ±0.03	25.33 ±1.42
cv. Dorika	64.87 ±1.98	1.03 ±0.08	0.37 ±0.17	3.35 ±0.97	1.29 ±0.62	0.52 ±0.12	24.01 ±1.02
cv. Namba Munana	62.81 ±1.72	1.20 ±1.09	0.23 ±0.12	3.03 ±0.15	1.15 +0.47	0.42 +0.04	25.11 +0.09
Sweet Potato:							
cv. Maseno 14	68.30 ±1.06	1.29 ±0.92	0.56 ±0.19	5.73 ±1.22	1.23 +0.22	0.57 +0.04	20.20 +1.21
cv. Bisale	70.18 ±1.56	1.53 ±0.04	0.82 ±0.08	6.13 ±1.05	0.93 ±0.55	0.68 ±0.09	16.56 ±0.95
Wheat flour	14.50 ±0.10	10.60 ±0.93	1.30 ±0.32	5.04 ±0.12	0.40 ±0.63	1.23 ±0.12	63.82 ±0.09

M - Means + SD (n=3)

The total sugar content of the pulps ranged between 3.03 and 6.13% with sweet potato cultivars having higher values than cassava cultivars. Among the sweet potato cultivars, cv. Bisale had a higher total sugar content than cv. Maseno 14 while among the cassava cultivars, cv. Serere had the higher sugar content.

The starch content also varied among the cultivars. The greatest variation was observed between the sweet potato cultivars while the difference in starch contents of cassava cultivars was not significant. The crude protein, Ash and Crude fat contents of root pulps were generally low showing that these crops are not good sources of these nutrients.

The total cyanide contents of the three cassava cultivars varied considerably as indicated in Table 5b. Cv. Serere had a total cyanide content of 33mg/kg fresh tissue and could therefore be classified as a low cyanide cultivar. Cv. Dorika had a cyanide content of 57.75mg/kg fresh tissue making it to be classified as a medium cyanide cultivar while cv. Namba Munana had a cyanide content of 98.53 and could therefore be classified as a high cyanide or poisonous cultivar.

Table 6: Total cyanide contents of some fresh cassava root pulps (mg/kg)[a]

Cultivar	Total Cyanide
Serere	33.46 ± 2.09
Dorika	57.78 ± 1.93
Namba Munana	98.53 ± 2.35

a - Means + SD (n=3)

5.1.2: Diastatic Activity of Fresh Cassava, Sweet Potato and Wheat flour:

The α- and ß-amylase activities of fresh sweet potato pulp and wheat flour are shown in Table 7. The table does not show the enzyme activity for cassava cultivars as no significant activity was observed. Sweet Potato cultivars showed varying activities with cv. Maseno 14 having higher B-amylase activity than cv. Bisale which in turn had considerably higher α-amylase activity than the former. This suggests that diastatic enzymes vary considerably with genotype. It would therefore be expected that during the baking process, more starch would be converted to sugars in cakes made from cv. Bisale. α-amylase is known to be heat resistant upto temperatures of 70°C and therefore remains active during most of the baking period while ß-amylase is easily destroyed by heat (Wurzburg, 1968, Pyler, 1973).

Cakes made from cv. Bisale will also be expected to have a more tender texture due to the high sugar content and also due to the liquifying action of α- amylase on starch which alters some of the important properties such as gelatinization (particularly paste viscosity), swelling power and water binding capacity. These properties among others affect cake texture. The α- and ß-amylase activities of wheat flour were lower than those of the two sweet potato cultivars.

Table 7: Diastatic activity of some varieties of Fresh Sweet Potato roots and Wheat flour.[a]

Cultivar	α-amylase activity (SDU)	ß-amylase (mg maltose/ml/min)
Sweet Potato:		
cv. Maseno 14	1.32 ± 2.02	3.2 ± 1.09
cv. Bisale	26.85 ± 1.22	1.95 ± 0.28
Wheat flour:	1.02 ± 0.09	0.91 ± 0.85

a - Means ± SD (n = 2)

SDU - Sweet potato Dextrinizing Units.

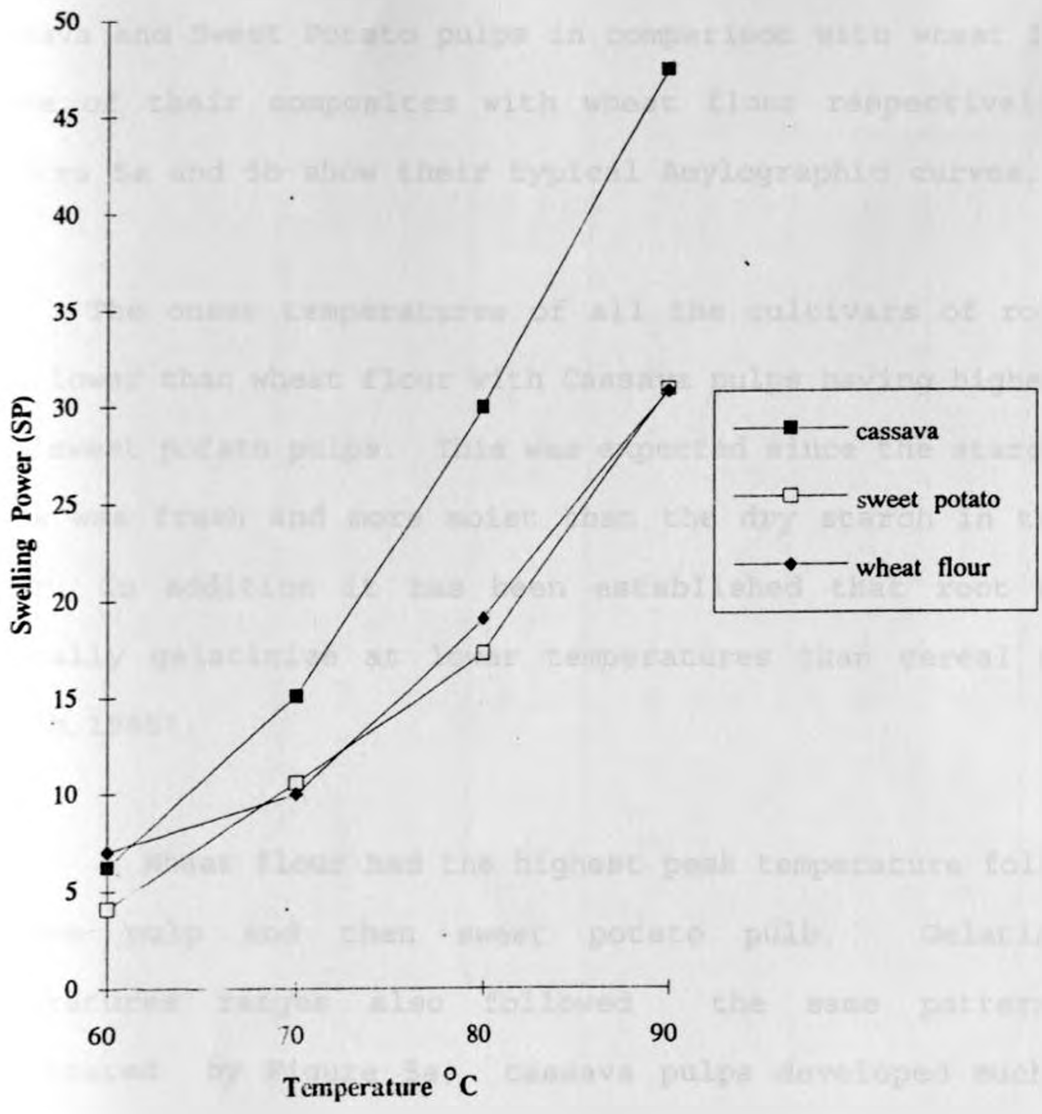
5.1.3: Swelling power of cassava and sweet potato starches:

Fig 4 shows the changes in the swelling power (sp) with increase in temperature for cassava and sweet potato starches in comparison with wheat starch.

For all the starches, the sp was quite low at 60^{0}C but increased steadily as the temperature was increased to 90^{0}C. At 90^{0}C Cassava starches had the highest swelling powers ranging from 47.88 to 48.21 gm of starch paste per gram of dry starch showing that cassava starch absorbed much more water thereby swelling more extensively than either sweet potato or wheat starch, as previously reported (Keya and Hadziyev,1987).

The starches of sweet potato cv. Maseno 14 and wheat flour had very close sp values of 32.86 and 30.75 respectively while the starch of cv. Bisale had the lowest sp of about 23.28 gm starch paste per gram of dry starch. This low sp could be attributed to the high $\propto$-amylase activity in this cultivar as indicated earlier in Section 5.1.2. The enzyme liquifies the starch hence reducing its swelling power. The results generally agree with the findings of Leach (1965) that cereal starches swell less than root starches.

Fig 4: Swelling power of cassava, sweet potato and wheat starches as a Function of Temperature



5.1.4: Pasting properties:

Table 8a and 8b show the Amylographic pasting properties of Cassava and Sweet Potato pulps in comparison with wheat flour and those of their composites with wheat flour respectively, while Figures 5a and 5b show their typical Amylographic curves.

The onset temperatures of all the cultivars of root pulps were lower than wheat flour with Cassava pulps having higher values than sweet potato pulps. This was expected since the starch in the pulps was fresh and more moist than the dry starch in the wheat flour. In addition it has been established that root starches generally gelatinize at lower temperatures than cereal starches (Leach,1965).

Wheat flour had the highest peak temperature followed by cassava pulp and then sweet potato pulb. Gelatinization temperatures ranges also followed the same pattern. As illustrated by Figure 5a, cassava pulps developed much higher peak viscosities than wheat flour or sweet potato pulps probably due to the higher swelling power of cassava starch that enables it absorb more water without rupture of the granules. In addition, cassava lacks the starch hydrolysing enzymes which have been shown

Table 8a: Amylographic pasting properties of cassava and sweet potato root pulps in comparison with wheat flour[a]

Cultivar	Onset Temp (°C)	Peak Temp (°C)	Gel. Temp Range (°C)	Peak viscosity (BU)
Cassava:				
cv. Serere	49.00 ± 0.50	54.25 ± 0.70	5.25 ± 0.60	2660 ± 3.72
cv Dorika	50.00 ± 0.92	57.25 ± 1.10	7.25 ± 1.09	2700 ± 2.50
cv Namba Munana	49.75 ± 2.50	56.00 ± 1.02	6.75 ± 1.12	2400 ± 3.55
Sweet Potato:				
cv. Maseno 14	48.00 ± 2.90	53.25 ± 1.87	5.25 ± 2.01	520 ± 2.35
cv. Bisale	46.00 ± 3.65	47.50 ± 0.52	1.50 ± 2.33	360 ± 2.40
Wheat Flour	53.00 ± 0.95	62.75 ± 0.54	9.75 ± 0.65	740 ± 3.00

a - Means + SD (n=3)

Table 8b: Amylographic pasting properties of cassava and sweet potato composites with wheat flour.[a]

Pulp type	% pulp	% wheat flour	Onset Temp (°C	Peak Temp (°C)	Gel. Temp. Range(°)	Peak viscosity BO
Cassava:						
cv. Serere	80	20	52.00	59.00	7.00	1800
	50	50	52.50	61.75	9.25	1200
cv. Dorika	80	20	51.25	59.00	8.00	1600
	50	50	52.00	61.00	9.00	1450
cv. Namba Munana	80	20	50.25	57.75	7.50	1750
	50	50	51.25	60.00	8.75	1320
Sweet Potato: cv. Maseno 14	80	20	49.80	55.80	6.00	530
	50	50	52.00	58.75	6.75	560
cv. Bisale	80	20	48.20	50.48	2.25	470
	50	50	50.75	53.25	2.5	500

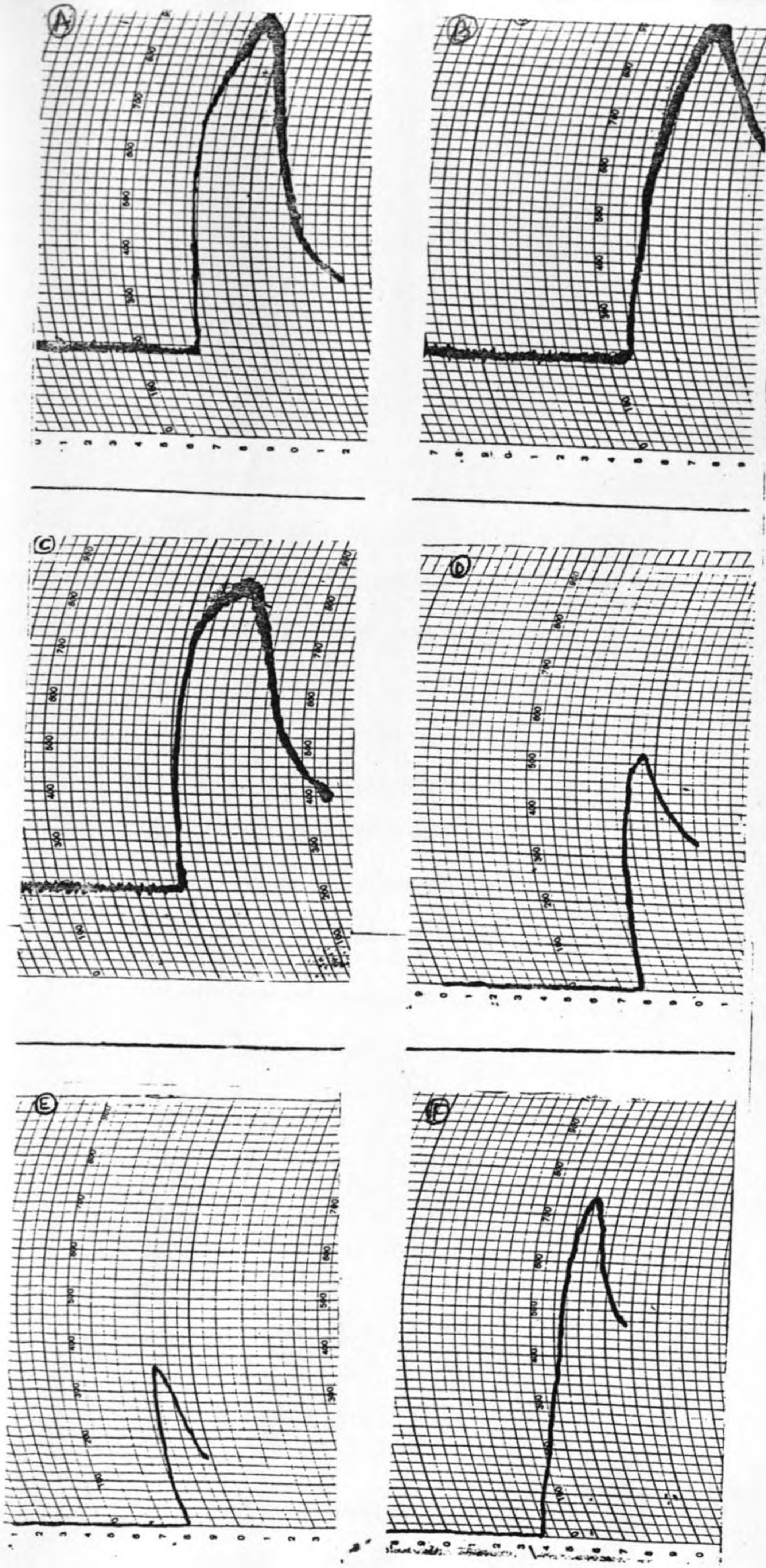

A
B
C
D
E
F

Fig. 5b. Typical amylographic curves for slurries of cass sweet potato pulp (80 %) and wheat flour (20 composites.

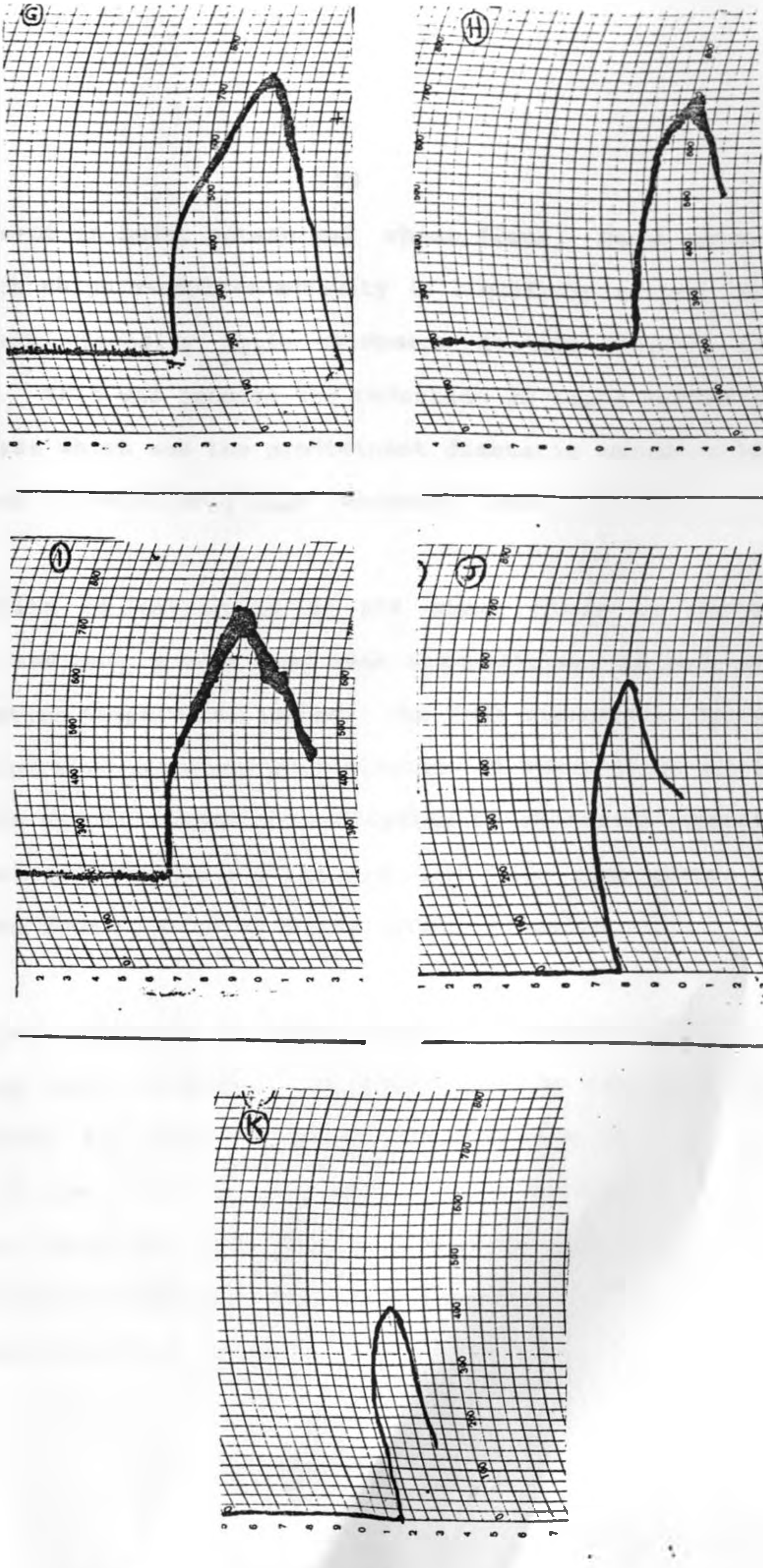
G - Cassava cv. Serere

H - Cassava cv. Dorica

I - Cassava cv. Namba munana

J - Sweet potato cv. Maseno 14

K - Sweet potato cv. Bisale


G
H
I
J
K

to be present in sweet potato and wheat flour. Sweet potato cv. Bisale with ahigh α-amylase activity (a liquifying enzyme) had the lowest peak viscosity while cv.Maseno 14 had slightly higher viscosity. This was because the reduction in paste viscosity due to ß-amylase which was the predominant diastatic enzyme in Maseno 14 cultivar is relatively slow (Wurzbug, 1968).

Addition of either 20 or 50% wheat flour to the pulps increased the pulp's onset and peak temperatures, as well as the Gelatinization temperature ranges. The Peak viscosities for sweet potato pulps also increased with addition of wheat flour due to an increase in starch concentration leading to increased competition for available water between the pulp and flour components. This reduced the hydration rates of the starch granules.

However, addition of wheat flour to cassava pulp greatly reduced the Peak viscosity. In this case the increased starch concentration may have prevented the swelling of the starch granules to their maximum size although the diastatic enzymes of wheat flour could also have hydrolysed part of the starch altering its properties.In addition, wheat starch resists swelling much more than cassava starch as shown in Figure 4.

5.2: Process development:

5.2.1: Pulp particle size distribution:

The pulp particle size distribution for cassava and sweet potato obtained by comminution times of 3, 6 and 9 minutes using the bowl cutter are shown in Tables 9a and 9b respectively. After 3 minutes of cumminution, both cassava and sweet potato roots had a larger percentage of particles retained by 1000μm sieve resulting in a pulp of course structure, while after 6 minutes the pulps had a majority of their particles retained by the 500μm sieve giving a pulp of slightly fine structure. Further comminution gave pulp of very fine structure with most particles being retained by the 350μm sieve.

A comparison of the particle size distribution for the two types of pulp at each comminution time shows that the reduction in particle size was faster in sweet potato roots than in Cassava roots showing that the former are more easily comminuted. Hence the pulp preparation costs for sweet potato may be lower than for cassava.

Table 9: Variation in Cassava and Sweet potato pulp particle size distribution with comminution time (%w/w of pulp retained by 1000, 500 and 350μm sieves)

	3 min			6 min			9 min		
	1000	500	350	1000	500	350	1000	500	350
Cassava	87.3 ±0.81	6.3 ±0.98	2.6 ±0.46	1.0 ±0.17	81.6 ±1.27	10.8 ±0.63	1.05 ±0.11	17.6 ±0.59	72.6 ±0.56
Sweet potato	86.6 ±0.77	7.2 ±0.95	3.0 ±0.66	0.9 ±0.12	82.7 ±0.56	11.3 ±0.33	0.4 ±o.55	12.5 ±0.36	79.2 ±0.12

Means ± SD n=3

5.2.2: Determination of optimum pulp particle size

One important cake quality attribute that may be influenced by particle size and hence pulp structure is the texture. Therefore in order to determine the most appropriate pulp structure for cakes of good texture, cakes were made from pulps of course, slightly fine and very fine structures and the acceptability of the texture of these cakes was sensorically assessed by carrying out a ranking for acceptance test using 15 panelists. Cake samples were presented simultaniously. The rank totals obtained for different pulp particle sizes and hence cake structures are shown in Table 10. The differences between all possible rank total pairs were compared to the tabulated critical value at 5% significance level obtained from expanded tables for the Friedman's Test (Watts et al, 1989).

For both cassava and sweet potato, the texture of cakes made from pulp of course particle size was least accepted while there was no significant difference in the acceptance of cakes made from slightly fine and very fine pulps. Therefore in order to obtain cakes of good texture, the pulp particles should be atleast slightly fine. Using very fine pulp, may however increase processing costs although the texture of the cakes is acceptable.

Table 10: Effect of pulp particle size on Texture of Cassava and sweet potato pulp cakes : (Rank totals)*

Pulp particle size	Cassava	Sweet Potato
Course	45 b	42 b
Fine	24 a	21 a
Very fine	20 a	28 a

* - Totals of 15 panelists

Ranks in columns followed by the same letter were not significantly different at P>0.05 by Friedman's Test (Watts et al 1989).

5.2.3: Control of Enzymatic Browning:

Most Fresh fruits and vegetables such as sweet potatoes are known to undergo enzymatic browning on peeling or comminution resulting in undesirable colour changes that greatly lower the quality of their processed products. In this study, three treatments as described in methods 4.2.2.1 to 4.2.2.3, were used to control enzymatic browning in the pulps and the effect of these treatments on the colour, texture and taste of cakes was assesed sensorically by a panel of 15 members using a nine point Hedonic scale (Appendix 1).

The panelists mean scores for colour, texture and flavour of cakes are shown in Table 11. Cakes made from cassava pulps that were not treated, treated with 0.5% sodium metabisulphite or 0.5% citric acid had acceptable colour. The same applied to cakes made from sweet potato pulp treated with either 0.5% sodium metabisulphite or 0.5% citric acid. But the colour of cakes made from untreated sweet potato pulp was very much disliked. This shows that enzymatic browning was much more pronounced in sweet potato pulp than in Cassava pulp. The texture of all the cakes was acceptable except for precooked cassava and sweet potato cakes, whose crumbs had a tender texture but had poor grain, lacked air

Table 11: Effect of metabisulphite, citric acid and pre-cooking on colour, texture and taste of cassava and sweet potato pulp cakes.

Treatment	Sensory mean scores*		
	Colour	Texture	Taste
Cassava (no treatment)	6.70 a	6.89 a	7.50 b
Cassava + 0.5% metabisulphite	6.78 a	7.02 a	7.66 b
Cassava + 0.5% citric acid	6.83 a	7.01 a	8.09 a
Cassava (pre-cooked)	6.04 b	4.04 c	5.26 c
Sweet potato(No treatment)	2.75 c	6.93 a	6.52 c
Sweet potato + 0.5% metabisulphite	6.80 a	7.06 a	7.45 b
Sweet potato + 0.5% citric acid	7.00 a	6.26 a	8.22 a
Sweet potato (pre-cooked)	6.15 b	4.10 c	5.02 c

* Means of 15 responses

Means in same column followed by same letter did not have significant differences between them at P > 0.05 by Duncan's multiple range test.

cells and were dense and hence not appealingto the panelists. Treatment with 0.5% citric acid gave the cakes a slightly tangy taste that was liked very much by the panelists, while treatment with 0.5% sodium metabisulphite did not alter the taste of the cakes.

5.2.4: Improvement of Cake shelf life.

A preliminary investigation of this project showed that pulp based cakes had poor keeping quality in comparison to a wheat flour cake. Several microbiological tests done including a gram stain and spore test showed the presence of gram +ve, spore forming rod shaped bacteria. These tests together with the spoilage characteristics observed on the cake crumbs particularly the stickiness and grey-brown spots led to the conclusion that the bacteria causing the cake spoilage was Bacillus subtilis. According to Buchanan and Gibbons (1974), Bacillus subtilis is a gram +ve, rod shaped spore forming bacteria which originates from the soil. It thrives best in pH range 6.5 - 8.0 and forms sticky thread-like strands on the medium in which it grows. The spores are not destroyed at baking temperatures and high pH but acid conditions inhibit the germination of the spores (Howlett, 1968).

It was also observed during the preliminary study that although the baking temperature was 190.5° C, the internal temperature of the cakes did not rise beyond 80°C. The pH of the pulps ranged between 6.5 and 7.4. Therefore the temperatures were too low to destroy the bacterial spores whose growth was favoured by the high pH and moisture levels. There was need therefore to develop a processing technique that would improve the shelf life of the resulting cakes.

In this study three treatments i.e. addition of 0.5% sodium metabisulphite, 0.5% citric acid and pre-cooking for 10 min at 70°C were assesed for their effectiveness in improving cake shelf life. Table 12, shows the number of days before signs of spoilage were observed and the type of spoilage observed in cassava and sweet potato cakes in comparison to a pure wheat flour cake.

Of the three treatments, 0.5% citric acid appreciably improved the shelf life of the cakes to about 5 days when mould growth was observed. However, treatment with 0.5% sodium metabisulphite did not improve the shelf life probably due to the high pulp pH (6.7). It has been established that the antimicrobial action of sodium metabisulphite which is through the formation of sulphurous acid is

Table 12: Effect of sodium metabisulphite, citric acid and pre-cooking on cake **shelf-life.at room temperature**

Treatment*	**Days before spoilage**	**Type of spoilage**
Cassava (no treatment)	3	Off odours, sticky crumb with grey-brown spots and long threads observed when crumb was broken
Cassava + 0.5% metabisulphite	3	" " "
Cassava + 0.5% citric acid	5	Mould growth
Cassava (pre-cooked)	3	Off-odours, sticky crumb with grey-brown spots and threads seen when crumb was broken
Sweet potato (no treatment)	2	"
Sweet potato + 0.5% metabisulphite	2	"
Sweet potato + 0.5% citric acid	5	Mould growth
Sweet potato (pre-cooked)	2	Off-odours, sticky crumb with grey-brown spots and threads seen when crum was broken
Pure wheat flour cake	upto 7	No signs of spoilage

* Cakes were cooled for 2 hours and stored in polythene bags

strongly influenced by pH (Brannen and Davidson, 1983) and that sulphurous acid is more effective under acidic conditions (pH less than 4). Plain heat treatment as was done in pre-cooking followed by baking could not destroy microbial spores which easily germinated due to favourable pH and a high moisture content of the cakes. Treatment with citric acid however lowered the pH of the pulps to about 4.2 and this coupled with the bakingtemperature partly destroyed the spores and inhibited their germination hence prolonging the shelf-life of the cakes.

5.2.5: Determination of optimum cassava pulp holding time for maximum reduction in cyanide content:

In any processing method for ellimination of cyanide toxicity in cassava that involves the use of the enzyme linamarase, the intensity of contact between the glucosides and the enzyme and the enzyme's activity greatly affect the speed and adequacy of the process.

In this study, pulps were held for 0, 0.5, 2 and 6 hours before baking at room temperature in order to determine the optimum pulp holding time for maximum reduction in cyanide. Table 13 shows the total and free cyanide contents of the cakes and the percent reduction in total cyanide with time before baking. In all the 3

Table 13 Total and free cyanide contents of cakes[a] and % reduction in total cyanide with time

Time (hr)	Serere			Dorika			Namba Munana		
	Total cyn.	Free cyn.	%* reduction	Total Cyn.	Free Cyn.	% reduction	Total Cyn.	Free Cyn.	% reduction
0	18.48 ± 1.08	0.33 ± 0.09	44.76	40.80 ± 1.32	1.85 ± 0.91	29.3	82.02 ± 2.83	2.01 ± 0.35	16.7
0.5	9.85 ± 0.95	0.55 ± 0.04	70.5	28.72 ±1.42	1.87 ± 0.99	50.3	62.43 ± 1.75	2.09 ± 0.48	36.8
2	6.05 ± 1.32	0.55 ± 0.08	81.9	16.10 ± 0.99	1.99 ± 1.08	72.1	48.95 ± 2.10	2.46 ± 0.88	50.3
6	2.60 ± 0.80	0.69 ±0.11	92.2	6.45 ± 1.01	2.45 ± 0.98	88.8	36.35 ± 1.09	2.89 ± 0.19	63.1

* % reduction in total cyanide (based on initial total cyanide before baking)

a - Means ± SD n = 3

cultivars, the total cyanide in the pulps reduced with length of holding time before baking leading to a reduction in total cyanide because the longer incubation time allowed for longer contact between the glucoside and the enzyme.

Baking the pulps immediately after comminution resulted in only a slight decrease.in the total cyanide. This may have been due to the fact that the enzyme was denatured by heat and its activity reduced before it had acted on the glucosides.

The cassava cultivar Serere, required only about 0.5 hour for effective removal of cyanide, and Dorika, a medium cyanide cultivar required about 2 hours. Namba Munana, a high cynanide cultivar would require more than 6 hours for effective reduction of cyanide to a safe level, since after 6 hours the level of cyanide in the cakes was still high. It appears therefore that the higher the initial cyanide content of a cultivar the harder it is to detoxify it. This may be because there is a rapid build up of end products especially hydrogen cyanide which if not removed fast enough slows down the hydrolysis of the glucosides.

5.3. Cake Quality Evaluation

5.3.1: Cake Baking Characteristics

Table 14 shows the baking time for the pure cakes and their composites with wheat flour. Pulp based cakes took longer to bake than the wheat flour cake. This could have been due to the high moisture content of the pulp based batter that had to be removed before the structure of the cake was firm.and the crust dry enough to become brown. Addition of wheat flour however, reduced the baking time. The temperature in the centre of all the types of cakes ranged between 85.0°C and 86.5°C.

5.3.2: Cake Volume:

Table 15 shows the volumes of cakes made from the pulps of cassava and sweet potato and their composites with wheat flour. Pure pulp cakes had much lower volumes than the wheat flour cake, with cassava pulp cakes generally having slightly higher volumes than sweet potato pulp cakes. The lower volumes for root pulp cakes were expected because root crops unlike wheat flour lack the characteristic gluten formation that entraps most of the gas generated by baking powder during baking hence increasing the cake volume. Addition of wheat flour to the root pulp however,increased cake volume but this increase was more noticeable on addition of 50 than 20% wheat flour as illustrated in Figure 6.

Table 14: Baking time for cassava,sweet potato pulp wheat flour composite cakes(Min)[a]

Cake type	% wheat flour in cake		
	0	20	50
Cassava:			
cv. Serere	50.0 ± 1.2	48.3 ± 1.6	40.1 ± 1.3
cv. Dorika	49.5 ± 1.1	48.6 ± 2.0	41.9 ± 0.9
cv. Namba Munana	49.8 ± 2.6	47.9 ± 1.8	41.6 ± 1.9
Sweet Potato:			
cv. Maseno 14	49.7 ± 1.4	49.0 ± 2.5	40.9 ± 1.7
cv. Bisale	50.9 ± 2.3	49.8 ± 2.0	42.0 ± 2.1

a - Means ± SD (n=3)

Baking time for pure wheat flour cake (control)

= 30.0 ± 0.9 mins.

Table 15: Volume of cassava, sweet potato pulp cakes and their wheat flour composites (cm^3)

Cake type	% Wheat flour in cake	Mean volume *
Wheat	100	154.0 a
Cassava		
cv: Serere	0	97.2 f
	20	112.0 d
	50	134.0 b
cv: Dorika	0	106.0 e
	20	113.0 d
	50	135.0 b
Sweet potato: cv: Maseno 14	0	84.0 h
	20	94.4 g
	50	124.1 c
cv: Bisale	0	75.1 i
	20	84.0 h
	50	122.0 c

* n = 3

Means with the same letter were not significantly different at $P > 0.05$ by Duncan's Multiple Range test.

Fig.6. Cassava, Sweet potato pulp/wheat flour composite

50% Sweet potato pulp
50% wheat flour

5.3.3: Extent of starch gelatinization:

The ratio of arbsobance at 600 nm, of the starch-iodine complex obtained in aqueous (A_1) to alkaline (A_2) extracts of cake crumbs expressed as a percentage was used as a measure of the extent of starch gelatinization and the results are presented in Table 16.

The extent of starch gelatinization differed between all types of cakes with sweet potato cakes having the highest percent gelatinization followed by cassava cakes and lastly the wheat flour cake. Significant differences were also observed between the two sweet potato cultivars with cv. Bisale having a higher percent gelatinization than cv. Maseno 14. These variations could be explained in terms of differences in their starch contents and pre-baking water content. Pulp based recipes had more water and this coupled with longer baking time at high moisture levels also favoured starch gelatinization in the pulp based cakes.

Addition of 20 or 50% wheat flour to the pulps reduced the extent of gelatinization due to reduced baking time and an increase in starch concentration which limits the available water.

Table 16: Extent of starch gelatinization in cassava, sweet potato and their wheat flour composite cakes[a]

Cake type	% wheat flour in cake	Extent of gelatinization %
Wheat flour	100	48.01 ± 2.33
Cassava:		
cv. Serere	0	55.75 ± 1.09
	20	52.39 ± 0.09
	50	49.89 ± 1.88
cv. Dorika	0	54.99 ± 1.53
	20	52.55 ± 2.01
	50	50.81 ± 3.02
Sweet Potato:		
cv. Maseno 14	0	63.82 ± 2.53
	20	59.33 ± 2.00
	50	55.23 ± 1.09
cv. Bisale	0	69.93 ± 0.92
	20	68.02 ± 1.83
	50	52.20 ± 0.97

a-Means ± SD n=3

5.3.4: Cake crumb penetration resistance

Crumb resistance to penetration by a standard probe and constant force was used as an indication of cake tenderness or firmness such that the higher the resistance, the firmer the cake. Cakes were wrapped in polythen paper bags before storage. Table 17, shows the penetration resistance as a fuction of storage time for the pulp cakes in comparison with a wheat flour cake. A graphical presentation of the same data is shown in Figure 7, while the change in moisture content of the cakes as a function of time is shown in Fig 8.

After half an hour of storage, the pure wheat flour cake had the highest penetration resistance followed by cassava cakes and lastly sweet potato cakes, indicating that the pulp cakes were initially more tender than the wheat flour cake. The greater tenderness in sweet potato was expected because sweet potato starch swells less than either cassava or wheat starch. In addition, the the high amount of amylolytic enzymes in sweet potato caused hydrolysis of most of the starch to sugars altering its water binding capacity such that it bound and absorbed less water. Therefore there was more free moisture in sweet potato cakes than in cassava or wheat flour cakes as indicated by Figure 8. Hydrolysis also increased the total sugar content and sugar is known to have a tenderizing effect on the cake crumb.

Table 17: Cake crumb penetration resistance of cassava, sweet potato pulp and their wheat flour composite cakes. (Kg/cm²)[a]

Cake type	% wheat flour in sample	Penetration Resistance				
		Half hour	1 day	3 days	5 days	7 days
Wheat flour	100	0.28 ± 0.18	0.40 ± 0.05	0.46 ± 0.23	0.46 ± 0.12	0.52 ± 0.19
Cassava:						
cv. Serere	0	0.23 ± 0.09	0.40 ± 0.01	0.50 ± 0.15	0.60 ± 0.09	0.60 ± 0.06
	20	0.24 ± 0.01	0.44 ± 0.11	0.60 ± 1.00	0.61 ± 0.13	0.61 ± 0.04
	50	0.27 ± 0.02	0.45 ± 0.87	0.55 ± 0.96	0.63 ± 0.08	0.63 ± 0.14
cv. Dorika	0	0.23 ± 0.04	0.44 ± 0.10	0.50 ± 0.06	0.59 ± 0.02	0.60 ± 0.12
	20	0.23 ± 0.11	0.43 ± 0.09	0.55 ± 0.21	0.65 ± 0.10	0.60 ± 0.08
	50	0.25 ± 0.02	0.35 ± 0.01	0.60 ± 0.08	0.60 ± 0.21	0.62 ± 0.12
Sweet Potato:						
cv. Maseno 14	0	0.19 ± 0.07	0.30 ± 0.11	0.39 ± 0.04	0.40 ± 0.22	0.40 ± 0.10
	20	0.20 ± 0.03	0.31 ±0.05	0.40 ± 0.01	0.41 ± 0.08	0.43 ± 0.09
	50	0.25 ± 0.08	0.32 ± 0.07	0.45 ± 0.65	0.46 ± 0.92	0.48 ± 0.06
cv. Bisale	0	0.12 ± 0.11	0.25 ± 0.13	0.32 ± 0.10	0.37 ± 0.08	0.40 ± 0.05
	20	0.15 ± 0.01	0.25 ± 0.07	0.35 ± 0.06	0.40 ± 0.03	0.41 ± 0.12
	50	0.20 ± 0.07	0.32 ± 0.02	0.40 ± 0.01	0.41 ± 0.14	0.42 ± 0.09

+[a] - Means ± SD n = 4

Fig.7. Cake crumb penetration resistance for cassava, sweet potato and wheat flour cakes as a function of storage time.

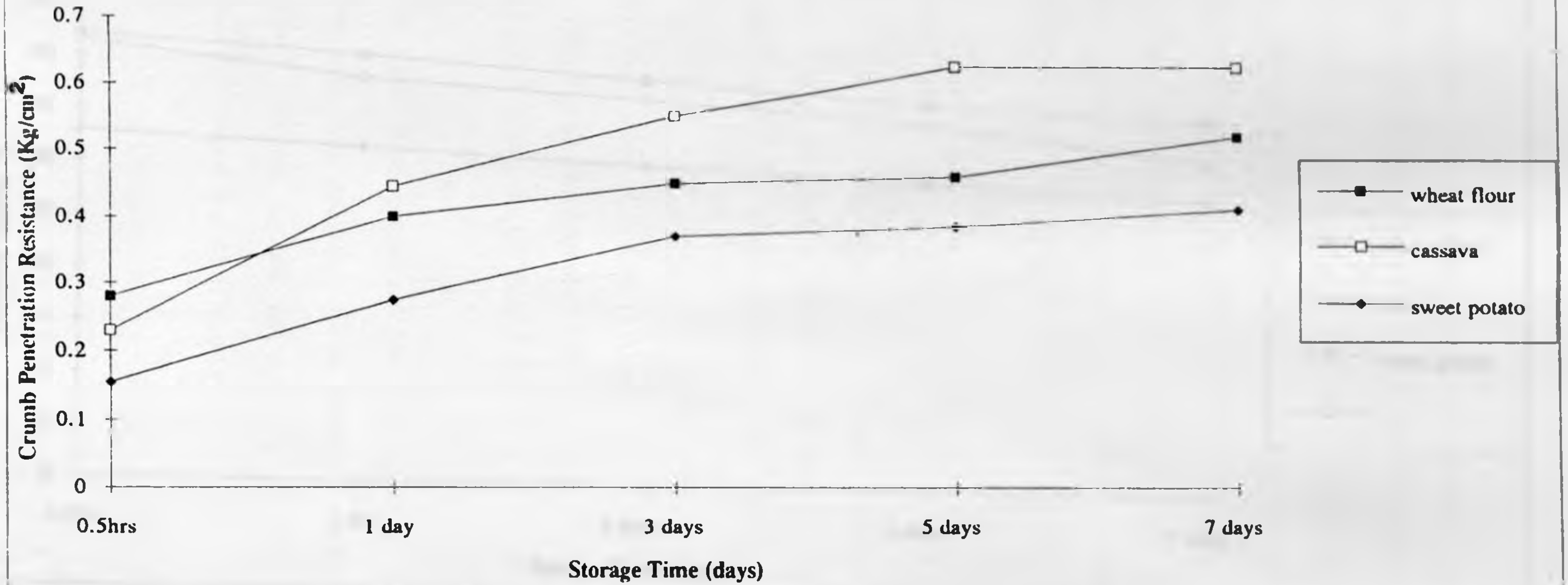
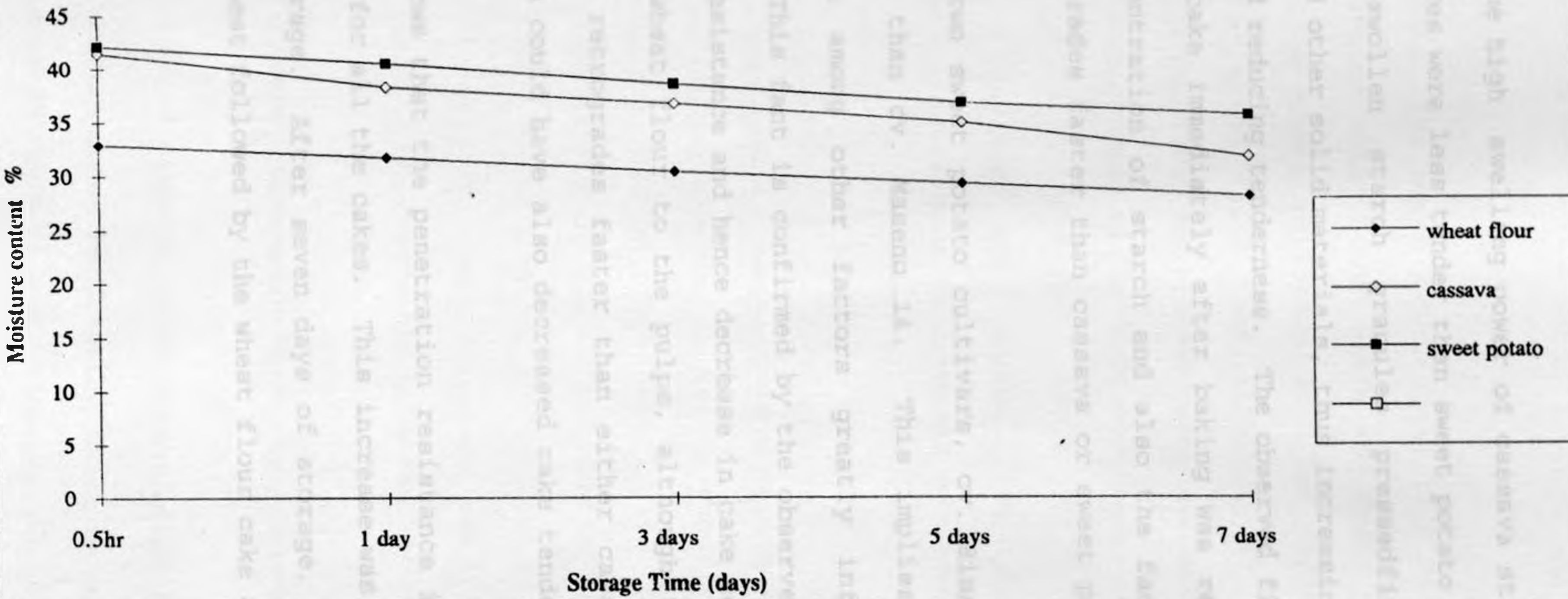


Fig.8. Changes in the moisture content of wheat flour, sweet potato and cassava cakes with storage time



Due to the high swelling power of cassava starch, cassava pulp based cakes were less tender than sweet potato cakes because the highly swollen starch granules pressedfirmly amongst themselves and other solid materials, thus increasing penetration resistance and reducing tenderness. The observed firmness of the wheat flour cake immediately after baking was related to the greater concentration of starch and also the fact that wheat starch retrogrades faster than cassava or sweet potato starch.

Of the two sweet potato cultivars, cv. Bisale gave more tender cakes than cv. Maseno 14. This implies that starch concentration among other factors greatly influences cake tenderness. This fact is confirmed by the observed increase in penetration resistance and hence decrease in cake tenderness with addition of wheat flour to the pulps, although the fact that wheat starch retrogrades faster than either cassava or sweet potato starch could have also decreased cake tenderness.

Figure 7. shows that the penetration resistance increased with storage time for all the cakes. This increase was greater after 1 day of storage. After seven days of storage, cassava cakes were the firmest followed by the wheat flour cake and lastly the

sweet potato cake. The sweet potato cake retained more moisture than the cassava or wheat flour cakes and hence remained tender during storage as shown in Figure 8. The cassava cake became firmer than the wheat flour cake although the wheat cake was initially the firmest of the three cakes as mentioned earlier. This may have been because of the high solubility in cassava starch (Keya, 1985; Keya and Hadziyev, 1987), which results in the release of more amylose that crystallizes outside the starch granules and contributes more to firmness in crumb texture during storage.

Several investigators have cited the importance of other factors such as recipe components, mainly sugar and fat (Sultan, 1986), starch gelatinization properties (pyler, 1979), prebaking water content and extent of starch gelatinization (Lineback and Wongsrikasem, 1980), in determining the texture of baked products. However, cake mixtures are complex systems and it is difficult to pin point the factor that exerts the greatest influence on texture.

5.3.5: Cake crumb microstructure by Scanning Electron Microscopy.

Crumb surfaces of cassava, sweet potato,wheat flour cakes and their composites as shown by Scanning Electron Microscopy (SEM) are presented in Figures 9a and 9b respectively. The pictures of pure pulp crumbs show extensively swollen starch granules coated with a protein film and forming a compact structure, without any air spaces. On the contrary the picture of the wheat flour cake crumb shows some air spaces. This indicated by the dark space slightly to the left of picture e. Note that dark spaces in pictures a,b,c, are shadows of swollen pulp material and not air spaces. This implies that pulp based cakes should be firmer than a wheat flour cake.

Inspite of their extensive swelling, sweet potato starch granules seem to have more space to swell into during gelatinization in the presence of adequate water and they do not appear to press firmly gainst each other as in the case of the starch granules in the cassava cake crumb. Hence the lower penetration resistance and greater tenderness in sweet potato cakes.Addition of wheat flour to the pulp cakes improved their crumb structure as air cells became visible. The air cells are indicated by the dark spaces in pictures g,h and j. The centre of picture i is also an air cell lined with swollen pulp material. Although this was expected to increase cake tenderness it was not the case as shown by the results of crumb resistance to penetration which increased with addition of wheat flour. This implies that other factors such as starch concentration and starch retrogradation properties besides crumb structure also affect cake tenderness.

Figure 9a. Scanning Electron Micrographs of cassava (a-x500; b-x1,000),sweet potato (c-x500; d-x1,000) and wheat flour (e-x500; f-x1,000) cake crumbs.

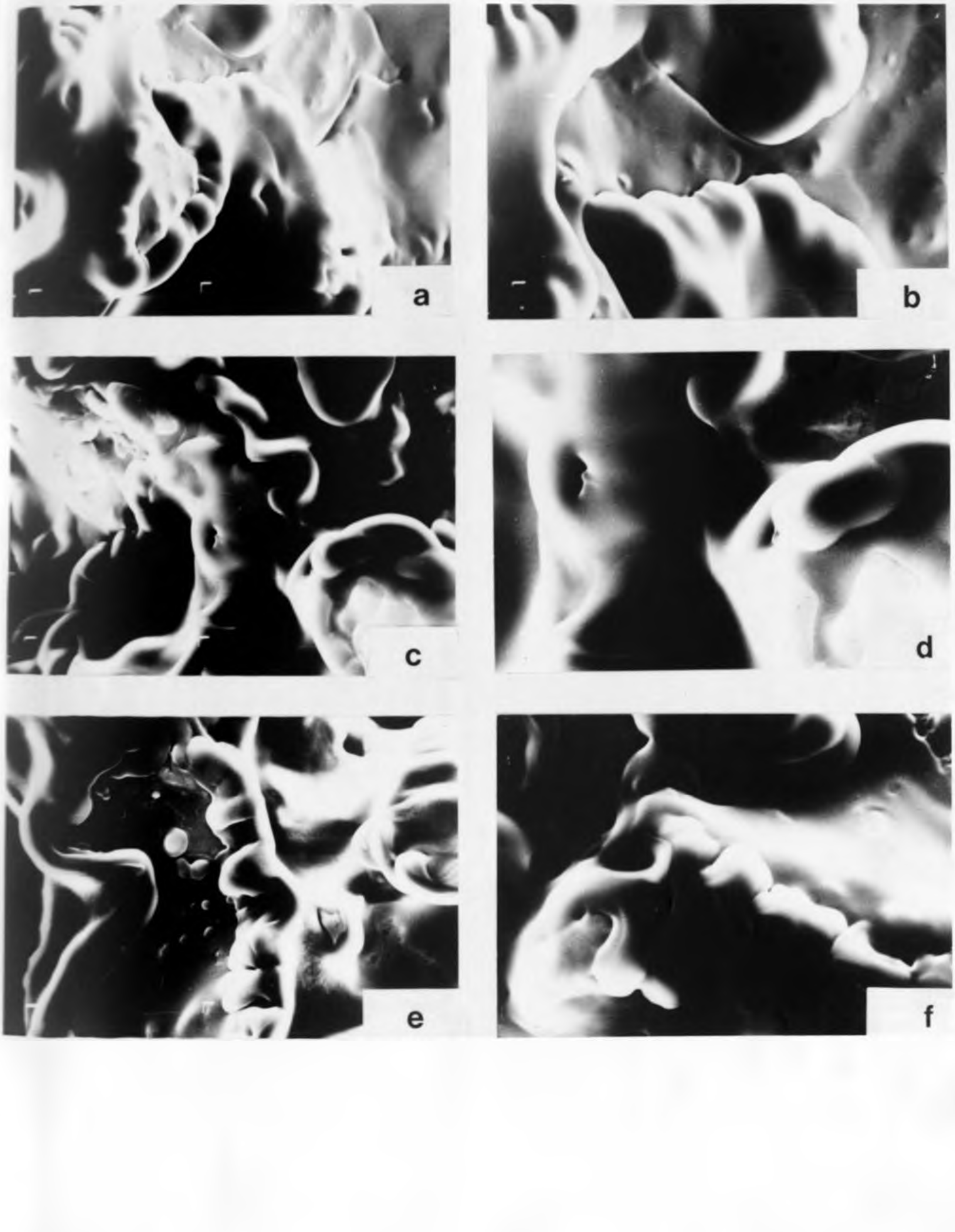

a
b
c
d
e
f

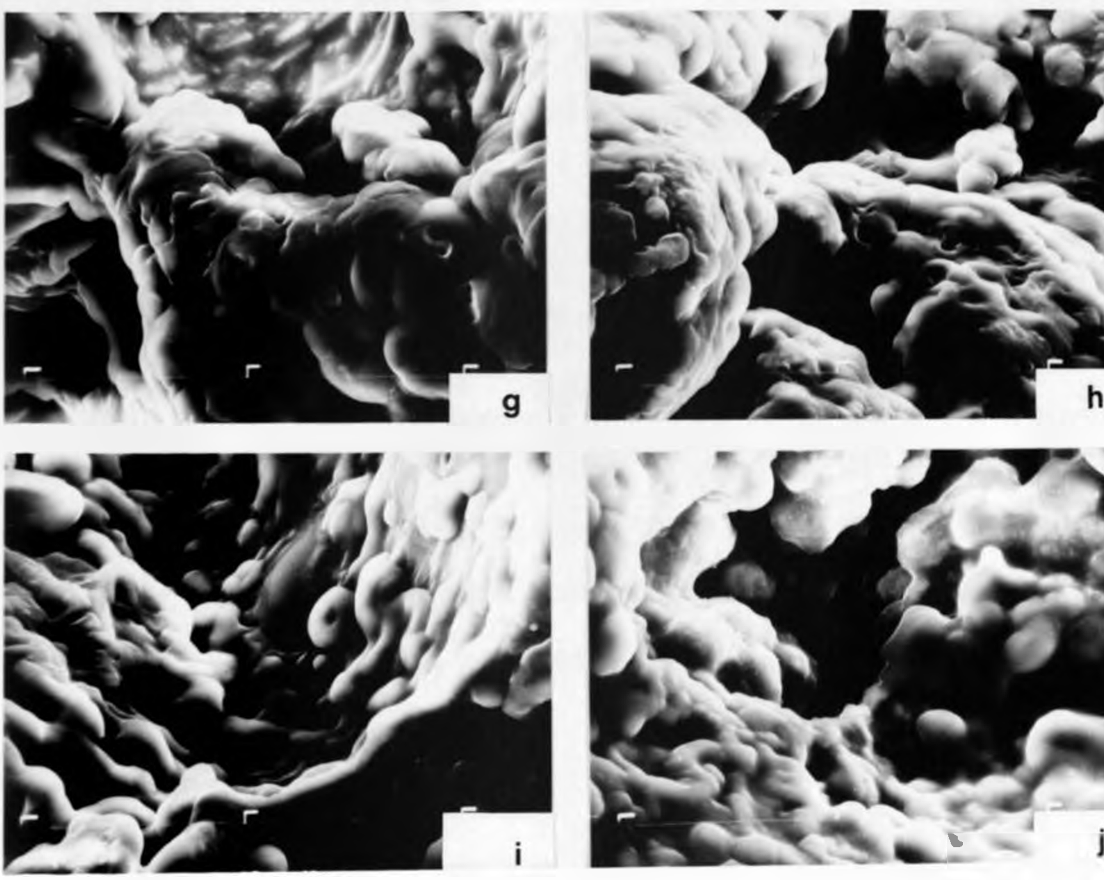
Figure 9b. Scanning Electron Micrographs of the cake crumbs of cassava, sweet potato and their wheat flour composites (x-500).

g - cassava (80 %) + wheat flour (20 %).

h - cassava (50 %) + wheat flour (50 %).

i - sweet potato (80 % + wheat flour (20%).

j - sweet potato (50 %) + wheat flour (50 %).


g
h
i
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5.3.6: Sensoric cake quality evaluation.

The panelists mean scores for texture, crust and crumb colour, flavour and overall acceptability of root pulp cakes and their composites with wheat flour are presented in Table 18a, while Table 18b shows the analysis of variance amongst the above quality attributes.

The null hypotheses tested were:-

1. There were no significant differences due to treatments, in the cake quality attributes evaluated.
2. Panelists did not differ significantly in their perception of differences in the quality attributes evaluated.

The F-calculated value for colour of cakes was greater than the F-tabulated values both at 95 and 99% levels of significance showing that significant differences existed in the colour of the different types of cakes. The wheat flour cake received the highest score and was liked very much, while the colour of pure pulp cakes was also acceptable.

Table: 18a. Mean Sensory scores for cassava, sweet potato pulp/wheat flour composite cakes*.

Type of Cake	Colour (Crust & crumb)	Texture	Taste & Flavor	Overall acceptability
Pure wheat flour	8.66 a	8.733 a	9.00 a	8.93 a
Cassava: cv. Serere I	7.26 b,c	6.40 d	5.60 e	6.20 d
cv. Serere II	7.06 b,c,d	7.26 c	6.07 d,e	6.53 c,d
cv. Serere III	6.93 b,c,d	8.12 b	6.73 c,d	8.20 b
cv. Dorika I	6.60 c,d	6.07 d	6.20 d,e	6.13 d,e
cv. Dorika II	6.60 c,d	6.47 d	6.33 c.d,e	6.47 c,d
cv. Dorika III	6.86 c,d	8.00 b	7.73 b	8.00 b
Sweet potato:				
cv. Maseno 14 I	6.40 d	6.00 d	7.07 c,b	6.80 c
cv. Maseno 14 II	6.80 c,d	6.07 d	6.67 c,d	6.47 c,d
cv. Maseno 14 III	7.27 b,c	8.00 b	7.80 b	8.07 b
cv. Bisale I	6.40 d	5.13 e	6.40 c,d	5.60 e
cv. Bisale II	7.20 c,b	6.13 d	6.47 c,d	5.60 e
cv. Bisale III	7.67 b	7.20 c	7.53 b	8.13 b

* - Means of 15 responses
I - Pure pulp
II - 80% pulp + 20% wheat flour
III - 50% pulp + 50% wheat flour
Note: Means in the same column with the same letter did not have any significant difference between them at p > 0.05 by Duncan's Multiple range test.

Table: 18b Analysis of variance for cake quality scores.

Quality attributed	Source of variation	Degree of freedom	Sum of squares	Mean square	F Value		
					Calculated	95%	99%
Colour (Crust & Crumb)	Cake type	12	67.046	5.587	6.50	1.75	2.18
	Panelists	14	8.995	0.642	0.75	1.67	2.04
	Error	168	144.338	0.859			
	Total	194	220.379				
Texture	Cake type	12	183.538	15.005	27.20	1.75	2.18
	Panelists	14	14.071	1.005	1.79	1.67	2.04
	Error	168	94.461	0.562			
	Total	194	292.071				
Flavour	Cake type	12	150.871	12.573	14.22	1.75	2.18
	Panelists	14	7.35	0.525	0.59	1.67	2.04
	Error	168	148.512	0.884			
	Total	194	306.738				
Overall acceptability	Cake type	12	221.046	18.420	36.04	1.75	2.18
	Panelists	14	11.056	0.789	1.54	1.67	2.04
	Error	168	85.876	0.511			
	Total	194					

Addition of wheat flour to cassava cakes did not significantly change their colour as shown by the mean scores of the pure cassava and the cassava/wheat flour composite cakes (Table 18a) which did not differ significantly at 95% level of significance by Duncan's Multiple Range Test. However, for sweet potato cakes addition of 20% wheat flour slightly improved their colour.

Insignificant variability in the panelists abilities to detect differences in the colour of cakes was observed at both 95 and 99% levels of significance. The texture of the different types of cakes was also found to differ significantly at both 95 and 99% levels as the calculated F value for texture was higher than the tabulated value. The wheat cake again received the highest score while the pure pulp cakes received lower scores although their texture was still acceptable. No significant differences existed in the texture of cakes made from the two cassava cultivars used in the study as determined by Duncan's Multiple Range Test. But significant differences were observed between the texture of cakes from the sweet potato cultivars. Cakes from cv. Bisale had a poor texture in comparison to cakes from cv. Maseno 14. The pulp of cv. Bisale had earlier been found to have a low starch content which could have contributed to the poor texture.

Starch concentration greatly affects paste viscosity during gelatinization (which occurs during baking) and it has been found that starches with higher paste viscosity have superior baking qualities than starches of low paste viscosities (Pyler, 1973). In addition the presence of α-amylase in large quantities in the pulp of this cultivar may have led to the hydrolysis of most of the starch altering some important properties such as swelling power and water binding capacity that greatly contribute to the texture of the cake.

Addition of 20 or 50% wheat flour improved the texture of the pulp cakes as shown by an increase in the mean scores. Wheat flour provided the essential gluten which helped to retain most of the gas generated resulting in cakes of good texture. Panelists differed significantly at 95% level in their ability to perseive differences in the texture of the cakes. This difference however became insignificant at 99% level which is a more relaxed level of significance. The flavour of sweet potato cakes was more preffered than that of cassava cakes, probably because sweet potato has a characteristic flavour that may have been liked by many of the panelists while cassava is blunt in flavour. Addition of wheat flour again improved the flavour of all the pulp cakes. Differences in the panelists ability to perceive differences in the flavour of cakes were insignificant at both levels of significance.

The overall acceptance of the cakes also differed significantly at the two levels of significance. From the Duncan's Multiple Range Test, the cakes can be grouped into different categories with cakes in the same category having no significant differences between them.

The groupings are:

1. Wheat flour cake which was liked extremely
2. Cakes of both cassava and sweet potato cultivars made from 50% pulp 50% wheat flour. These cakes were liked very much.
3. Cakes made from pure pulps and from 80% pulp and 20% wheat flour for cassava cv. Dorika and sweet potato cv. Maseno 14. These cakes were liked moderately.
4. Cakes made from pure sweet potato pulp cv. Bisale and 80% of the same pulp and 20% wheat flour. These were only slightly liked.

It can therefore be concluded that addition of upto 50% wheat flour to root pulps greatly enhanced their overall acceptance, and that cassava pulps generally made better quality cakes than sweet potato cakes.

Panelists did not differ significantly in their responses to cake overall acceptability at both 95 and 99% levels of significance. Since texture had the greater F-value it can be assumed that it was the quality attribute that contributed more to the quality differences among the different types of cakes.

5.3.7: Cake chemical composition:

Table.19 shows the chemical composition of pure cassava and sweet potato pulp in comparison with a pure wheat flour cake. A comparison of this composition with the initial chemical composition of the pulps before baking shows a marked increase in most of the nutrient components except moisture and starch which decreased on baking.

The total sugar contents of sweet potato cakes were higher than cassava cakes as shown in Table 19, although the sweet potato cakes had lower amounts of sugar in their recipes. This shows that there was greater conversion of starch to sugars in sweet potato cakes by the inherent amylolytic enzymes. This fact is confirmed by the higher starch content of cassava cakes than sweet potato cakes. The high sugar content may have contributed in part to the greater liking of the flavour (taste and smell) of sweet potato cakes than cassava cakes.

The results showed a marked increase in Crude fat, Ash and Crude protein contents of the pulp based cakes, which could be attributed to the addition of some recipe components mainly shortening, milk and eggs. This therefore shows that cake making can greatly improve the nutritional quality of cassava and sweet potato.

Table 19 : The chemical composition of cassava, sweet potato and wheat flour cakes (gm/100gm[a])

Cake type	Moisture	Total sugars	Crude Fat	Ash	Crude fibre	Starch	Protein
Cassava: cv. Serere	41.65 ±0.24	13.33 ±0.24	12.76 ±0.20	2.13 ± 0.11	4.82 ±0.07	20.76 ±2.91	3.10 ±1.01
cv. Dorika	41.22 ±2.85	13.50 ±0.58	13.94 ±0.12	2.18 ±0.20	4.95 ±0.11	21.92 ±1.81	3.15 ±1.01
Sweet Potato: cv. Maseno 14	42.03 ±1.43	23.30 ±0.33	12.61 ±0.64	2.50 ±0.06	2.35 ±0.24	9.58 ±0.14	4.00 ±0.18
cv. Bisale	42.20 ±1.77	24.18 ±1.02	12.66 ±0.45	2.42 ±0.18	2.23 ±0.04	8.70 ±0.23	4.73 ±0.12
Wheat flour	33.59 ±1.22	25.30 ±0.92	16.74 ±0.71	2.04 ±0.05	1.33 ±0.07	11.77 ±0.97	7.23 ±1.53

a-Means ± SD (n=3)

5.3.8. Cake storage stability:

The shelf-lives of pure cassava, sweet potato and a wheat flour cake as indicated by the number of days before signs of spoilage appeared, are shown in Table 20. (Pure pulp cakes had earlier been treated with o.5% citric acid in order to reduce the pH). Figures 10a, 10b and 10c show the changes in the microbial loads of cakes wrapped in polythene bags and stored at room temperature, refrigeration temperature and in a deep freezer, respectively for a period of upto 14 days.

At room temperature, the cassava and sweet potato cakes had shorter shelf-lives than the wheat flour cake probably due to the high moisture content and a favourable temperature that allowed growth of spoilage microorganisms. Refrigeration at 4^{0}C increased the cakes shelf-life from about 5 days to about 10 days while deep freezing further increased the shelf-life to over 14 days.

The type of spoilage observed at room temperature was mainly due to moulds and bacteria that caused stickiness of the crumb and off-odours (Table 20). For both cassava and sweet potato cakes, microscopic examination, gram stain and spore test done on a sample of the cake crumbs after 5 days of storage at room temperature showed the presence of gram +ve, rod-shaped spore forming bacteria.

Table 20: Shelf-life of cassava, sweet potato and wheat flour cakes at room temperature, refrigeration (+4°c) and deep freezing.

Type of cake	Storage condition	Days before spoilage	Type of spoilage
Cassava: cv. Serere	Room temp.	5	Mould growth off-odours, sticky crumb
	Refrigeration(+4°C)	10	Mould growth
	Deep freezing	>14	No signs of spoilage
cv. Dorika	Room temp.	5	Mould growth, sticky crumb
	Refrigeration(+4°C)	10	Moulds and yeasts growth
	Deep freezing	>14	No signs observed
Sweet potato: cv. Maseno 14	Room temp.	4 to 5	Mould growth, off-odours, sticky crumb, Brown spots on crumb
	Refrigeration(+4°C)	8	Mould growth, off-odours
	Deep freezing	>14	No signs observed
cv. Bisale	Room Temp.	4 to 5	Mould growth, off-odours, sticky crumb with brown spots
	Refrigeration (+4°C)	8	Moulds and yeasts, off-odours
	Deep freezing	>14	No signs observed
Wheat flour	Room Temp	7	Mould growth
	Refrigeration(+4°C)	>14	No signs observed
	Deep freezing	>14	No signs observed

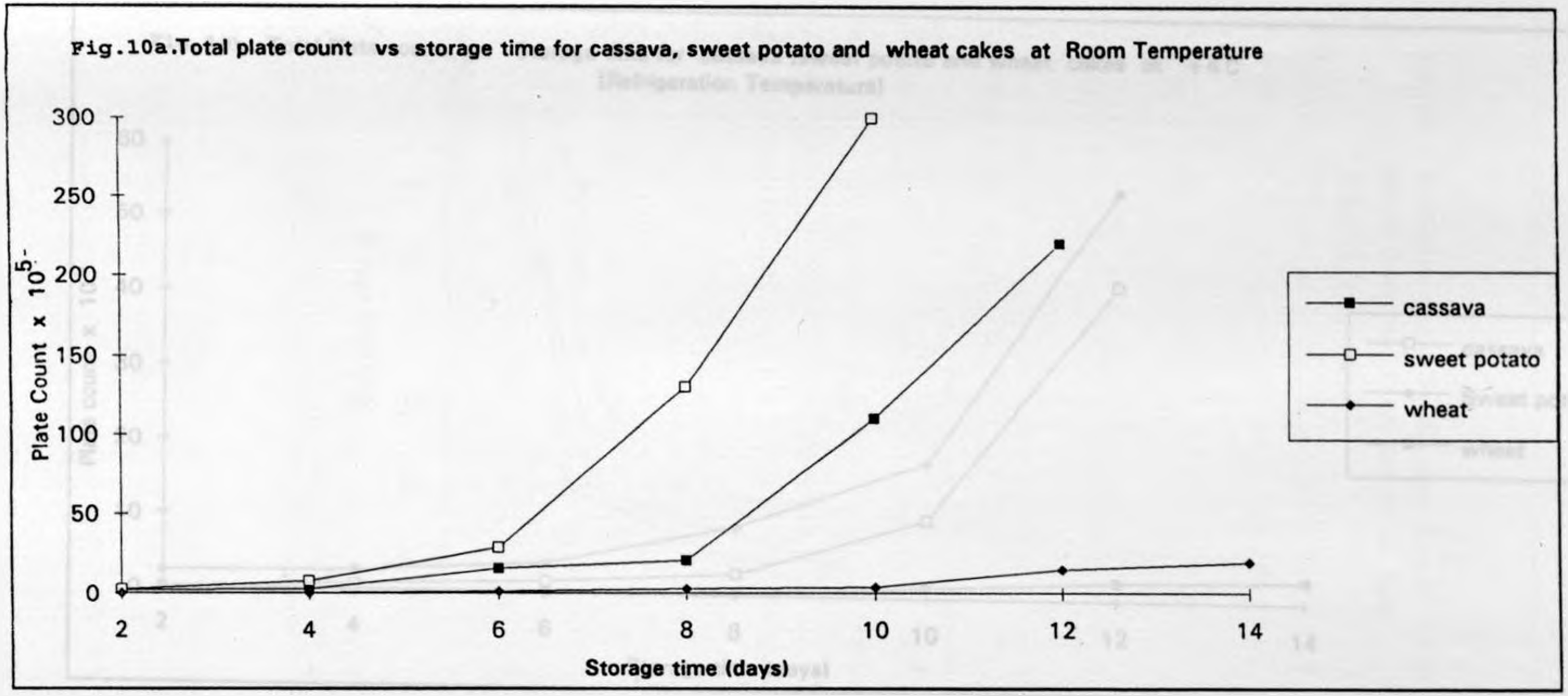


Fig.10a.Total plate count vs storage time for cassava, sweet potato and wheat cakes at Room Temperature
300
250
200
150
100
50
0
Plate Count x 10^5-
2
4
6
8
10
12
14
Storage time (days)
cassava
sweet potato
wheat

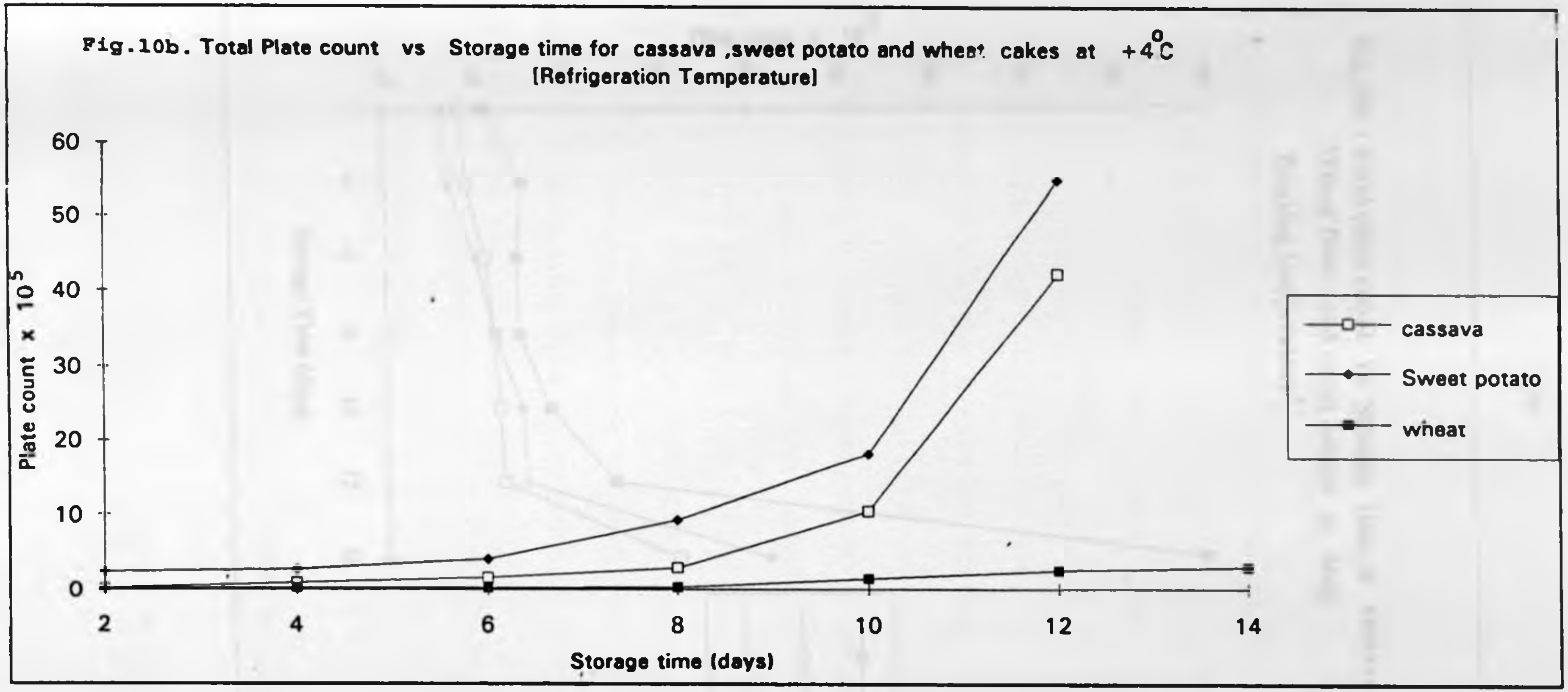
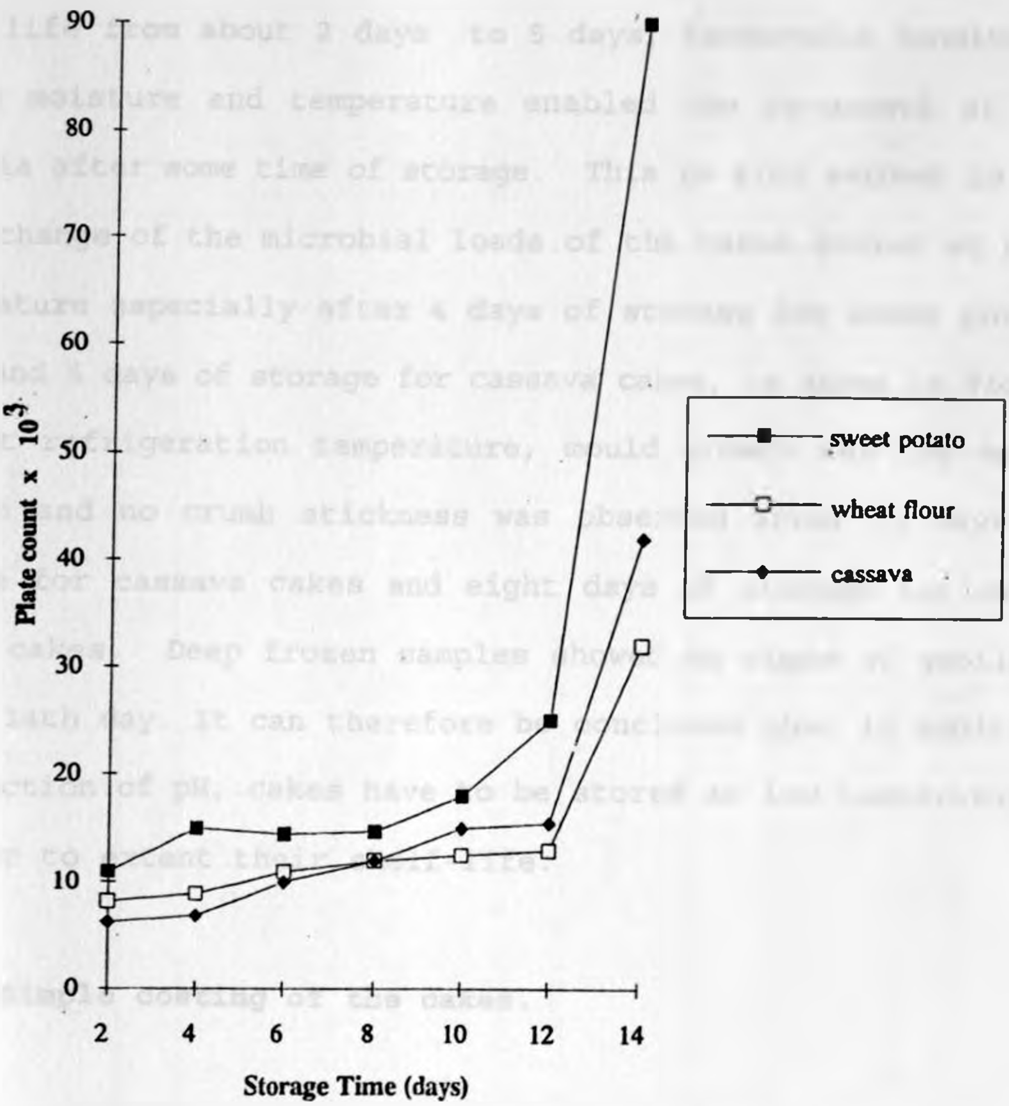


Fig.10b. Total Plate count vs Storage time for cassava ,sweet potato and wheat cakes at +4°C
[Refrigeration Temperature]
60
50
40
30
20
10
0
Plate count x 10^5
2
4
6
8
10
12
14
Storage time (days)
cassava
Sweet potato
wheat

Fig.10c : Total plate count Vs Storage time of cassava, Wheat flour and sweet potato at deep freezing temperature



This showed that although reduction of pH had earlier been found to suppress germination of spores, and extend the cake's shelf-life from about 2 days to 5 days, favourable conditions mainly moisture and temperature enabled the re-growth of the bacteria after some time of storage. This is also evident in the rapid change of the microbial loads of the cakes stored at room temperature especially after 4 days of storage for sweet potato cakes and 5 days of storage for cassava cakes, as shown in Figure 10a. At refrigeration temperature, mould growth was the major problem and no crumb stickness was observed after 10 days of storage for cassava cakes and eight days of storage for sweet potato cakes. Deep frozen samples showed no signs of spoilage by the 14th day. It can therefore be concluded that in addition to reduction of pH, cakes have to be stored at low temperatures in order to extent their shelf-life.

5.3.9: Simple costing of the cakes.

Tables 21 t0 23 show the input costs for cassava, sweet potato and wheat flour cakes respectively. The tables show that it is cheaper to produce cassava and sweet potato cakes than a wheat flour cake.

Table 21: Input cost for a cassava cake.

Item	Cost (KShs.)
300gm Pulp @ 5.00 per Kg root	2.14
65.0gm Sugar @ 20.00 per Kg.	1.30
65.0gm Shortening @ 30.00 per Kg	1.95
3 Eggs @ 2.50	7.50
12.5gm Milk powder @ 98.50 per Kg	1.23
9gm baking powder @ 10.00 per 50gm	1.80
Total	15.92

Approximate cost of ingredients for a cassava cake = 16.00 per 390gm of cake Produced.

Therefore, price per Kg of cake =Ksh. 41.02

Table 22: Input cost for a sweet potato cake:

Item	Cost (Kshs.)
300gm pulp @ 5.00 per Kg root	2.00
50.0gm Sugar @ 20.00 per Kg	1.00
50.0gm Shortening @ 30.00 per Kg	1.50
3 Eggs @ 2.50	7.50
13.8gm Milk powder @ 98.50 per Kg	1.35
9gm Baking powder @ 10.00 per 50gm	1.80
Total	15.15

Approximate cost of ingredients for a sweet potato cake ≈ 15.00 per 370gm of cake produced.

Therefore, price per Kg of cake = Kshs. 40.50

Table 23: Input cost for a wheat flour cake.

Item	Cost (KShs.)
225gm Wheat flour @ 20.00 per Kg	4.50
200gm Sugar @ 20.00 per Kg	4.00
150gm Shortenning @ 30.00 per Kg	4.50
3 Eggs @ 2.50 per egg	7.50
101ml liquid Milk @ 6.50 per litre	0.65
9gm Baking powder @ 10.00 per sign	1.80
Total	24.45

Approximate cost of ingredients for a wheat flour cake = 24.45 per 400gm of cake.

Therefore, price per Kg of cake = 61.12

= KShs. 61.00

CONCLUSIONS:-

From the results of the study, it can be concluded that:-

(i) Fresh pulps of cassava and sweet potato have characteristics that render them suitable for direct processing into cakes. Although the cakes were not of the same quality as the wheat flour cake they were still acceptable and could serve as cheaper substitutes for the costly wheat flour cakes.

(ii) Cake quality was affected by the type of root crop, cultivar, starch content, diastatic activity and the degree of comminution among other factors. Cassava pulps made more acceptable cakes than sweet potato pulps. The high diastatic activity in sweet potato pulps adversely affected their baking performance by influencing some important physical properties of starch such as gelatinization and swelling power. In order to produce cakes of good texture the pulp structure should be fine with average particle size of approximately 500 μm. Although finer particle size would also suitable, this would increase proccessing costs due to longer comminution time.

(iii Enzymatic browning in sweet potato pulp can be effectively controlled by addition of either 0.5 % citric acid, 0.5 % sodium metabisulphite or pre-cooking for 10 min. at 70°c. However it would be preferable to use citric acid as it has the additional advantage of extending cake shelf life by lowering the pH of the pulp and therefore preventing growth of some spoilage micro-organisms.

(iv) The pulp making process together with baking can greatly reduce cassava cyanide toxicity. The complete rupture of cells, enables maximum contact between the enzyme linamarase and the cynogenic glucosides. In order for this process to be effective, there is need to store the pulps for some time before baking. In this study, baking the pulps after 0.5 and 2 hrs for the low and medium cyanide cultivars respectively resulted in over 70% reduction in the cyanogenic glucoside content.

(v) Besides improving the nutrient content of cassava and sweet potato, baking cakes direct from their fresh pulps would save the resources and time required for making flour first. The technique would also encourage greater consumption of the two root crops by urban and rural consumers which have been neglected in favour of the more sophisticated foreign processed foods.

RECOMMENDATIONS:

(I) Although the cake making process improved the nutrient content of cassava and sweet potato, further investigations should be carried out to verify the nutritional value of the cakes.

(ii) The recipes recommended in this study could be further improved to produce a variety of better quality cakes. The possibility of making other products such as biscuits, bread etc from the pulps of cassava and sweet potato could be investigated in order to increase the range of their processed products.

(iii) Incorporation of legume flours such as soybean flour as a means of further increasing the protein content of the root crops could be investigated.

(iv) This technique should be verified under local conditions and taking into account the cultural and socio-economic limitations.

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APPENDIX 1: Score sheet for cake sensory evaluation.

Name................................... **Date..../..../19..**

Please look at and taste the cake samples presented to you and indicate your degree of liking for Colour, Taste (including flavour), Texture, and overall acceptability of each sample on the basis of the following scale:-

9 - Like extremely

8 - Like very much

7 - Like moderately

6 - Like slightly

5 - Neither like nor dislike

4 - Dislike slightly

3 - Dislike moderately

2 - Dislike very much

1 - Dislike extremely.

Place the number matching your degree of liking for each quality attribute in the corresponding box for each sample.

Sample code:					
Colour					
Taste					
Texture					
Overall acceptability					

Comments:...