STUDIES ON THE DEVELOPMENT OF PALM PULP POWDER

BY

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A C K N O W L E D G E M E N T S

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Thank you.

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CHAPTER ONE

GENERAL INTRODUCTION

INTRODUCTION

The pulp of the palm fruit (*Elaeis guineensis* Jacg) is widely used in Ghana and other African countries in the preparation of various local dishes. In order to extract the pulp used in the preparation of these dishes, the fruits are removed from the bunches, boiled, pounded, mixed with warm water and pressed in a seive to express the pulp from the fibres. This exercise is time consuming, has high fuel consumption and requires a lot of labour. These disadvantages can be eliminated if dehydrated palm pulp in the form of a powder can be produced as a convenient product to be utilized in the preparation of the local dishes.

Attempts have been made at preserving the expressed pulp of the palm fruits. Nkulenu Industries have processed a cream from the palm pulp for export. Individuals export the fruits in the form of dried fibres containing the pulp.

The aims of this study are:

i) to produce a standardised dehydrated palm pulp product that can be stored easily and be utilized as a convenient intermediate product in the preparation of local palm fruit dishes, such as palm soup, palm stew, akplidzi etc.

ii) to utilize the dehydrated product as a means of reducing bulk and preserving the fruits which have a high spoilage rate after harvest.

iii) to produce a product convenient for export.

LITERATURE REVIEW

THE PALM FRUIT

The oil palm is a very variable plant. Considerable variations occur in the fruits. The fruit is a sessile drupe which varies in shape from nearly spherical to ovoid or elongated and bulging at the top. The length varies from 2 to 5 cm and the weight from 3g to over 30g. The pericarp consists of the outer exocarp or skin, the mesocarp or pulp and the endocarp or shell. Externally, the fruits vary considerably, particularly when ripening. The most common type of fruit, which includes most of the local West African varieties, is the nigrescence. This is deep violet to black at the apex and colourless at the base before ripening. On ripening the colour varies considerably depending on it's carotene content from entirely red or with a small black or brown halo at the tip to black over the upper half but red at the base. A relatively uncommon type the Virescens is green before ripening and matures into a light reddish-orange, with the apex of the fruit remaining green. There is an extremely rare type the albescens which contains very small quantities of carotene and this may be of virescens or nigrescence.

The most important differences in the internal structures of palm fruits is in the thickness of their shell. The different internal forms are:

i) Dura - which has a shell thickness of 2-8mm with a low to medium (35 - 55%) mesocarp content and no fibre ring. This is the local Ghanaian variety.

ii) Pisifera - which is shell-less.

iii) Tenera - with a shell thickness of $\frac{1}{2}$ to 4mm and a high (60 - 96%) mesocarp content and a fibre ring. This is a hybrid of the dura and pisifera. This form is known locally as the 'Agricultural variety.'

DETERIORATION OF PALM FRUIT

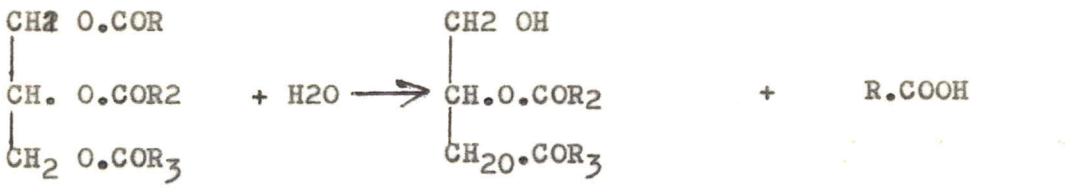
The mesocarp of palm fruit contains fiber, fat, water, vitamins, proteins carbohydrates and minerals. The fat is present mainly as palm oil. Palm oil consists largely of glycerides, the fatty acid components being palmitic, oleic, linoleic and stearic acids, together with small quantities of cartenoid substances.

Deterioration of palm fruits occur through mechanical, chemical and microbial agents.

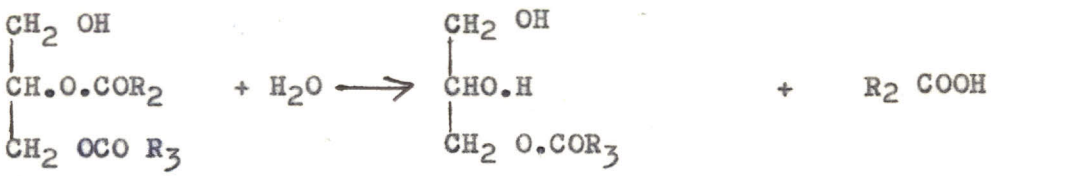
Hydrolysis

The acidity of growing palm fruit is almost zero. However it rises soon after harvest. This is due to the hydrolysis of the glycerides resulting in the formation of free fatty acids (f.f.a) together with varying proportions of mono and di-glycerides. This is one of the most important reactions leading to the deterioration of palm fruits. Fruits of high f.f.a. content are generally considered to be of lower palatability. The f.f.a. fraction of extracted palm oil is roughly proportional to the refining loss during processing other than saponification. Even for soap-making operations which involve total saponification, oils of highest f.f.a's are generally avoided. (D.G. Coursey).

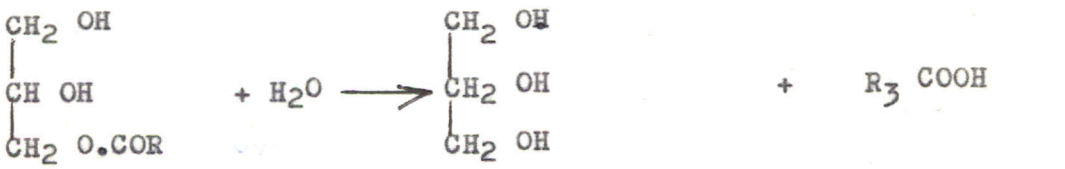
The formation of free fatty acids occur rapidly in palm fruits under the influence of naturally occuring enzymes of the fruit pulp. Physical damage such as bruising of the fruit or plucking of inidividual fruits from the bunch serves to accelerate the reaction by liberating lypolytic enzymes, lipases, from the cells of the pericarp, thereby bringing them into more intimate contact with oil droplets.



Triglyceride Diglyceride Free fatty acid



Diglyceride Monoglyceride Free fatty acid



Monoglyceride Glycerol Free fatty acid

Hydrolysis is also accelerated by the growth of moulds which contain lypolytic enzymes on the fruits. This growth occurs a few days after harvest. Some such lypolytic fungi are Rhizopus, Aspergillus, Penicillum, Trichoderma, Circinella, Cunnignhamella, Fusaruim and Rhoma.

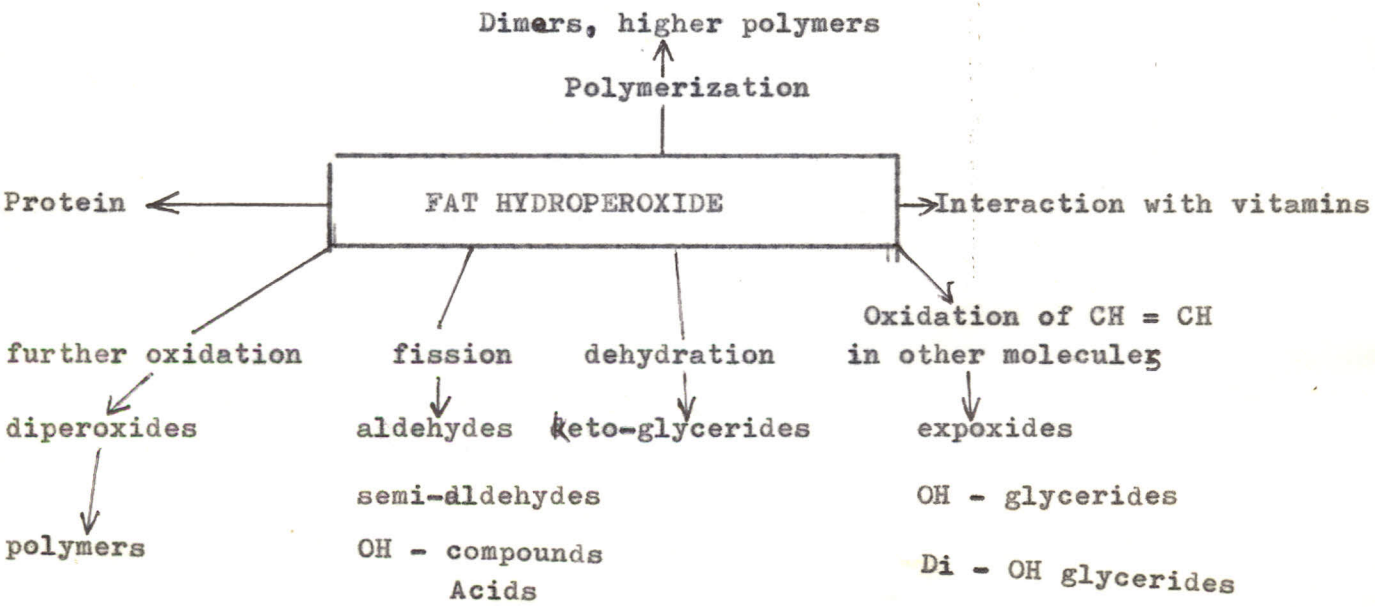
Rancidity

The development of disagreeable odours and flavour, rancidity, is of less importance in the deterioration of palm fruits than hydrolysis. This is due to the high content of natural anti-oxidants and comparably low content of unsaturated fatty acids in palm fruits. It is an oxidative process which occurs either by interaction with atmospheric oxygen (autooxidation) or by the action of lipid oxidative enzymes.

Atmospheric Oxidation (Autooxidation).

Atmospheric oxidation of unsaturated fats is autocatalytic and occurs in 3 stages; initiation, propagation and termination. The initiation step involves the formation of a free radical eg. the removal of a liable hydrogen from a carbon adjacent to a double bond ie. an α-methylene hydrogen, by energy from heat or light. The propagation step involves the free radical attack on the fatty acid removing the most liable hydrogen. This is usually the hydrogen on a methylenic carbon adjacent to a double bond. The resulting radical may yield several hybrid radicals due to stabilization by resonance. Molecular Oxygen then attaches to the resonance hybrid often resulting in a shift of double bond. The initially removed hydrogen then adds on to the attached oxygen of the peroxide resulting in the formation of a hydroperoxide. The free radical peroxide when formed can react with another α-methylenic carbon forming hydroperoxide and another free radical which further propagates the reaction. The termination stage involves the reaction of two radicals to give non-radical products.

The hydroperoxides are the primary products of atmospheric oxidation but these do not contribute appreciably to the undesirable flavours and odours. The off-flavours and odour are caused by secondary degradative products formed from the decomposition of the hydroperoxide.



Saturated fatty acids are more resistant to autooxidation than unsaturated fatty acids and are oxidised with difficulty to give hydroperoxides which give alcohols and ketones on decomposition Temperatures of 130 - 150°C are needed for oxidation to significant.

Factors which increase the rate of fat oxidation are metal catalysts, haematin compounds, light, irradiation, temperature, oxygen, moisture and prooxidants. Anti-oxidants have a reducing effect on oxidation of fats.

Sterilization

Sterilization is the complete destruction of all forms of life in the food sterilized. This may be achieved by heat treatment. The temperature necessary to sterilized different foods and products varies. In addition to destroying microorganisms sterilization by heat of palm fruit, soften them for pounding and inactivates lipolytic enzymes which hydrolyse triglycerides into glycerol and fatty acids.

DEHYDRATION

The principle of dehydration is to transfer sufficient heat to food to cause most of its water content to evaporate. The water content of a food is related to its water activity (AW) which is a measure of available water. Microorganisms have a range of water activity within which they can grow or survive. When moisture content of food is reduced on dehyration it reduces water activity of the food below a critical level and the food is preserved. Water is made unavailable because of the following reasons:

i. Solutes tie up moisture as water of solution so an increase in the concentration of dissolved substances contitutes drying of the material.

ii. Hydrophilic coloids or gels make water unavailable.

iii. Water of crystallization or hydration is unavailable to microorganisms as crystallized water cannot be used by microorganisms.

The moisture requirements of microorganisms is generally affected by variations in food, temperature, availability of oxygen, pH and the presence of inhibitors. A reduction of Aw to 0.60 inhibits growth of microorganisms (Frazier, 1958).

Methods of Dehydration

These methods of dehydration were investigated in this project in connection with the drying of palm pulp slurry:

Spray Dryer

The essential features of a spray dryer are:

a) An air heating and circulating system

b) A spray forming device

c) A drying chamber

d) A product recovery system

The liquid to be dried is brought into intimate contact with a steam of heated air. The droplets usually have diameters of 10 to 200 microns, thus presenting a very large surface area per volume of material to the drying air. The hot air changes the small liquid droplets into fine powder and absorbs the liquid as water vapour in less than a second. The heat content of the drying air is utilized for the evaporation of water. The air temperature thus falls to the saturation temperature. The powder is removed from the chamber with the drying air. It is lead pneumatically through a pipe to a dynamic cyclone filter where it is sucked out from the air.

Short drying times of the order of 1-10 sec. and relatively low product temperatures are the main features of spray drying. Most of the drying occurs under conditions which promote constant drying rate. The solids temperature does not rise much above the temperature of the drying air until drying nears completion. With good equipment design and operating conditions, resident time of the particles in the drying chamber can be controlled so that the time that the particles remain in contact with heated air is kept to a minimum, thus their temperature is kept low.

The spray dryer used in this study was an Anhydro Laboratory Spray Dryer using centrifugal atomization.

Drum Dryer (Film dryer, roller dryer)

A drum dryer consists essentially of one of more hollow metal cylinders, revolving on horizontal axis and heated internally by steam, water or other liquid heating mediums. A film of the wet material of uniform thickness is applied to the drum surface.

As the drum rotates, drying takes place and the dried material is removed from the drum surface by a scrapping device located usually $\frac{1}{2}$-$\frac{3}{4}$ of a revolution from the point of application of the food. The factors affecting the drying rate and the final moisture content of the drying material are the speed of rotation of drum, steam pressure or heating medium temperature and film thickness.

The drum dryer used in this study was a double drum dryer heated internally by steam. The feed was introduced into the trough between the drums.

Freeze Dryer

This method of drying involves the freezing of the material followed by the sublimation of the ice from the frozen state to produce a dried product. Sublimation is brought about by maintaining a water vapour

pressure gradient between the immediate surroundings of the material and the ice front within the material. Complete drying takes place in 3 stages; initially by freezing, water is withdrawn from the hydrated components of the food by the formation crystals of ice or enthedic mixtures. By subsequent sublimation of these crystals, When all the ice has been removed, the solid remaining will still have a small amount of water absorbed within the structure of its components. This water is removed by evaporation in the freeze-drying equipment by raising the material temperature of dried off in another drier.

CHAPTER TWO

EXPERIMENTAL

MATERIALS AND METHODS

Source of Palm Fruits

Two (2) types of palm fruits were used in the studies. The Dura form (local variety) was purchased from markets in Accra in the loose form i.e. removed from the bunch. A limited quantity of the Tenera form (referred to in Ghana as Agricultural type) were purchased from the Agricultural Research Station at Kade. The bulk of the palm fruits were supplied on weekly basis by the Oil Palm Research Station (C.S.I.R.), Kusi, a collaborating Institute in the project.

STANDARDIZATION OF PROCESSING PROCEDURE

a) **Pre-Sterilization Handling**

The consignment of palm fruits were weighed and divided into three. These were handled differently to determine the most suitable handling procedure.

i. The whole bunches were washed with tap water without quartering (cutting) them up.

ii. The bunches were quartered and washed thoroughly.

iii. The bunches were quartered, sprinkled with water and covered for 48 hours to make the fruits loose on the bunches. The fruits were picked with the hand and the bruised ones discarded. The fruits were washed and weighed.

b) **Sterilization/boiling**

Three (3) methods for sterilization/boiling were tried on each of the samples.

i. Boiling: The weighed samples were boiled in large aluminium pans for about 1 hour.

ii. Steaming: The samples were weighed and steamed in a retort at 0 p.s.i., 100°C for 30 minutes.

iii. Sterilization: Samples were weighed and retorted at 15 p.s.i., 121°C for 15 minutes.

c) Pounding

The fruits were pounded thoroughly in a large wooden mortar with a wooden pestle to separate the exocarp and mesocarp from the endocarp. ie. skin, fibre and pulp from the nuts and shell.

d) Expression of Pulp

Tap water was used to ~~the pulp from~~ express the pulp from pounded fruits which were still warm. However warm water was used to express the pulp from cold pounded fruits. A measured volume of water was added to a known weight of the pounded fruits and mashed to express the pulp from the fibre. The mixture was then pressed in an aluminium sieve to separate the slurry of the pulp from the fibre and nuts. The fibre and nuts were weighed and the volume of the palm pulp slurry measured. The specific gravity of the slurry was determined with a hydrometer. Different volumes of water were added to known weights of pounded fruits to obtain palm pulp slurries of different specific gravities. Slurries of higher specific gravities were obtained by boiling off some of the water from the expressed pulp solution. The work was carried out in duplicates.

e) Dilutions

A slurry of known fat content was serially diluted to obtain slurries with the following fat contents; 2%, 4%, 6%..24%. These were done in duplicates.

f) Sterilization of Palm Pulp Slurry

All the samples were boiled for 30 minutes to destroy the microorganisms present.

g) Emulsification

Each of the duplicates of the samples were homogenised in a Warring Blender to obtain a homogenised and non-homogenised slurry for each of the samples.

h) Dehydration

i. Hot Air Drying: Ten (10) litre aliguots of each of the samples were measured into Petri dishes to form very thin layers. These were put into a hot air oven at 70°C for 24 hours to dry.

ii. Freeze Drying: Two (2) litres of each sample were measured into separate enamel trays and put into a Freeze Dryer. The drying was finished off in a Hot air oven.

iii. Drum Drying ; One litre of a sample was introduced in the form of a thin drip into the trough between the drums of a Double Drum-Dryer. The steam pressure inside the drumswas maintained at 96 p.s.i; The speed of the drum rotation was varied till an optimum speed for dehydrating the palm pulp slurry was obtained. This process was repeated with all the samples.

iv. Spray Drying:- 10 litres of palm pulp slurry were fed slowly into an Anhydro Laboratory Spray Dryer using nozzle atomization: The inlet temperature of the Dryer was kept at 180°C giving an outlet temperature of 110°C. This process was repeated with all the samples of different specific gravities.

Chemical and microbiological analyses were carried out on the fresh palm fruits, different samples of the palm pulp slurries and the palm pulp powder obtained after dehydration.

STANDARDIZED PROCESSING PROCEDURE

a) Washing, Quartering, Boiling/Sterilization

Five (5) bunches of palm fruits weighing 80kg were quartered and washed with water. The quartered bunches together with the loose fruits were brought to the boil for 1 hour in large aluminium pans.

b) Pounding

The boiled fruits were picked with the hand from the quartered bunches ~~discarding~~ discarding the bruised fruits. The fruits were then weighed. and pounded in a wooden mortar using a wooden pestle.

c) Expression of Pulp

To obtain a palm pulp slurry with specific gravity of 0.95, 28.7 litres of warm water were added to 25.8 kg of pounded fruits and thoroughly mashed. This is equivalent to 1.1 litre of water to 1kg of fruit. The palm pulp slurry was obtained by pressing the mixture in an aluminium sieve. The specific gravity of the slurry was measured and where necessary warm water added to bring it to 0.95.

d) Dehydration of Palm Pulp Slurry to Palm Pulp Powder

Spray freeze and drum drying methods were used to dehydrate the slurry into powder.

i. Drum-Drying: The sample to be dried was boiled quickly in a steam jacketted kettle to evaporate some of the water. The thickened slurry of specific gravity 0.995, moisture content 70% and fat content 24% was fed in the form of a thin drip into the trough between the drums of the Drum Dryer. The steam pressure inside the drums was maintained at 96 psi producing a temperature of 150°C on the surface of the drums. The rotation of the drums was kept at 5 rev/min. The dried palm pulp was collected in the form of flakes and coarse powder. The palm pulp powder was packaged in polythene pouches. Chemical and microbiological analyses were carried out on samples of the palm pulp powder.

ii. Spray Drying: The slurry of sp. gr. 0.95 was fed into the Anhydro Laboratory Spray Dryer at an inlet temperature of 200°C. The feed pump was set to give a flow rate of 2.14cc/sec. Pulley number 2 was used in the centrifugal atomizer. These parameters gave an outlet temperature of 110°C. The palm pulp po powder produced was collected in the receptacle.

RECONSTITUTION

Preliminary trials were conducted to determine the ratio of palm pulp powder to water necessary to make palm soup of acceptable consistency. The acceptable ratio was found to be 1 part of palm pulp powder to 6 parts of water for the Dura type and 1:8 for the Tenera type on weight basis. The ratios in volumes are:- Dura type - 1:4; Tenera type 1:6.

Preparation of Palm Soup from Palm Pulp Powder

Ingredients: 300g palm pulp powder
2 litres of hot water
500g meat
500g smoked fish
2 medium - sized tomatoes
1 medium - sized onion
1 teaspoon ground red pepper
Salt to taste.

Method:

The meat was cut into small pieces and chopped onions and salt added. The meat was simmered for 10 minutes. 300g of palm pulp powder was blended into 2 litres of hot water. (This is equivalent to 12 cups of water to 3 cups of palm pulp powder). The blended powder, tomatoes, pepper and fish were added to the simmering meat and cooked for 30 minutes. The tomatoes were removed and ground into paste and added to the soup. The soup was cooked till it attained a desired consistency.

Sensory Evalution

The palm soup prepared from the palm pulp powder was evaluated by a taste panel for flavour and preference. A triangle sensory test was used to determine whether there were any differences between the soup from the palm pulp powder and palm soup prepared from fresh palm fruits.

Each of 14 panelists was served with three (3) coded samples of palm soup. Two of the coded samples were identical soups prepared from fresh palm fruits. The odd sample was the soup prepared from the palm pulp powder. The panelists were asked to select the odd sample and to indicate their preference for either the odd or the identical samples. The data collected was analysed statistically.

STORAGE

Samples of the spray dried palm pulp powder processed from the tenera type of palm fruits were subjected to storage trials. This was to determine the shelf life of the product and the appropriate conditions of storage. The acceptable period for each condition of storage was also investigated. Samples were analysed chemically and microbiologically at fortnight intervals to monitor chemical and microbial changes that occured during storage. These analysis were:

i. Moisture content
ii. Fat content
iii. Free fatty acids and acid value
iv. Peroxide value
v. Microbiological analysis
vi. Sensory Evaluation.

The storage conditions which were investigated were:

i. Shelf - This is the simplest storage condition investigated. Samples were kept on the shelf at an ambient temperature of 29°C and relative humidity of 79%.

ii. Storage in the dark:-

Since rancidity is initiated by the removal of an X-methylene hydrogen by energy from light or heat, storage in the dark was investigated to see its effect on the development of rancidity in the dehydrated samples. The average temperature inside the dark cupboard was 29°C and the relative humidity 79%.

iii. Refrigeration:-

This affects microbial activity and eliminates heat as a source of energy for the initiation of atmospheric oxidation of fat (rancidity). The refridgeration temperature was 4°C and relative humidity 60%.

iv. Freezing:

The lower temperatures of freezing have an even greater effect on microbial activity than refrigeration. The storage temperature was 0°C and relative humidity 50%.

METHODS OF ANALYSIS

1. Determination of Moisture

This was done by the oven dried method as outlined in 'The Chemical Analysis of Foods' by David Pearson. It invdved a measurement of the free water content on evaporation. This did not represent the exact moisture present since the volatile constituents of the fatty sample evaporated along with water. Any loss on drying was taken as moisture content.

ii. Fat Determination

The Soxhlet Continous Extraction Method as outlined in 'The Chemical Analysis of Foods' by Pearson was used. The fat was extracted from the dried sample with petroleum ether (B.P. 40°- 60°C). The solvent was then removed from the extract by evaporation and the residue weighed and recorded

as fat. With palm pulp slurry samples, a known weight of treated sand was mixed with a known volume of the slurry and the water dried off in an oven. The dried sample was reweighed and any weight in excess of the weight of the sand recorded as the weight of sample for extraction. The mixture of sand and dried slurry was transferred into a clean extraction thimble, plugged with cotton wool before being placed in the extraction unit of the soxhlet apparatus.

iii. Free Fatty Acids and Acid Value

The acid value is the number of milligrammes of potassium hydroxide required to meutralize the acidity of 1g of fat or oil. The results of the titration are also expressed as the percentage free acidity and calculated as a percentage of palmitic acid in palm oil. This method is outlined into Chemical Analysis of Foods by Pearson.

iv. Test For Rancidity

The senses of taste and smell detect incipient rancidity more readily than chemical tests. However the extent of rancidity is best measured by chemical determination.

Peroxide Value:-

The peroxide value is a measure of products which react as peroxides contained in the oil which are formed as intermediary products of oxidative rancidity. The peroxide value was determined by Lea's Method. This method depends on the reaction of potassium iodide in acid solution with bound oxygen followed by titration of the liberated iodine with sodium thiosulphate. A rancid taste begins to be noticeable when the peroxide value is between 10 and 20. However in interperating such figures it is necessary to take into account the particular oil or fat involved.

v. Microbiological Analyses

The microbiological examinations were carried out to:

i. Assess the efficiency of the sterilization process

ii. Determine the microbial load of the material at different stages of processing and to detect insanitary practices.

iii. Assess the quality of the standardized slurry and the palm pulp powder.

Preparation of Samples: Ten (10) millilitres of each slurry sample were serially diluted using sterile saline dilution blanks. With the powdered palm pulp, 10g of each sample was weighed into a sterile bottle and 190ml of sterile saline dilution blanks added. The samples were added. The samples were allowed to rehydrate for 30 minutes at refrigeration temperatures and then shaken vigorously for 2-3 minutes. Serial dilutions were prepared from the rehydrated samples.

Total Count:- One (1) millilitre aliquot of each diluted sample was placed in Petri dishes in duplicates and Total Plate Count Agar poured on them. These were incubated at 32°C for 3 days before the colonies were counted. Results were recorded as number of bacteria per millilitre or gram of the sample.

Yeasts and Moulds: - One (1) millilitre aliquot of each sample was placed in duplicates, in Petri dishes and poured with malt agar. The plates were incubated for 5 days. The plates were observed after 3 days in order to count the colonies. Moulds were recorded as yeasts or mould per millilitre or gm of the sample.

Spore-forming Bacteria, Thermophilic:- About 60-70 ml of the liquid phase of the diluted slurry samples were transferred into a sterile flask and heated to boiling for 5 minutes. The same process was repeated on the liquid phase of the initial rehydrated palm pulp powder samples. This was

to destroy any vegetative bacterial cells in the samples. Serial dilutions were prepared from the heated diluted samples and aliquots innoculated on total count agar plates. The total colonies were counted.

Coliform Bacteria:- Brilliant green lactose bile agar was innoculated with the various samples and incubated for 24 hours at 32°C to ascertain the presence of any coliform bacteria.

vi. Sensory Evaluation

Two (2) methods of sensory evaluation were used in the studies. These were:-

1. The Triangle Sensory Test as already outlined under reconstitution.
2. Samples of soup from fresh palm fruits and palm pulp powder were assessed by panelists using a hedonic scale to indicate the degree of likeness for the coded samples.

CHAPTER THREE

RESULTS AND DISCUSSIONS

PROCESSING PROCEDURE

Handling and Sterilization of Fruits

Boiling the whole bunch of palm fruit unquartered made it extremely difficult to pick the fruits with the hand. This is because the fruits were held very firmly on the stalk and it was very difficult to get a firm hold of the single fruits. It is expected that when picking of the fruits is to be done mechanically with a Palm Fruit Stripper, boiling the bunches unquartered will be the most convenient method.

Quartering the fresh bunches before boiling made picking of the single fruits manually, relatively easier. However it was much easier to pick the single fruits after the bunches had been quartered, sprinkled with water and covered for 48 hours. This was done even before the loose fruits were boiled. The disadvantage of this method is that the fruits are not boiled immediately after harvest, hence some amount of hydrolysis takes place resulting in an increase in the free fatty acid (f.f.a.) content of the fruits. This increase in f.f.a. reduces the palatability of the fruit.

All the three methods of boiling/sterilization ie. boiling, steaming and retorting at 15p.s.i., 121^{o}C for 15 minutes softened the fruits for pounding. The fruits, boiled in open pans gained about 3% increase in weight. Fruits steamed or retorted had an average of 3% loss in weight. During boiling the fruits were submerged in hot water. Heat softened the skin of the fruits thereby making it easy for the fruits to absorb water till they became saturated. Steaming and retorting were carried out with dry steam. This made water less available then boiling in water. Some of the water content of the fruits vapourised during the heating process and were lost through the softened skin into the surrounding steam.

The mould and yeast count of the mesocarp of the fresh washed fruits before boiling/sterilization was 60 x 10^1/g. The bacteria count was 244 x 10^1/g. However there was no viable mould, yeast or bacteria count obtained from samples after boiling, steaming or retorting. Thus all the three methods of boiling/sterilization are effective at destroying the microbial load of the fruits.

Expression and Sterilization of Palm Pulp

Tables I and II show the results from studies carried out to determine the ratio of water to fruits to give slurries of varying specific gravities with the Tenera and Dura forms of palm fruits.

Table 1

SPECIFIC GRAVITIES OF EXPRESSED PALM PULP SLURRIES

a) Dura Form

No.	Vol. of Water Added To 0.5kg Pounded Fruits in ml.	Volume of Slurry Obtained in ml.	Specific Gravity of Slurry
1	600	705	0.990
2	650	750	0.985
3	700	810	0.980
4	750	860	0.975
5	800	900	0.975
6	850	955	0.975
7	1000	1000	0.975
8	1300	1390	0.078

TABLE II

b) Tenera Form

No.	Volume of Water Added To 0.5kg. Pounded Fruits in ml	Volume of Slurry Obtained in ml.	Specific Gravity of Slurry
1	600	800	0.990
2	650	850	0.985
3	700	920	0.975
4	750	970	0.950
5	800	1020	0.970
6	850	1060	0.975
7	900	1100	0.975
8	950	1160	0.975

Specific gravity of the warm water used for expression of the pulp = 0.980.

Specific gravity of the cold tap water = 0.992.

Tables I and II show that using the same volume of water to express the pulp from the same weight of Tenera and Dura forms of palm fruit give slurries of different specific gravities. These could be due to differences in the amount of pulp in a given weight of the 2 forms of palm fruit. The variation could be due to slight differences in the densities of the pulp from the two forms of fruit resulting from different levels of various chemical components in the fruits eg. the Tenera form has a high level of fat than the dura form.

Generally the specific gravity of the expressed pulp fell from a value slightly below I, to a minimum value lower than the specific gravity of the water being used for the expression after the addition of about 3 parts of water to 2 parts of fruit. However, the minimum specific gravity attained by the slurry from the Tenera form, 0.950 was lower than that from the Dura form, 0.975. With the addition of more water the specific gravities rose slowly towards that of the water being used for the expression.

TABLE III

EXPRESSION OF PALM PULP

Form of Palm Fruit	Weight of Fruit	Volume of water used For expression	Volume of Slurry	Specific Gravity of Slurry	Weight of Fiber and Nuts	Percentage of Fiber and Nuts
Dura	1.0kg	1.06l	1.23l	0.98	0.783kg	78%
Tenera	1.0kg	1.1l	1.48l	0.95	0.620kg	62%

The volume of water needed to express practically all the pulp from the Tenera form is larger than that required by the Dura form since the former contains more pulp than the later. Also the specific gravities of the slurries obtained are different.

The weight of the fibre and nuts discarded after pounding and expression of the palm pulp accounted for 60% of the Tenera form of the palm fruit and 78% of the Dura type. These by-products are raw materials for other products. The fiber can be used as fuel, as material for smoking water pots and as animal feed. The palm kernel is used to make cooking oil.

Studies carried out to determine whether sterilization of palm pulp slurries immediately after expression is necessary showed that unsterilized slurries started deteriorating after 24 hours under refridgeration. Frozen unsterilized slurries kept for about 7 days before deteriorating. Sterilization of palm pulp slurries before refridgeration or freezing is necessary for slurries which are not to be dehydrated immediately.

DEHYDRATION

(a) Hot Air Drying

Slurries which were dehydrated in a hot air oven gave a product which was in the form of large thin films. They were hard, discoloured and could not be broken up readily. The product was found to be unsatisfactory for reconstitution into soup.

(b) Freeze Drying

The freeze dried product was in the form of a fine powder. Reconstitution of the powder into soup did not present any problems. The reconstituted product was assessed as acceptable by a taste panel.

(c) Drum Drying

Emulsification is not appropriate for palm pulp slurries to be drum-dried. This is because the emulsions break up as soon as the droplets hit the hot surface of the drums. Slurries of fat content between 2 and 25% can be conveniently dried without loosing too much of the fat. However products from slurries with less than 4% fat were not assessed as satisfactory.

It was found convenient to reduce the water content of the slurries before they were drum-dried. This was done by concentrating the slurry; by boiling in a steam jacketted kettle. The concentrated slurry fed into the drum-drier had a water content of 70%, fat content of 24% and specific gravity of 0.995. The steam pressure inside the drums were kept at 96 p.s.i. giving a temperature of 150°C on the drum surface.

The speed of the drums were kept at 5 rev/min. It is necessary to introduce the slurry slowly in the form of a thin drip into the trough between the drums to avoid the oil from dripping off the drums. Some oil however drips off the surface of the drums during the dehydration process.

TABLE IV

DEHYDRATION OF PALM FRUIT (DURA)

DURA PALM FRUIT	% % MOISTURE	SPECIFIC GRAVITY	F.F.A. VALUE	PEROXIDE VALUE	% FAT (DWB)
Fresh Palm Fruit (mesocarp)	40.4	-	9	9	51.2
Expressed Palm Pulp Slurry	83.2	0.955	4.6	11	14.2
Concentrated Palm Pulp Slurry	71.6	0.9995	4.7	12	23.6
Palm Pulp Powder	1.75	-	4.9	15	62.1

TABLE V

DEHYDRATION OF PALM FRUIT (TENERA)

TENERA PALM FRUIT	% MOISTURE	F.F.A. as Palmitic	PEROXIDE VALUE	% FAT (DWB)
Fresh Palm Fruit (mesocarp)	69.8%	0.33	4.0	56
Palm Pulp Slurry	70.4%	3.7	9	9.4
Palm Pulp Powder	1.4%	4.2	14	86.3

~~Fig.~~ Table V.

The drying rate of the slurry was 1.15l/hr. and production rate of the palm pulp powder was 100g/hr.

TABLE VI

YIELD OF PALM PULP POWDER FROM PALM FRUITS
(Drum Drying)

Form of Palm Fruit	Material (g)	Weight of Material (g)	Weight of Palm Pulp Powder	Percentage Yield
Dura	Palm Fruit	3150	112	3.6
	Pulp of Palm Fruit (wwb)	690	112	16.2
Tenera	Palm Fruits	2700	200	7
	Pulp of Palm Fruit (wwb)	800	200	25

The yield of palm pulp powder from the tenera fruits is higher than the yeild from dura fruits as the tenera contain more pulp. The percentage of nuts and fiber in a dura fruit is higher than in the tenera fruit.

The amount of powder obtained from the pulp accounted for about one quarter of the weight of the pulp. The loss is made up mainly of the water removed from the pulp during dehydration. Another source of loss of pulp is that running off the surface of the drum during drying. A third source of loss of pulp occurs during the transfer of slurry from one container into another. This loss is magnified in the results shown in Table VI because of the small quanities involved in this experiment. A small quantity of pulp left sticking to the walls of a container made up a significant part of the whole slurry due to the small volume of the slurry. Handling of larger quantities of the fruits makes this loss less significant.

Sensory Evaluation

The palm pulp powder blends easily in hot water into a slurry which is used for soup making. The reconstituted soup has a slightly darker colour than that prepared from fresh palm fruits. The reconstituted soup has enough oil on its surface after preparation.

TABLE VII

RESPONSE OF TASTE PANEL TO RECONSTITUTED DURA PALM SOUP

Correct Response in 14 Test		PREFERENCES	
		Soup of P.P. Powder	Soup of Fresh Palm Fruit
Set I	13	8	5
Set II	10	7	3
Set III	12	6	6
Average	12	7	3.7

In Table VII three sets of 14 panelists were asked to identify an odd sample from 3 samples made up of two identical soups prepared from fresh palm fruits and a third from palm pulp powder. They also indicated their preference. The odd samples was correctly identified by 12 panelists out of 14. There is therefore a definite detectable difference between soup prepared from fresh palm fruits and that prepared from palm pulp powder at 0.1% significance level. 70% of the panelists preferred the taste of the soup prepared from palm pulp powder to the soup made from fresh palm soup. Taste Panelists comments showed that this preference was mainly due to a desirable caramelised flavour detectable in the soup prepared from the palm pulp powder.

Chemical analysis of the palm pulp powder gave a peroxide value of 15 yet there was no detectable incipient rancidity. Generally a racid taste beings to be noticeable in a fatty food when the peroxide value is between 10 and 20. However this depends on the particular fat or oil involved. A free fatty acid value of 4.9% did not cause a reduction in the palatability of the palm soup.

Since soup from fresh palm fruits is acceptable in Ghanaian homes the preference of taste panelists of soup from palm pulp powder makes it also an acceptable product.

Palm pulp powder, drum-dried from tenera form of palm fruits were also found acceptable by a taste panel and also preferable to soup prepared from fresh tenera palm fruits.

SPRAY DRYING

Several problems were encountered with the operation of the Anhydro Laboratory Spray Dryer. The first problem was to get the slurry into the dryer in the form of a fine fog. This was achieved by adjusting the feed pump to give a flow rate of 2.14 c/sec. Once this was done the spray was instantly dehydrated into a powder. However most of the palm pulp powder formed stuck to the walls of the drying chamber instead of being drawn pneumatically by the cyclone into the receptacle. The powder was recovered from the drying chamber after the machine had been switched off. Thus most of the product stayed in the drying chamaber of about 200°C for a few hours instead of a few seconds. This intense heat treatment had an undesirable effect on the product causing it to oxidise with a resultant bleaching. Drying was therefore done in batches, the maximum drying period limited to 4 hours.

A second major problem was the formation of a paste of the drying material in the arm of the Spray Dryer leading into the receptacle. This paste formation sometimes occured when there was powder formation in the drying chamber and the outlet temperature of the dryer was above 90°C. Theoretically any product comming out of the drying chamber at an outlet temperature of above 90°C should be in powdered form. It is possible that water vapour removed from the palm pulp slurry droplets during dehydration in the drying chamber recondensed in the arm of the Dryer dissolving the dry powder into a thick paste. This problem when it occured could not readily be overcome by raising the inlet temperature of the dryer. The drop in temperature in the arm making recondensation of water vapour possible, could be due to leakages in the joints of the arm.

TABLE VIII

SPRAY DRYING OF PALM PULP

TENERA PALM FRUIT	MOISTURE	FAT %	F.F.A.	PEROXIDE VALUE	WEIGHT OR VOLUME
Fresh Palm Fruit	33.5% (mesocarp)	52% (mesocarp)	0.30	4.0	86kg
Palm Pulp Slurry	86%	9.4%	2.1	6.3	120 litres
Palm Pulp Powder	0.5%	70%	3.7	8.2	17.2kg

TABLE IX

YIELD OF PALM PULP POWDER FROM TENERA PALM FRUITS
(Spray Drying)

MATERIAL	WEIGHT OF MATERIAL	WEIGHT OF PALM PULP POWDER	PERCENTAGE YIELD
Palm Fruit	90kg	18kg	20%
Pulp of Palm Fruit	30kg	18kg	60%
Pulp of Palm Fruit on D.W.B.	20kg	18kg	90%

The Production rate of the palm pulp powder was 1.1kg/hr.

The yield of palm pulp powder from fruits during spray drying was much higher than the yield from drum drying. This is because there was no loss of slurry out of the machine during drying as occured with the drum dryer. The much larger quantities of materials handled also made the % loss of slurry during handling extremely small. The 10% loss of pulp can be accounted for by losses through handling and loss of some volatile constituents during drying.

Sensory Evaluation

Number of Panelists = 16

Points awarded by panelists:

5 - Very good
4 - good
3 - satisfactory
2 - not quiet satisfactory
1 - poor
0 - unacceptable.

TABLE X

MEAN VALUES OF SENSORY EVALUATION

SAMPLE	COLOUR	FLAVOUR	TASTE	OVERALL ACCEPTABILITY
Soup of Fresh Tenera Palm Fruit	4.3	3.4	3.7	4.1
Soup of Tenera Palm Pulp Powder	3.9	2.9	3.0	3.01

The soup made from reconstituted spray dried palm pulp powder was found satisfactory by the taste panel. However there was a preference of the soup made from fresh palm fruits to that of the powder. Comments given by panelists indicated that there was not enough oil on the surface of the soup prepared from palm pulp powder. This problem could have been caused by loss of oil during dehydration since the product stayed in the drying chamber of about 200°C for about 4 hours instead of a few seconds. The excessive heat treatment could have caused the evaporation of the more volatile components of the oil which normally surface on soup. Chemical analysis showed that the palm pulp powder had less fat (70%) than the palm pulp slurry (90% on d.w.b.)

The problem could also be due to the inability to break up the fat emulsion in the product during cooking. Several trials were conducted using much larger volumes of water in preparation of the palm soup to prolong the cooking time. Such soups still lacked oil. Further work should be done using destabilizers and demulsifying agents in the preparation of the soup.

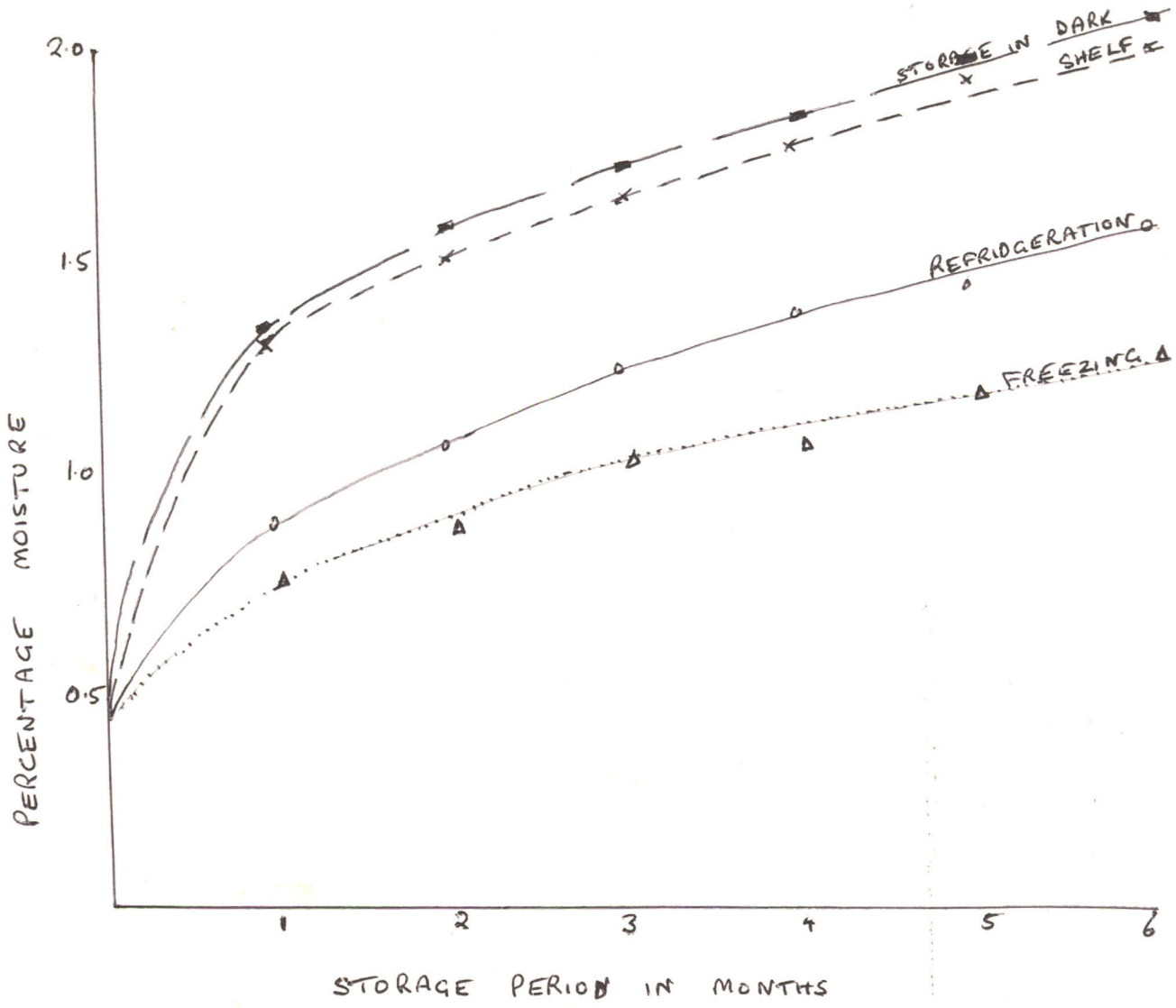
STORAGE

Conditions of storage investigated were; shelf (Relative humidity 79%, temperature 27°C) storage in a dark cupboard (R.H. 79%, temp. 27°C) refridgeration (R.H. 60%, temp. 4°C) and freezing (R.H. 50%, temp. 0°C) The palm pulp powder used for storage studies were all spray-dried tenera palm fruits. Variable factors in the four different conditions of storage investigated include temperature, relative humidity and light. These factor have effect on chemical reaction; enzyme action, moisture uptake and microbial activity.

Fig. I shows that there was a very slow uptake of moisture under all the four storage conditions. Thus initially the moisture content of the products were not in equilibrum with the relative humidity of the environment under which the samples were stored. The uptake of moisture was slowest in the samples kept frozen followed by storage at 4°C, storage

FIG I

GRAPH OF MOISTURE AGAINST STORAGE PERIOD.



in the dark and shelf respectively. There is a relation between the rate of moisture uptake and the relative humidity of the environment. The moisture uptake was slowest in the environment with the lowest relative humidity and highest in the environment with the greatest relative humidity. This is because there is more water available in the more moist environment. Under freezing conditions the frozen water is least available for uptake. Work should be done to determine at what residual moisture content of the powdered product there is an equilibrum established between the product and its environment. This will prevent moisture uptake by the product.

The average moisture content of the products after 6 months storage was about 2.1%. At the low moisture content the water activity of the product is not enough to support microbial growth. However figs.II and III show that there were bacteria, mould and yeast counts in all the samples even before the samples attained this moisture content. This suggests that the moisture taken up by the samples were not evenly distributed throughout the product. Thus eventhough the average moisture content of the product were around 1% after 4 weeks storage parts of the product near the pores in the polythene pouches through which moisture entered the product must have had moisture contents of at least 7% (enough to support microbial activity). The bulk of the product was much dryer, thus giving an overall moisture content of about 1%.

Figures II and III represent the viable bacteria, mould and yeasts counts on the palm pulp powder samples stored under the different storage conditions. Freshly dehydrated samples collected asceptically from the spray dryer had no viable bacteria, mould and yeasts counts. However analysis of fresh packaged samples showed an average vaiable bacteria count of 0.4×10^1 and yeast and mould counts of 2×10^1. This therefore represent contamination of the product during packaging. No pathogenic bacteria or Escherichia coli were isolated from samples analysed. The

FIG II

GRAPH OF BACTERIA COUNT AGAINST STORAGE PERIOD

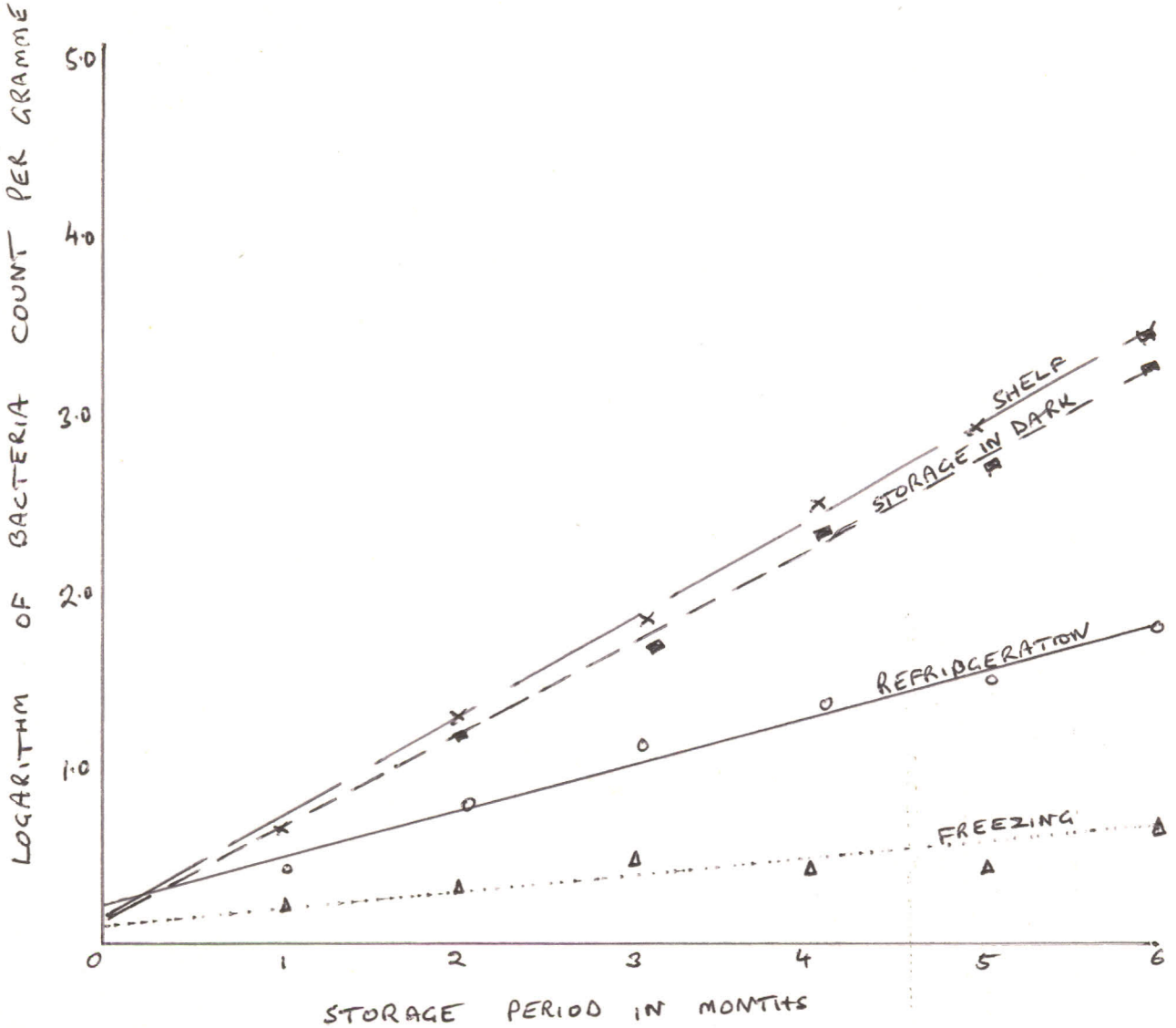


FIG III

GRAPH OF VIABLE MOULD AND YEAST COUNT AGAINST STORAGE PERIOD

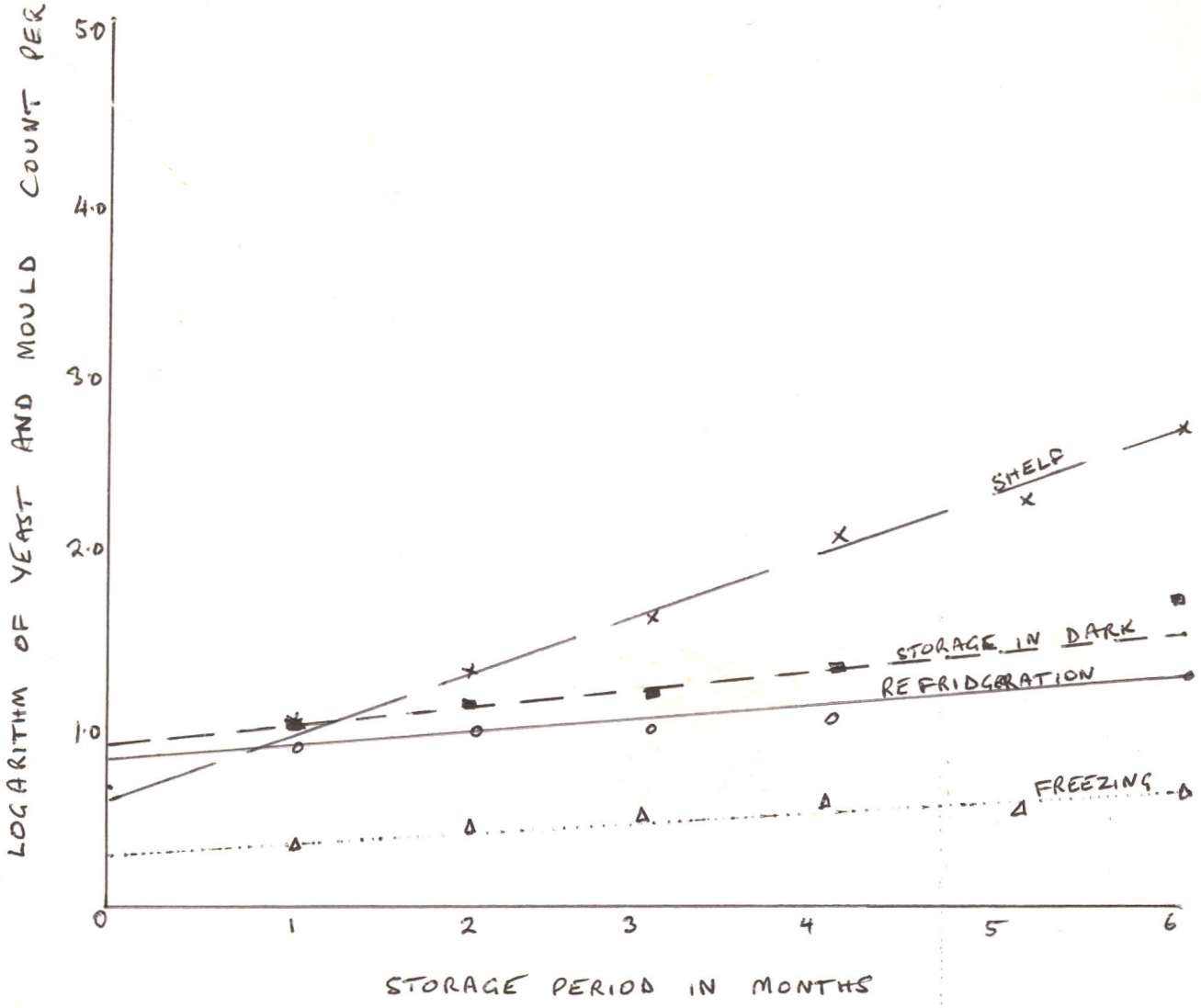


FIG III

most dominant bacteria isolated from the samples were Bacillus sp. The types of moulds isolated were Rhizopus sp. and Aspergillus sp.

Since the graphs of the logarithms of bacteria, mould and yeast against storage period are linear, the growth of these organisms during storage were exponential. The graphs show that there is the least microbial grow under the freezing conditions, followed by samples stored at 4°C (ie. under refridgeration). The rate of microbial growth was higher comparatively in samples stored at room temperature on the shelf and in the dark. Thus the main factor affecting microbial growth was temperature.

The high temperatues used in dehydration, 200°C, and the very low moisture content of the fresh product would have destroyed any vegetative organisms. Viable counts obtained during storage might therefore have been growth from spores.

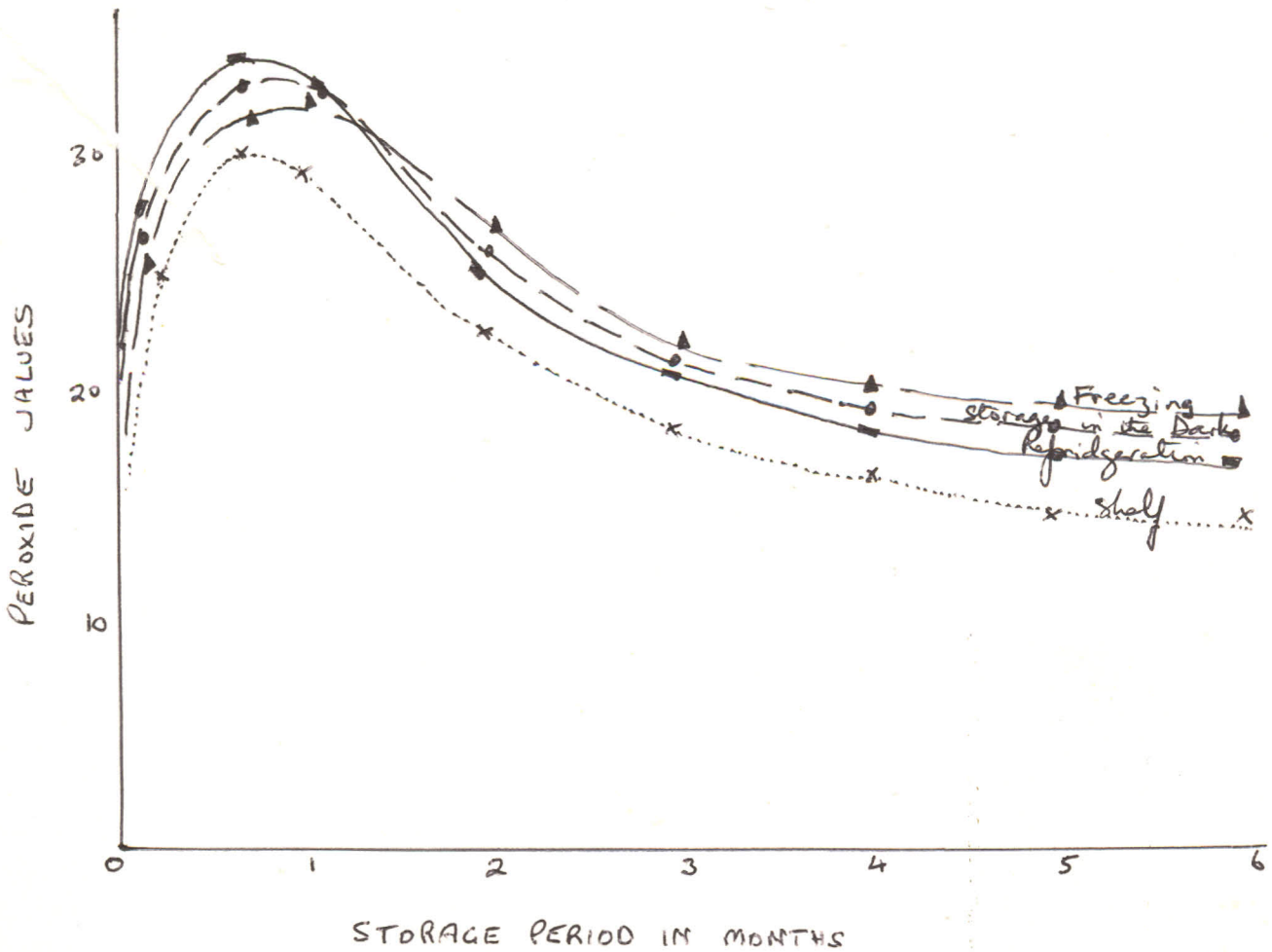
After five months storage, the bacteria, moulds and yeast loads in the samples under all four conditions of storage were within acceptable values for this type of product.

Analysis of fat contents show that there was no significant change in the fat content throughout storage.

Fig. IV shows that there was a very rapid build up of hydroperoxides within the first week of storage. Taste panel results however showed that there was no detectable incipient rancidity in the products at this period of storage. Over the storage period the peroxide value decreased slowly. Thus there was

FIG IV

GRAPH OF PEROXIDE VALUE AGAINST STORAGE PERIOD



a very slow breakdown of the hydroperoxides formed, into degradatory products which impart rancid flavour and taste to the product. Taste panel results show that a rancid taste became detectable in the samples stored on the shelf after 6 weeks storage. Fig. IV shows that the peroxide value of the sample stored on the shelf had fallen to a value of about 20 at this period of storage, much lower than the values attained by samples stored under other conditions of storage. Thus the breakdown of the hydroperoxides into degradative products of the samples stored on the shelf was faster than in samples stored under refridgeration, freezing and in the dark, all conditions under which light is excluded.

After 4 months storage there was still no rancid taste detectable in the samples stored under refridgeration, freezing and in the dark. The slowest breakdown of hydroperoxides occured in the samples kept frozen. Thus the factors which retarded the development of rancidity in the products were low temperature and absence of light.

The very slow development of rancidity of the palm pulp powder without the addition of antioxidants is due to the presence of natural antioxidants in the product.

Taste panelist found all the samples acceptable after 6 weeks storage. However the panelists found the sample kept on the shelf unacceptable after 2 months storage. The detailed results of the sensory evaluation of

the samples after 2 months storage is shown in Fig. V and Table XI. The reference samples was soup prepared from freshly harvested palm fruits of the same form as the powder ie. tenera. 14 panelists used the hedonic scale to indicate the degree of likeness for the coded samples. The scale ranged from 9 - extremely like to 1 - dislike very much.

Fig. V

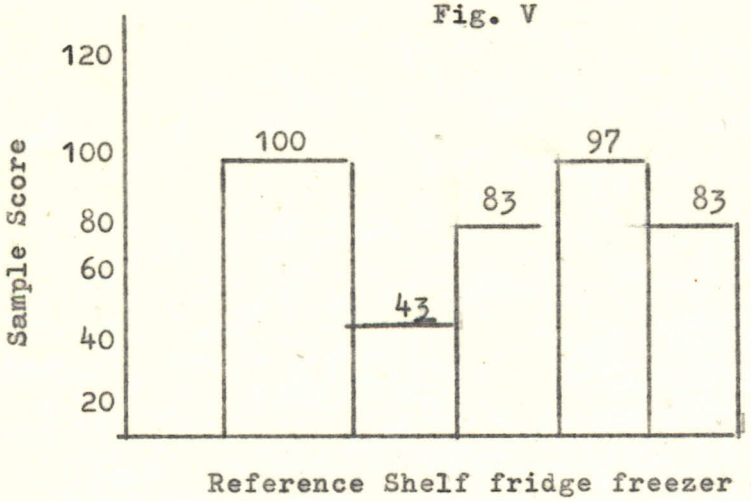


TABLE XI

ANALYSIS OF VARIANCE OF SENSORY EVALUATION OF SAMPLES STORED FOR 2 MONTHS

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	VARIATION RATIO
Sample	4	152	38.0	8.64
Panelists	13	370	28.5	6.48
Errors	52	229	4.4	
T o t a l	69	57	0.8	

Significance was tested at 1% level, t 59 = 2.52 thus the probability of observing a value of t with 59 degree of freedom greater in absolute value than 2.25 is exactly 1%. The variation ratio of 8.64 exceeds 2.52 so there is a significant difference between the samples stored under various conditions.

The sample score of samples stored in the dark, frozen, under refridgeration and the reference sample were high. The sample score of the frozen sample was very close to that of the refrence sample, 97 and 100. If a sample score of 50 is taken as on acceptable value then sample kept on the shelf is unacceptable after more than 6 weeks storage. The best storage condition is freezing.

The shelf life of samples stored in the dark was determined to be 10 weeks, refridgerated sample 9 months and the sample kept frozen are still acceptable after 14 months storage.

Drum dried samples kept on the shelf started to melt after 6 weeks.

CHAPTER FOUR

C O N C L U S I O N

The results of this study shows that palm pulp powder can be processed from palm fruits as a convenience food. This is a means of preserving the palm fruits which normally deteriorate rapidly after harvest. Suitable dehydration methods for drying the pulp expressed from the palm fruits include freeze drying, drum drying and spray drying. The product is easy to handle, readily reconstituted into soup and convenient for export.

Spray dried palm pulp powder packaged in polythene pouches have a shelf life of 6 weeks. The shelf life of samples stored in the dark was 10 weeks, refridgerated sample 9 months and frozen sample 14 months. Thus of the storage conditions investigated in the study, freezing is the best method followed by refridgeration, storage in the dark and shelf respectively. It is expected that much more suitable packaging techniques can be found such as vacuum seaking in an aluminium foil, which will combine the advantages of excluding light and oxygen, factors which promote rancidity of the product.

Drum dried products have a better taste than spray dried sample and were even preferable to soup from fresh palm fruits by a taste panel. However they are not as dry and have a slightly shorter shelf life, 4 weeks, than spray-dried samples.

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