EFFECT OF CHEMICAL PRE- MILLING TREATMENTS ON THE PHYSICO-CHEMICAL PROPERTIES OF *Mucuna sloanei* 'UKPO'

BY

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CERTIFICATION

I certify that this research work, Effects of Chemical Pre-Milling Treatment on the Physico-Chemical Properties of *Mucuna sloanei* 'ukpo', was carried out by Onyemah Kelechi Obioma (Reg. No 20094698488) in the Postgraduate School, Department of Food Science and Technology, School of Engineering and Engineering Technology, Federal University of Technology Owerri, Imo State, Nigeria.

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DEDICATION

I dedicate this work to the Eternal Creator: Yahweh Elohim, to all the HolyGhostants' and to my Parents Mr and Mrs D. Onyemah.

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Beautiful beyond description is my God; Yahweh Elohim, whose love and mercy remain indescribable. I will forever love You, Father; Thank You!

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ABSTRACT

This study examined the effects of chemical pre-milling treatment on the physico-chemical as well as pasting properties of *Mucuna sloanei* 'ukpo' flour. The seeds were treated with Distilled water, Citric Acid, Sodium bicarbonate, and Sodium Chloride solutions at various levels of concentration (1% 2.50%, 5% 7.5%, 10% w/v) before milling into flour. Proximate and functional properties of the flour were evaluated. Functional property analysis, of the Chemical treated flour showed that flour of distilled water gave best results for swelling index (3.50); Distilled water treated sample gave highest value for emulsion capacity (69.09%) and stability (69.09%), foam capacity (8.0%) and stability (8.0%). Sodium bicarbonate showed best result for water absorption capacity (WAC) (6.47ml/g), Citric Acid flour sample had better result for Oil Absorption capacity (OAC) (2.29ml/g). Sodium chloride and sodium bicarbonate showed better results for bulk density (BD) (0.78g/ml) and (0.78g/ml) respectively. The control showed better pasting properties items of peak viscosity (PV), 609RVU, Trough Viscosity (TV), 619RVU; Final viscosity (FV), 1495RVU; set back viscosity (SB), 951RVU. Cake sample produced with blends containing 75% wheat and 25% ukpo flour ranked best among the other cake samples blends, though the control sample remained exceptional in the overall sensory evaluation.

Keywords: Food thickeners, Processing Aids, Swelling Index Final Viscosity, Setback Viscosity, Pasting Temperature, Sensory Evaluation, Cake.

CHAPTER ONE

INTRODUCTION

1.1 Background Knowledge

Mucuna sloanei - "Ukpo" is a tropical leguminous crop, belonging to the sub-family **papilionaceae** of flowering plants. They have different varieties, which include: *Mucuna urensi, Mucuna pruiens, Mucuna flagellipes,* etc. They are mostly climbing wooden vines that twines through the rain forest trees likes botanical boa constrictors (Ukachukwu, 2000) their seed pods are covered with dense whiskers- like hairs called **trichomes**, which can be very painful when there is contact with the skin. This serves as a protection from predators (Ukachukwu, 2000). Other names include: 'ewe-ina' as known by the Yorubas, 'Ibaba' by the Efiks, 'Marara' by the Hausas and 'Ukpo' by the Ibos.

In the eastern parts of Nigeria, for example *Mucuna sloanei* is widely used, but in small quantities as a soup thickener. The seeds are also carried by natives to prevent haemorrhoid. The female seeds- hernibasi which sinks in water are collected and polished and used in making lovely necklace and bracelets by natives. Apart from its

application as a soup thickener, it has found application in the food industry as a food gum (hydrocolloids).

Hydrocolloids refer to high molecular weight polymeric compounds, mostly carbohydrates that are characterised by their ability to give highly viscous solutions at low concentrations. (Ihekoronye and Ngoddy, 1985). Many such gums from tropical countries find uses in the food industry as emulsion stabilizers, thickening agents, syneresis inhibitors, lubricants and clarifiers. Natural food gums can either be plant seed gums: example guar gum and locust bean gum, plant exudates: example gum Arabic and ghatti gum; plant extracts example. Pectin or seaweed extracts: eg Agar and Carrangeenans.

1.2 STATEMENT OF PROBLEM

Before this time, that is, in the 70s and 80s *Mucuna sloanei* used to be prominent as a soup thickener to natives of the South-South and South-east parts of Nigeria. But this is no longer the case, as some other soup thickeners have gain prominence in culinary applications in this same region; this has led to the less demand for *Mucuna sloanei*, and as such has led to it becoming endangered, as

farmers no long show great interest cultivating the crop. The neglect however is due to its characteristic dark colour during wet processing and subsequent food preparation.

Considering the increasing need for adequate food supply to the increasing population of Nigeria and the world over the need to adopt new techniques of processing and application of these endangered food crops such as *Mucuna sloanei* in the food industry becomes necessary, as these actions will help save these food crops from going into extinction as well as encourage their optimal utilization. More so different food gums or thickeners may be more or less suitable in a given application due to differences in taste, clarity and their responses to chemical and physical conditions.

1.3 OBJECTIVES OF THE STUDY

The main objective of this research work is:

To evaluate the effect of chemical pre-treatment on some physico-chemical properties of 'Ukpo', and test its performance in composite flour cake production.

Specific objectives:

(i) To determine the proximate composition of 'Ukpo' seed and the treated 'Ukpo' samples.

(ii) Evaluate the functional/pasting properties of Ukpo flour as affected by chemical treatment.

(iii) To produce cake from blends of Ukpo/wheat flour and conduct sensory evaluation.

1.4 JUSTIFICATION

Mucuna sloanei has since began to loose relevance in the homes of Nigerians especially those of the South south and South east regions of Nigeria because, there seems to be better replacement of *Mucuna sloanei* – 'Ukpo' as a soup thickener. This unacceptable trend is what this project works aims to handle and further optimize the utilization of this food crop in the food industry; by evaluating the effect of chemical pre-treatment on some physico-chemical and pasting properties of the tropical legume crop, with a view to expanding its application, as well as creating new food products for the purpose of food product diversification.

1.5 SCOPE OF WORK

The scope of this research work includes the following:

Raw material procurement, Chemical pre-treatment of *M*. *Sloanei* , Proximate composition determination of *M. Sloanei*, Physico-chemical and pasting properties analysis, others include; Sensory analysis on new food product and lastly the Statistical analysis of data generated.

CHAPTER TWO

LITERATURE REVIEW

2.1 IDENTIFICATION AND ORIGIN OF *MUCUNA SLOANEI*

The enormous legume family contains species of tropical vines, but some of the most interesting belong to the genus *Mucuna* (Armstrong, 2010). *Mucuna* is a genus around 100 accepted species of climbing vines and shrubs of the family *Fabaceae (Leguminosae)*, sub-family *Papilionaceae* of flowing plants; found worldwide in the woodlands of tropical areas. It is popularly known as velvet bean, devil bean, and cow-hitch or cowhage (Duke 1981; Buckles 1995).

Mucuna Sloanei, as a food thickner, is known to originate from Asia and was later introduced into the Western hemisphere via Mauritius (Nkpa, 2004). Initially, it was *M. cochinchinensis,* which was cultivated in parts of Southern Nigeria and Senegal and for the first time was located in French Cochin – China (Hashim and Idrus 1977). After this, it was believed to have spread to other known accessions and subspecies (Ukachukwu and Obioha 1997).

The *Mucuna sloanei* is a climbing perennial herb, and produces long fairly longitudinal ribbed pods which are covered with brownish to reddish yellow hairs. The leaves are 3–palmate, alternate or spiralled, and the flowers are pea-like but larger, with distinctive curved petals and occurring in racemes. Each pod contains one to four seeds which are white when immature but black when mature and dry. The seed has dark helium which is about $^{1}/_{2}$ to 2/3 of the circumference of the seed; and contained in each seed are two white cotyledons which are covered by the testa (Enwere, 1998).

Having a three layered characteristic appearance, seed of *Mucuna sloanei* somewhat resembles the eyes of a large mammal, giving rise to common names like; horse – eye beans, deer-eye beans, ox-eye beans or hamburger seed etc (Quattrocchi, 2000). More so, it is locally called 'ukpo' by the Ibos, *Karasuu* by the Hausas and *Yerepe* by the Yorubas (farm 2 pot, 2012). The name of the genus is derived from *Mucuna* a Tupi-Guarani word; having over 100 species among which are the *Mucuna flagellipes, Mucuna urenus, Mucuna acuminate, Mucuna pruriens, Mucuna Amblyodon, Mucuna argyrophylla, Mucuna aura, Mucuna calophylla, Mucuna canaliculata, Mucuna championii,*

Mucuna curranii, Mucuna cyclocarpa, Mucuna discolor, Mucuna nigricans, Mucuna reticulate, etc (ILDIS, 2005).

2.2 NUTRITIONAL COMPOSITION OF *MUCUNA SLOANEI*

The nutritional importance of *Mucuna* seeds as a rich protein supplement in food and feed has been well documented (Siddhuraju *et al*., 2000; Bressani, 2002; Bhat *et al.,* 2008). Even though different varieties of *Mucuna* are known, reports on the nutritional composition are available for only a few of the accessions and others have remained still unexplored. In general, among the few analysed (*M. sloanei, M, gigantean, M, jaspeada, M. monosperma, M. pruriens, M.cochinchinensis, M. utilis, M. Veracruz – black),* the crude protein content is known to vary between 20 and 31.44g/100g (Afolabi *et al.,* 1985; Ravindran and Ravindran, 1988; Rajaram and Janardhanan, 1991; Mohan and Janardhanan,1995; Siddhuraju *et al,* 1996; Ezeagu *et al.,* 2003; Bhat *et al.,* 2008). Variations in the protein content have also been observed in the seeds collected from different geographical locations. For example, a high amount of crude protein has been reported in four (4) of the *M. Pruriens* accessions from India (20.2% to 29.6%) (Vadivel and Janardhanan, 2000, Vijayakumari *et al., 2002)* while seeds of 3 morphotypes of *Mucuna urens* from Nigeria

have been shown to have crude protein levels between 19.97% and 20.57% (Adebooye and Phillips 2006). Among the amino acids, lysine in *Mucuna* seeds are reported to vary between 327 and 412 mg/g N, and usually the seeds are deficient in sulfur amino acids (116 and 132 mg/g N) (Rajaram and Janardhanan 1991, Josephine and Janardhanan 1992). Aspartic (8.9% to 19%) and glutamic (8.6% to 14.4%) acids were predominant in *M. Pruriens* seeds (Janardhanan and Lakshmanan 1985; Josephine and Janardhanan 1992; Siddhuraju *et al.,* 2000), while higher concentrations of essential amino acids (555 mg/g protein) in *Mucuna* seeds (a total of 6 speices analysed) have also been reported by Adebowale and others (2005a). Among the seed proteins studied, globulins (9% to 62%) were higher, followed by albumin (4% to 21%), glutelin (1.3% to 2.9%), and prolamin (0.8% to 2%) (Janardhanan and Lakshmanan 1985; Vadivel and Janardhanan, 2000).

The nutritional importance of *Mucuna sloanei* (ukpo) lies in high content of protein and lysine. They are usually limited in the sulfur containing amino acids, particularly, methionine, and are better sources of phosphorus, but only fair in their supply of iron and

calcium. Generally *Mucuna sloanei* "*Ukpo"* contains 20.0-25.4% crude protein, 43.% - 49% carbohydrate, 5.05-7.0% fat; 25.0% - 27.4% crude fibre, and about 6.46% - 14% moisture (Enwere, 1998)

2.3 IMPORTANCE AND UTILIZATION OF *MUCUNA SLOANEI*

Mucuna is grown as a minor food and feed crop by tribal and ethical groups of Asia and Africa, and the dried seeds and beans are used for edible purpose after proper processing (Dako and Hill, 1977; Iyayi and Egharevba, 1998; Adebowale and Lawal, 2003; Haq, 1983; Afolabi *et al.*, 1985; Wanjekeche et al, 2003). Ukachukwu and Obioha (1997) reported the consumption of *Mucuna* seeds by rural populations of Nigeria (Enugu and Kogi sects) during extreme famine or when there was scarcity of common legumes. Consumption of *M. cochinchinensis and M. utilis* after pounding, cracking or boiling (up to 40 min), as well as in preparation of oil soups (stew), is common among populations of Southern Ghana (Osei – Bonsu *et al., 1996).*

Ukpo seed is processed into flour and used as soup thickener and stabilizer, where its gelation properties impart gummy, texture in soups (Diallo and Berhe, 2003; Oudhia, 2002; Ezueh, 1997). This is a desirable attribute for the eating of gari, fufu, pounded yam and so on. Saha and Muli (2000) reported the use of seeds of *Mucuna* in

beverage preparations by farmers on the Kenyan coast. In fact, many varieties, accessions, and subspecies of this underutilized wild legume are in high demand in food and pharmaceutical industries. Meanwhile, a major setback in the utilization of *ukpo* in food is its tendency to darken in colour after food preparation and exposure to air and ambient temperature. As a consequence, soups thickened with *Mucuna sloanei* flour darken after preparation (Enwere, 1998). Outside its culinary uses, other parts of the *ukpo* plant have various medicinal properties. The plants are used in herbalism against a range of conditions, such as urinary track, neurological and menstruation disorders, constipation, edema, fevers, tuberculosis, ulcers. Parkinson's disease (Katzenschlager et al., 2004) and helminthiases like, elephantiasis (Oudhia, 2002). The pods of some species are covered in coarse hairs that contain the proteolytic enzyme mucunain that causes itchy blisters when they come in contact with the skin. These hairs, when harnessed, are a common ingredient in itching powder. On the other hand, however, the hairless parts of certain species are as well used by some South Americans Shamans to make an entheogenic snuff (chamakura, 1994).

2.4 *MUCUNA* AS FEED

Mucuna forage is used for ruminant feeding (Carsky *et al*, 1998). However, it is not currently used for ruminants in West Africa. In Nigeria, it is reported to be relished by and beneficial to the performance of rabbits (Ukachukwu, *et al,* 1999). However, some trials have been carried out on pigs, fish and broilers (Ukachukwu and Obioha, 2000). For instance, it has been shown experimentally on pigs in Southern Benin that supplementing pig diet with 100 g/day of roasted or cracked and soaked (overnight) *Mucuna* seeds for 12 months produced weight gain of 30 – 50% better than the control, and that the weight gain with *mucuna* compared favourably to supplementation with fish meal or soyabean. Besides, *mucuna* supplementation is considered less expensive with better return for the farmer, which could stimulate a market for *mucuna* (CIEPCA Newsletter, 1999).

2.5 LIMITATION TO *MUCUNA'S* USE AS FOOD: ANTI-NUTRITIONAL AND TOXIC COMPOUNDS.

As it is common with legumes, a relatively larger number of antinutritional substances have been found in *Mucuna* seeds. Such

compounds include polyphenols or tannins, which can bind with proteins, lowering digestibility (Laurena *et al.,* 1994). In *Mucuna*, however, most of the tannins are seemingly located in the seed coat, which are typically discarded on food preparation, rather than in the cotyledon.

L-Dopa (3, 4 – hydroxyl – 1 – phenylalamine) is a non-protein amino acid chiefly in the treatment of Parkinson's disease. Its effects can be both gastrointestinal, including nausea, vomiting, anorexia and neurological, including severe depression and unmasking of dementia. However a consensus on these anti-nutritional factors exists among the food scientists who have studied *Mucuna* to their relatively low levels as well as heat liability, they do not seem to pose a danger to humans, if proper cooking takes place prior to eating.

2.6 CAKE MAKING

Cake Ingredients: Flour, Eggs, Margarine, granulated sugar, baking powder, flavour (vanilla extract), brandy (preservative).

The following step-by-step manual method/procedure for making conventional cakes was applied:

1. **Creaming method:** The creaming operation was carried out with a spatula and a bowl; a bowl enough to contain two times

the size of margarine and sugar to be creamed. The stirring (creaming) was carried out in one direction until the mixture became fluffy (margarine becomes softer and less dense in weight), and the initial yellowish colour of margarine turned lighter and cream in colour. The stirring in one direction was to ensure the end product had a smooth consistency, devoid of irregular air spaces in the cake matrix.

2. Preparing the Baking Pan

In preparing the Baking pan it was rubbed (smeared) with soft margarine all round inside the pan. The greasing of the pan prevents the cake from sticking to the pan, thereby making it easy for it to be brought out from the pan when done, without denting the cake.

3. Whisking of the Egg: The eggs were broken into a bowl and whisked into a smooth blend with the help of a table fork. The whisked eggs was poured into the creamed mix of butter and sugar and stirred to consistency. It was mixed until a smooth fluffy blend of sugar, butter and eggs was obtained.

4. Preheating the Oven: The oven that was used was improvised; a large pot (about two and half times the size of the cake pan) was

used. A flat stone was placed inside the pot to help suspend the cake pan within the pot; to prevent the cake pan from having direct contact with the pot. The idea is to create the usual convective and radiative heat environment in a conventional oven. The heat source was the Green rectangular kerosene stove of the butterfly brand. The preheating of the oven environment was to facilitate the cooking of the batter and the rising of the batter, until it is done and ready to be brought out.

5. **Addition of Flavour:** Vanilla essence (liquid) flavour was used to add flavour to the cake. Brandy was also added to serve the purpose of preservation.

6. **Addition of Flour and Baking Powder:** The flour that was used is composite flour – a blend of wheat flour and 'Ukpo' flour. Here it was blended at different ratios: 100%:0% wheat flour: 'Ukpo' flour, 75%:25% wheat flour to 'Ukpo' flour, 50%:50% wheat flour: 'Ukpo' flour 25:75% wheat flour: 'Ukpo' flour respectively. The baking powder was added to the flour, it was sifted through a sieve to obtain smooth consistency. The flour was then added into the sugar, butter and egg blend and stirred to consistency. The batter was poured into already greased cup like cake pans enough to fill the cups to the three

quarter capacity of the cake pans. They were then transferred into the preheated oven to bake for 40mins at 134^{o}C. The cake was checked after 30min to ascertain the level of perfectness of the cake. This was done by inserting a spoon at the centre of the cake if the spoon turns out to be free from the sticky paste of the batter on the inside, it is said to be done and ready to be removed from the oven. The cake was then allowed to cool and ready to be eaten.

CHAPTER THREE

MATERIALS AND METHODS

3.1 MATERIALS

Raw seeds of *Mucuna sloanei* were bought from Eke-ukwu Owerri market, as well as the cake ingredients: Flour, Eggs, Margarine, granulated sugar, baking powder, flavour (vanilla extract), brandy (preservative).

The reagents used were of 'ANALAR' Grade and were purchased from FINLAB Laboratories, Owerri.

3.2 METHODS

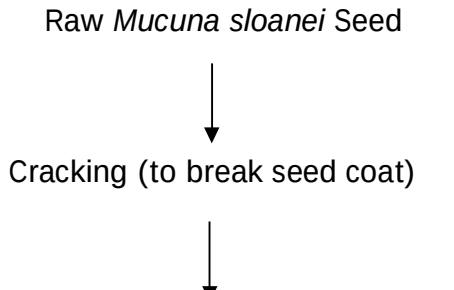
3.2.1 Sample Preparation

Sorting: The raw seeds were sorted to remove bad and damaged seeds.

Chemical Pre-Milling Treatment

The sorted seeds were cracked open with a sledge hammer to allow for water to seep into the seed. The water helps in softening the seed and allow for easy removal of the seed coat. The seeds were steeped for about 9hours to facilitate the easy removal of the testa and tegmen of the seed, to give rise to a pair of white cotyledons. Samples of the white cotyledons were boiled in four (4) batches of different solutions: Batch One- Acid solution containing 1%, 2.5%, 5%, 7.5%, 10% Citric acid at 100^{o}C, 0.5g/ml (loading capacity) for 10

min respectively; Batches Two- Sodium bi-carbonate and Three- Sodium Chloride were boiled in similar manner; batch four (Control) was boiled in distilled water at the same loading capacity and temperature. After the boiling operation, the seeds/cotyledons were allowed to cool, and thereafter were dried in a moisture extractor oven (Model: ME/75/55/DIG) at 65^{o}C. The dried seeds were afterward pulverized (milled) into flour. The flour was screened (sieved) through a standard test sieve (SETHI: BSS 52) to obtain flour particle size.



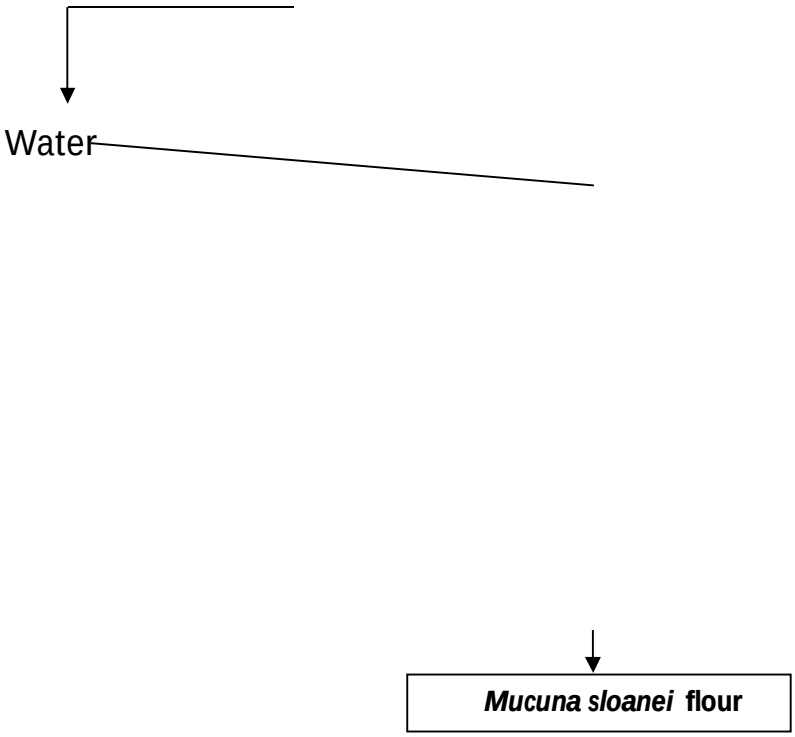


Fig. 3.1 Sample Preparation of Mucuna sloanei flour of three different treatments

Plate One: Mucuna *sloanei* seeds

Plate Two*: Mucuna sloanei* flour- Control sample

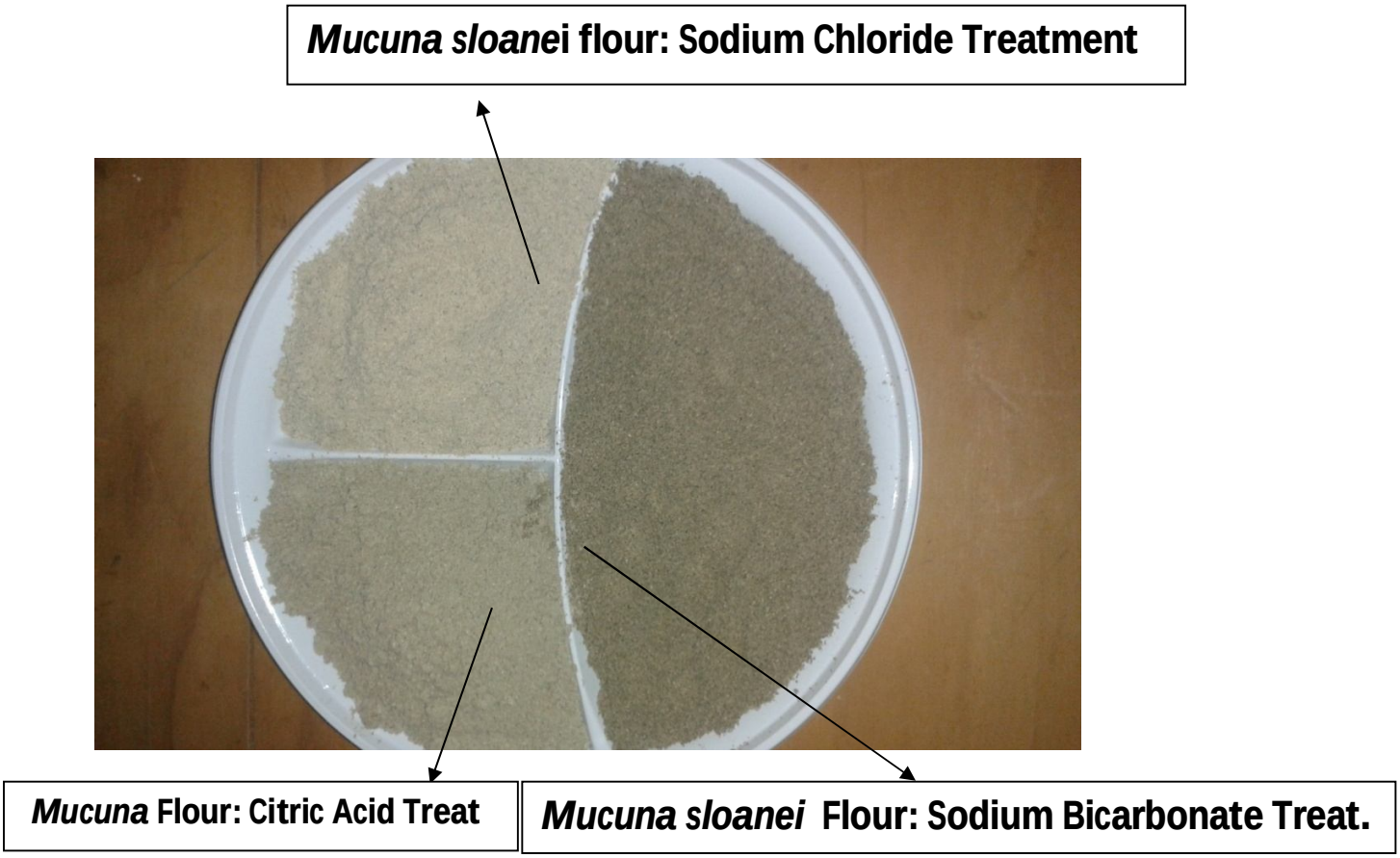


Plate Three: Showing *Mucuna sloanei* flour- with three different treatments

3.2.2 Proximate Analysis

3.2.2.1 Determination of moisture content

The moisture content was determined using the conventional method (AOAC, 1995).

The moisture cans were dried in the oven and cooled in a desiccators. The cans were weighed in a Sartorius electric weighing balance and exactly 5g of each sample weighed into them and dried in a carbolite electric moisture extraction oven at 105^{o}C for three hours in the first instance. It was them cooled in a desiccator and weighed and then returned to the oven for further drying. Drying, cooling and weighing were repeated until there was no further reduction in weight (constant weight). By difference in weight, the weight of the moisture loss was obtained and expressed as a percentage of the sample analyzed.

The formula below was used:

$$\%\, moiture\ content = \frac{w2-w3}{w2-w1} \times \frac{100}{1} \text{ ---------- } eqn\ 1.$$

W_1 = weight of empty moisture can

W_2 = weight of can + sample before drying

W_3 = weight of can + sample after drying to a constant weight.

3.2.2.2 Determination of protein content

This was done using the Kjeldahl method described by James (1995). The nitrogen content was determined and multiplied by the factor 6.25 to obtain the protein content. One gramme of dry sample was dispensed with drops of distilled water. A tablet of selenium catalyst was added to it and to another empty flask (reagent blank) 10mls of concentrated H_2SO_4 acid was added to each of the flask (including the bank) and boiled under a fume cupboard until a clear solution (digest) was obtained. The digest from each sample including the blank was carefully transferred quantitatively to a 100ml volumetric flask and diluted to 100 mark with distilled water.

Ten mls portion of each digest was mixed with equal volume of 45% sodium hydroxide (NaoH) in a Machan (Kjeldhal) distillation apparatus and distilled. The distillate was collected into 10ml of Boric acid solution containing drops of mixed indicators (methyl red and bromocresol green). A total of 50mls distillate was collected and titrated against 0.02N H_2SO_4 solution.

A reagent blank was run as a control, the N_2 was calculated and the formula for protein content given as shown below.

$$\% \, Protein = \%N_2 \times 6$$

$$\% N_2 = \left\{\frac{100}{W} X \frac{14XN}{103} X\ va\right\} Vt\ T - BLK \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn\ 2$$

W = Weight of sample analysed

N = Normality of the titrant

Vt = Total digest volume

Va = Volume of digest analysed

T = Titre value of reagent blank

10^3(a) = Convert from mg to g

3.2.2.3 Determination of fat content

This was done by the continuous solvent extraction method using a soxhlet apparatus. The method as described by Min and Boff (2003) was used.

Five grams (5g) of each sample was wrapped in a fitter paper and put in a porous thimble. The thimble (with the sample was placed in a soxhlet reflux flask and mounted unto a weighed oil extraction flask containing 200mls of petroleum ether. The upper end of the reflux flask was connected to a condenser. The solvent in the flask was heated and was condensed into the reflux flask containing the sample. Immediately, the sample was completely submerged in the

condensed solvent and remained in contact with it until the flask is filed up and siphoned over thus, carrying extracted (oil) fat down to the boiling flask, the above process was allowed to go on repeatedly for about 4 hours before the defatted sample was removed and the solvent recovered. The extraction flask (with the oil smear-extraction oil) was dried in the oven at 60^{o}c for 30 minutes (to remove residual solvent) it was cooled in a desiccators and weighed. The oil (fat) content was calculated as shown below:

$$\%\,Fat = \frac{W3 - W2}{W1} \times \frac{100}{1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn\ 3$$

W1 = Weight of sample analyzed

W2 = Weight of empty extraction flask

W3 = Weight of flask + oil (fat) extracted

3.2.2.4 Determination of crude fibre content

Crude fibre was determined by the Weerde method (Pearson 1976, James 1995). Five grams (5g) of the sample was boiled in 200mls of 1.25% sulphuric acid (H_2SO_4) for 30 minutes under reflux. It was washed with several portions of boiling water using a two-fold muslin cloth to retain the particles. The sample was then carefully

and quantitatively transferred to the boiling flask and boiled again for 30minutes in 1.25% sodium Hydroxide (NaoH) solution. After washing it was transferred to a weighed crucible and dried at 105^{o} for an hour, cooled in a dessicator and weighed. It was taken to a muffle furnace for ashing after cooling in a dessicator. It was reweighed and the weight of crude fibre was obtained using the calculation below and expressed as a percentage of the sample.

$$\%\, Crude\ fibre\ = \frac{W2 - W3}{W1} X\ \frac{100}{1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn\ 4$$

W_1 = Weight of sample

W_2 = Weight of sample and crucible after drying at 105^{o}

W_3 = Weight of sample (as ash) and crucible after ashing in furnace.

3.2.2.5 Determination of ash content

This was determined by furnace incineration gravimetric method A.O.A.C (1990).

A weighed sample (5.0g) was put in a fared crucible and placed in muffle furnace. It was allowed to burn at 550^{o} until it became gray ash. Care was taken to avoid loos of ash by wind action and the sample was cooled in a dessicator and weighed. By weight difference,

the weight of ash was obtained and expressed as a percentage of the sample analyzed as shown below.

$$\%\, Ash = \frac{W3 - W2}{W1} X \frac{100}{1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn\ 5.$$

W_1 = Weight of sample analyzed
W_2 = Weight of empty crucible
W_3 = Weight of crucible + ash

3.2.2.6 Determination of carbohydrate content

The carbohydrate content of the test sample was determined by estimation using the arithmetic difference method described variously by Pearson (1976) and James (1995). The carbohydrate content was calculated and expressed as the Nitrogen free extract as shown below:

$$\%\, CHO(Nitrogen\ free\ extract - NFE)$$

$$= 100 - \%\,(a + b + c + d + e) \ldots\ldots\ldots\ldots\ldots\ldots eqn\ 6.$$

Where:

a = protein
b = fat
c = ash
d = crude fibre
e = moisture

3.2.3 Functional Properties

3.2.3.1 Determination of swelling index

One gram (1g) (dmb) of each flour sample was transferred into a clean dry graduated cylinder. The flour samples were gently levelled and the volumes noted. Distilled water was added to each sample at different ratios to make up to 10mls. The cylinder was swirled and allowed to stand for 60mins, while the change in volume (swelling) was recorded every 15min, the swelling power of each flour sample was calculated as a multiple of the original volume as done by Ukpabi and Ndimele (1990). The formula for determining Swelling Index is shown below:

$$S = \frac{V2}{V1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . eqn\ 7.$$

Where S = Swelling Index

V_1 = Initial Volume

V_2 = Final Volume

3.2.3.2 Determination of water absorption capacity

The method of Sosulki (1962) as described by Abbey and Ibeh (1988) was adopted. 1g (dmb) each of the flour samples were weighed separately and also together with a clean dry centrifuge tube into which it was placed. Distilled water was mixed with the samples to make up to 10ml dispersion. They were then centrifuged at speed of

3500rpm for 15mins. The supernatant was dispersed and the tube with the contents reweighed. The gain in mass is the water absorption capacity of the sample.

3.2.3.3 Determination of oil absorption capacity

This was determined by the volume of water absorbed by one gramme of the sample. The method described by Okaka and Potter (1979) was used. One gramme of sample was weighed out and put into a clean dry centrifuge tube. 10mls of oil (Grand Pure Soya cooking oil, Nigeria) was added to the tube and mixed very well. The mixture was allowed to stand for 30 min before being centrifuged at 1000rpm for 30 min. The supernatant was decanted and the volume noted. By difference, the volume of oil absorbed/held by the sample was obtained. It was calculated as follows:

$$OAC\ (ml/g) = \frac{V1 - V2}{W}\ X\ S.G \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn\ 8.$$

Where V_1 = Initial Volume of oil (10ml)
V2 = Volume of the Supernatant
S.G = Specific Gravity of the oil (0.884g/ml)
W = Weight of Sample (1g)

3.2.3.4 Bulk density determination

Bulk density of flour samples were determined by Weighing the sample (5g) into 10ml graduated cylinder, tapping several times against the top of a table, until constant volume was attained. Bulk density was then determined by expressing the final volumes as g/ml.

$$Bulk\ Density(BD) = \frac{Mass}{Constant\ Volume} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn\ 9.$$

3.2.2.5 Determination of emulsion Capacity and stability

This was determined according to Yatsumatus *et al.,* (1972). 7g (dmb) of each sample were suspended in 100ml of distilled water and 100ml of refined soya-bean oil at room temperature and rapidly blended for 5min in a blender.

The emulsions prepared were centrifuged at 2000 rev for 5min, the ratio of the height of the emulsified layer to the total height of the fluid was calculated and E.A expressed as percentage.

$$E.A(\%) = \frac{Height\ of\ Emulsified\ layer\ in\ the\ tube}{Height\ of\ the\ total\ fluid\ in\ the\ tube}\ x\ \frac{100}{1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn\ 10$$

For emulsion stability the emulsion prepared as above was heated for 30 minutes at 80ºC, cooled with tap water for 5minutes and centrifuged at 2000rev for 5min. emulsion stability was calculated and expressed percentage.

$$E.S(\%) = \frac{Height\ of\ Emulsified\ layer\ in\ the\ tube}{Height\ of\ the\ total\ fluid\ in\ the\ tube}\ x\ \frac{100}{1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn\ 11$$

3.2.3.6 Determination of foam capacity and stability

This was determined according to Narayana and Narasinga Rao (1982). 1g (dmb) of each sample were suspended in 50ml distilled water. The solution was poured in a warning blender and Blended (whipped) at 1600rpm for 5mins at room temperature. The resulting mixture was poured into a measuring cylinder and the volume of the foam was recorded after 30 seconds and over a period of 10 – 60 minutes.

The volume of foam of 30 seconds after whipping is expressed as foam capacity.

$$FC\ (\%) = \frac{Va - Vb}{Vb}\ X\ \frac{100}{1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn\ 12$$

Fc = foam capacity (%)

Va = volume after whipping (ml)

Vb = volume before whipping (ml)

$$FS\ (\%) = \frac{Va(60\ minutes) - Vb}{Vb}\ X\ \frac{100}{1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn\ 13$$

Fs = foam stability (%)

Va(60minutes) = volume after whipping for 60minutes(ml)

Vb = volume before whipping (ml)

3.2.4 Pasting Properties Determination

Pasting characteristics were determined with a Rapid Visco Analyzer (RVA) (Model RVA 3D+, Newport Scientific Australia). First, 2.5 g of *Mucuna sloanei* flour sample were weighed into a dried empty canister; then 25 ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA as recommended. The slurry was heated from 50-95°C with a holding time of 2 min followed by cooling to 50°C with 2 min holding time. The rate of heating and cooling were at a constant rate of 11.25°C per min. Peak viscosity, Trough, Breakdown, Final viscosity, Set back, Peak time and Pasting temperature were read from the pasting profile with the aid of thermocline for windows software connected to a computer (Newport Scientific, 1998). The viscosity was expressed in terms of Rapid Visco Units (RVU), which is equivalent to 10 centipoises.

3.2.5 CAKE MAKING

Cake Ingredients: Flour, Eggs, Margarine, granulated sugar, baking powder, flavour (vanilla extract), brandy (preservative).

The following step-by-step manual method/procedure for making conventional cakes was applied:

1. **Creaming method:** The creaming operation was carried out with a spatula and a bowl; a bowl enough to contain two times the size of margarine and sugar to be creamed. The stirring (creaming) was carried out in one direction until the mixture became fluffy (margarine becomes softer and less dense in weight), and the initial yellowish colour of margarine turned lighter and cream in colour. The stirring in one direction was to ensure the end product had a smooth consistency, devoid of irregular air spaces in the cake matrix.

2. Preparing the Baking Pan

In preparing the Baking pan it was rubbed (smeared) with soft margarine all round inside the pan. The greasing of the pan prevents the cake from sticking to the pan, thereby making it easy for it to be brought out from the pan when done, without denting the cake.

3. **Whisking of the Egg:** The eggs were broken into a bowl and whisked into a smooth blend with the help of a table fork. The whisked eggs was poured into the creamed mix of butter and sugar and stirred to consistency. It was mixed until a smooth fluffy blend of sugar, butter and eggs was obtained.

4. **Preheating the Oven:** The oven that was used was improvised; a large pot (about two and half times the size of the cake pan) was used. A flat stone was placed inside the pot to help suspend the cake pan within the pot; to prevent the cake pan from having direct contact with the pot. The idea is to create the usual convective and radiative heat environment in a conventional oven. The heat source was the Green rectangular kerosene stove of the butterfly brand. The preheating of the oven environment was to facilitate the cooking of the batter and the rising of the batter, until it is done and ready to be brought out.

5. **Addition of Flavour:** Vanilla essence (liquid) flavour was used to add flavour to the cake. Brandy was also added to serve the purpose of preservation.

6. Addition of Flour and Baking Powder: The flour that was used is composite flour – a blend of wheat flour and 'Ukpo' flour. Here it was blended at different ratios: 100%:0% wheat flour: 'Ukpo' flour, 75%:25% wheat flour to 'Ukpo' flour, 50%:50% wheat flour: 'Ukpo' flour 25:75% wheat flour: 'Ukpo' flour respectively. The baking powder was added to the flour, it was sifted through a sieve to obtain smooth consistency. The flour was then added into the sugar, butter and egg blend and stirred to consistency. The batter was poured into already greased cup like cake pans enough to fill the cups to the three quarter capacity of the cake pans. They were then transferred into the preheated oven to bake for 40mins at 134^{o}C. The cake was checked after 30min to ascertain the level of perfectness of the cake. This was done by inserting a spoon at the centre of the cake if the spoon turns out to be free from the sticky paste of the batter on the inside, it is said to be done and ready to be removed from the oven. The cake was then allowed to cool and ready to be eaten.

3.2.6 Sensory Evaluation

The different cake samples were then subjected to sensory evaluation to ascertain the level of acceptance or rejection of the new product. This was carried out by a twenty-five (25) man semi-trained

taste panelist. The composite flour used in preparing the cake was of the conventional wheat flour and 'Ukpo' flour at the ratio 100%: 0, 75%:25%, 50%:50%, 25%:75% (Wheat:Ukpo) flour respectively. Their acceptance or rejection was in terms of appearance, aroma, flavour, mouthfeel and general acceptability. The scoring by the panellists was based on a Nine (9) point hedonic scale of Dislike extremely, Dislike very much, Dislike moderately, Dislike slightly, neither like nor dislike, Like slightly, like moderately, Like very much and Like extremely; 1 – 9 respectively. CCA1, CCA2, and CCA3 are sample codes representing 75%:25%, 50%:50%, 25%:75% (Wheat:Ukpo) cake product samples of Citric acid treatment respectively; for category two: CSB1, CSB2, and CSB3 are sample codes representing 75%:25%, 50%:50%, 25%:75% (Wheat:Ukpo) cake product samples of Sodium bicarbonate treatment respectively; for category three: CSC1, CSC2 and CSC3 are sample codes representing 75%:25%, 50%:50%, 25%:75% (Wheat:Ukpo) cake product samples of Sodium Chloride treatment respectively; CCTRL represents the control sample 100% Wheat flour. The data obtained from the scoring of the panelists were subjected to statistical analysis.

3.2.7 Data Analysis

Data collected from the proximate composition analysis, the Physico-chemical properties, Pasting properties as well as the Sensory Evaluation analyses were subjected to 2-Way ANOVA. Significant means were separated using Least Significant Difference (LSD) test. Tabular representation of 2-Way Factorial Design carried out in this experiment is shown in the appendix.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS

Table 4.1 Mean values for proximate composition of (*Mucuna sloanei*) 'ukpo' of Different treatments.

	Moisture	Protein	Fats	Crude fibre	Ash	Carbohydrate
Control	13.70[a] ±3.44	19.80[a] ±2.42	5.00[a] ±1.32	7.40[a] ±0.72	5.00[a] ±1.57	49.10[a] ±4.12
C/Acid	11.72[a] ±0.45	25.18[a] ±10.31	4.02[a] ±1.29	4.49[b] ±0.76	2.22[b] ±0.04	52.35[a] ±10.97
$NaHCo_3$	12.60[a] ±0.72	23.76[a] ±2.25	0.67[b] ±0.54	6.79[a] ±0.03	3.41[ab] ±0.41	52.75[a] ±1.22
Nacl	11.87[a] ±0.35	23.06[a] ±4.20	0.46[b] ±0.47	8.35[a] ±0.65	2.42[b] ±0.58	53.83[a] ±5.69
LSD $_{0.05}$	**4.94**	**16.12**	**2.74**	**1.72**	**2.39**	**18.16**

Means with different superscript in the same column are significantly different at $p \leq 0.05$.

Concentration of treatment solution: 1%w/v

Proximate composition values are mean of triplicate scores.

Table: 4.2

MEAN VALUES OF FUNCTIONAL PROPERTIES AS AFFECTED BY CHEMICAL PROCESSING AID

Source of Variation	Component of Variation	Parameters							
		S I	WAC	OAC	BD	EC	ES	FC	FS
CPA									
	Distilled water	3.50[a] ±0.00	5.76[a] ±0.00	2.13[a] ±0.00	0.65[a] ±0.00	69.09[a] ±0.00	69.09[a] ±0.00	8.0[a] ±0.00	8.0[a] ±0.00
	Citric Acid	2.78[b] ±0.31	5.77[a] ±0.56	2.29[b] ±0.12	0.76[b] ±0.02	50.91[b] ±3.26	50.91[b] ±3.64	6.8[a] ±1.79	5.72[b] ±0.00
	Sodium - Bicarbonate	2.59[b] ±0.48	6.47[c] ±0.70	2.21[ab] ±0.09	0.78[b] ±0.02	50.91[b] ±3.26	50.91[b] ±3.64	6.4[a] ±4.34	5.40[b] ±0.80
	Sodium chloride	3.03[ab] ±0.35	5.83[a] ±0.38	1.88[c] ±0.19	0.78[b] ±0.01	58.53[c] ±3.13	58.53[c] ±3.50	5.6[a] ±2.51	4.8[b] ±1.83
	LSD 0.05	**0.4834**	**0.4275**	**0.1302**	**0.0168**	**3.6014**	**3.6014**	**2.8737**	**1.7576**

1.6235

* Mean values with different superscripts along the same column are significantly different at (P<0.05)

- CPA = Chemical Processing Aid
- SI = Swelling Index
- WAC = Water Absorption Capacity
- OAC = Oil Absorption Capacity
- BD = Bulk Density
- EC = Emulsion Capacity
- ES = Emulsion Stability
- NS: = No Significant effect
- FC = Foam Capacity
- FS = Foam Stability
- $LSD_{0.05}$ = Least significant different of 95% confidence level

Table: 4.3

MEAN VALUES OF FUNCTIONAL PROPERTIES AS AFFECTED BY PROCESSING AID CONCENTRATION

Source of Variation	Component of Variation	Parameters							
		S I	WAC	OAC	BD	EC	ES	FC	FS
Processing Aid Concentration (PAC)	**1.0%**	2.88^{a} ±0.78	5.99^{a} ±0.63	2.13^{a} ±0.13	0.73^{a} ±0.07	55.46^{a} ±9.90	55.46^{a} ±9.90	6.00^{a} ±2.45	6.00^{a} ±2.45
	2.5%	3.03^{a} ±0.36	6.33^{a} ±0.76	2.11^{a} ±0.18	0.74^{a} ±0.06	58.18^{b} ±9.03	58.18^{b} ±9.03	5.50^{a} ±2.89	4.25^{b} ±2.63
	5.0%	2.92^{a} ±0.48	5.66^{ab} ±0.35	2.05^{ab} ±0.35	0.75^{a} ±0.07	58.64^{b} ±7.77	58.64^{b} ±7.77	6.75^{ab} ±1.5	6.90^{a} ±0.84
	7.5%	3.13^{a} ±0.27	6.23^{a} ±0.39	2.19^{ac} ±0.21	0.75^{a} ±0.07	57.25^{ab} ±8.72	57.25^{ab} ±8.72	6.25^{a} ±2.06	6.25^{a} ±1.71
	10.0%	2.93^{a} ±0.51	5.57^{ab} ±0.17	2.15^{a} ±0.11	0.74^{a} ±0.06	57.27^{ab} ±9.90	57.27^{ab} ±9.90	9.00^{b} ±3.46	6.50^{a} ±1.91
	LSD 0.05	**0.3580**	**0.4019**	**0.1302**	**0.0057**	**3.2212**	**3.2212**	**2.5703**	**1.5721**

* Mean values with different superscripts along the same column are significantly different at (P<0.05)

- PAC = Processing Aid Concentration
  SI = Swelling Index
  WAC = Water Absorption Capacity
  OAC = Oil Absorption
  BD = Bulk Density
  EC = Emulsion Capacity
  ES = Emulsion Stability
  FC = Foam Capacity
  FS = Foam Stability
  $LSD_{0.05}$= Least significant different of 95% confidence level

Table: 4.4

MEAN VALUES OF PASTING PROPERTIES AS AFFECTED BY CHEMICAL PROCESSING AID

Source of Variation	Component of Variation	P_{Temp}	P_{Time}	PV	TV	FV	BD	SB
		Parameters						
Chemical Processing Aid (CPA)	Distilled water	50.15^{a} ±0.00	5.60^{a} ±0.00	553.75^{a} ±0.00	527.29^{a} ±0.00	1512.88^{a} ±0.00	26.45^{a} ±0.00	985.58^{a} ±0.00
	Citric Acid	50.19^{a} ±0.01	5.80^{a} ±0.62	552.39^{a} ±109.52	493.73^{a} ±99.47	1357.66^{a} ±181.13	58.67^{b} ±27.34	863.93^{a} ±89.30
	Sodium - Bicarbonate	54.67^{a} ±9.98	7.0^{b} ±0.00	337.64^{b} ±193.71	288.40^{b} ±175.04	976.88^{b} ±448.88	49.24^{ab} ±20.76	676.81^{b} ±255.61
	Sodium chloride	50.21^{a} ±0.02	5.87^{a} ±0.44	559.70^{a} ±150.49	519.05^{a} ±124.56	1364.96^{a} ±176.69	38.98^{ab} ±34.77	849.38^{a} ±94.23
LSD		**5.4398**	**0.3862**	**107.15**	**91.73**	**217.77**	**25.23**	**130.63**

* Mean values with different superscripts along the same column are significantly different at (P<0.05)

- CPA -Chemical processing Aid
  NSD - No significant different among means
  P_{Temp} - Pasting Temperature
  P_{Time} - Pasting Temperature
  PV - Peak Viscosity
  TV - Trough Viscosity
  FV - Final Viscosity
  BD - Breakdown Viscosity
  SD - Setback Viscosity

$LSD_{(0.05)}$ = Least significant difference at 95% confidence level

Table: 4.5

MEAN VALUES OF PASTING PROPERTIES AS AFFECTED BY PROCESSING AID CONCENTRATION

Source of Variation	Component of Variation	Parameters						
		P_{Temp}	P_{Time}	PV	TV	FV	BD	SB
(PAC)	1%	50.18[a] ±0.02	5.93[a] ±0.72	651.03[a] ±108.97	586.08[a] ±86.80	1533.8[a] ±23.80	64.95[a] ±33.69	933.14[a] ±77.78
	2.5%	50.19[a] ±0.03	6.06[a] ±0.63	529.98[b] ±31.24	491.16[b] ±40.94	1422.53[ac] ±82.51	38.82[b] ±19.05	937.80[a] ±44.83
	5%	50.19[a] ±0.03	5.90[a] ±0.74	505.47[b] ±180.07	457.57[b] ±169.77	1314.57[bc] ±344.09	47.90[b] ±37.71	857.00[a] ±176.83
	7.5%	50.20[a] ±0.05	5.94[a] ±0.76	446.21[bc] ±155.04	417.95[b] ±157.80	1201.69[bc] ±344.79	28.26[b] ±2.94	783.74[ac] ±191.60
	10%	55.77[b] ±11.18	6.55[b] ±0.64	371.67[bc] ±169.24	332.82[c] ±172.35	1042.85[b] ±420.99	36.76[b] ±13.16	707.95[bc] ±249.00
$LSD_{(0.05)}$		**4.47**	**0.35**	**95.84**	**82.05**	**194.78**	**22.56**	**116.84**

* Mean values with different superscripts along the same column are significantly different at (P<0.05)

PAC-Processing Aid Concentration
P_{TEMP} – Pasting Temperature
P_{TIME} – Pasting Time
PV – Peak Viscosity
TV - Trough Viscosity
FV - Final Viscosity
BD – Breakdown Viscosity
LSD $(_{0.05)}$ – Least Significant Difference at 95% Confidence level

Table: 4.6: MEAN VALUES OF SENSORY EVALUATION

Source of Variation	Component of Variation	SENSORY PARAMETERS Appearance	Aroma	Flavour	Mouth feel	G. Acceptability
Sample	Ctrl	8.12[a] ±1.56	6.72[a] ±2.15	7.36[a] ±1.85	7.8[a] ±1.73	8.35[a] ±2.09
	CCA_1	5.84[b] ±2.27	5.12[b] ±1.59	5.40[b] ±1.87	5.6[b] ±1.58	5.24[b] ±1.88
	CCA_2	5.16[b] ±1.95	3.8[ce] ±1.50	4.2[c] ±1.61	2.56[c] ±0.82	3.64[c] ±1.58
	CCA_3	5.92[b] ±1.89	6.16[a] ±2.01	6.56[d] ±1.92	6.76[d] ±1.54	6.64[b] ±1.68
	CSB_1	3.88[c] ±1.86	3.48[c] ±1.19	3.88[c] ±2.01	4.04[e] ±1.21	3.92[c] ±1.82
	CSB_2	4.0 ±2.61[c]	1.92[d] ±0.40	3.12[ce] ±2.01	1.68[f] ±0.63	1.76[d] ±0.88
	CSB_3	2.20[d] ±1.08	1.56[d] ±0.51	2.56[f] ±1.36	1.72[gf] ±0.61	1.76[d] ±0.66
	CSC_1	4.64[c] ±1.91	4.32[ce] ±1.35	4.88[bc] ±1.89	4.4[e] ±1.41	5.00[eb] ±1.96
	CSC_2	3.76[c] ±1.92	3.00[e] ±1.26	4.2[c] ±1.96	2.16[c] ±0.69	3.12[c] ±1.69
	CSC_3	4.50[c] ±1.98	4.84[dc] ±1.18	4.76[bc] ±1.13	6.44[d] ±1.12	5.68[b] ±1.35
LSD (0.05)		**0.8437**	**0.7299**	**0.7950**	**0.6038**	**1.4916**

* Mean values with different superscripts along the same column are significantly different at (P<0.05)
CTRL-Control(100%Wheat);**CCA-**Cake Citric Acid sample;**CSB**–Cake Sodium Bicarbonate; **CSC-**Cake Sodium Chloride
1-75%wheat:25%ukpo; **2**-50%wheat:50%ukpo; **3**-25%wheat:75%ukpo

4.2 DISCUSSION

4.2.1 Proximate Analysis

The result of proximate analysis on the three different treatments of *Mucuna sloanei* seeds were presented in Table 4.1 all results were based on dry matter basis.

The moisture content for all the treated samples showed no significant difference (P<0.05). However the control sample had the highest value of 13.7% and the citric acid sample had the least value for moisture content 11.72%. For the purpose of shelf life stability, the lower the moisture content value, the better the shelf life stability.

The protein content for all the samples showed no significant difference (P<0.05). this result shows that the three (3) different treatments of acid, alkaline and salt on the seeds of *mucuna sloanei* at 10% concentration by weight has no significant difference on the protein content. The citric acid treatment however shows the highest value 25.18%, followed by the sodium bicarbonate sample 23.76%, the sodium chloride sample 23.06% and the control with the least protein content 19.80%.

The Crude fat content ranged from 0.46% to 5.00% (Table 4.1). The crude fat content among the different treatments show significant difference (P<0.05) The result on crude fat content as shown in (Table 4.1) shows that the treatments of alkaline and salt solution has a negative effect on the crude fat content of the sample when compared with the control and citric acid samples which had the

highest values. For food products where low fat content is desired the sodium bicarbonate and salt treatment sample could be applied. For example in composite flours where high protein and less fat is desired, for example in meat analogue.

The crude fibre content of the samples ranged from 8.35%-4.49%, with sodium chloride sample having the highest value 8.35% and the citric acid sample having the least value 4.49%. Table 4.1 shows significant difference ($P<0.05$) among the samples. The citric acid treatment shows significant difference among the other samples ($P<0.05$). This low value for the citric acid treatment could be due to the partial break down of carbohydrate materials of *mucuna sloanei* seed during the treatment; since carbohydrate materials for example cellulose, hemi-cellulose and gums from form the principal source of crude fibre in food materials (Ihekoronye and Ngoddy, 1985). Crude fibre helps in the prevention of constipation, heart diseases, colon cancer, etc.

The ash content of the flours ranged between 2.4% and 5.00% (Table 4.1). The ash content for the control samples shows significant difference ($P<0.05$) from the other samples. The values for the other samples show no significant difference ($P>0.05$) among themselves. Ash content is an indication of the mineral content of food. The control sample had the highest value for the ash content 5% while the citric acid sample had the least value for ash 2.22%. This results suggests that control sample will be best suitable in applications where mineral elements are desired.

The carbohydrate content of the flour samples varied from 49.10%-53.83%. The sodium chloride sample had the highest value for carbohydrate 53.83%, while the control had the least value for carbohydrate. There is no significant difference (P<0.05) for carbohydrate content among the samples.

4.2.2 Functional Properties

4.2.2.1 Swelling index

Swelling index is the measure of the ability of starch to imbibe water and swell. From the result presented on Tables 4.2 and 4.3, it can be seen that there is significant difference (p<0.05) among the CPA factor, while among the PAC factor there is no significant difference (p>0.05).

With respect to CPA factor (Table 4.2) result showed that the Control flour sample exhibited the highest value for Swelling (3.50) followed by Sodium chloride (3.03), Citric acid (2.77), and Sodium bicarbonate (2.59). The main effect of Citric acid and Sodium bicarbonate from the statistical analysis showed no significant difference (P>0.05) among both factors with respect to Swelling of 'Ukpo' flour. The Distilled water sample shows higher Swelling power 3.50; on the other hand chemical pre-milling heat treatment of boiling has a significant effect (P<0.05) on the resultant flour samples of 'Ukpo'. This suggests that the chemical pre-treatment

might have altered the integrity of associative forces within the granules thereby resulting to lower swelling index values when compared distilled water samples. This is in agreement with *Aryee et al.,* (2006) which says water absorption capacity depends on the associative forces among starch components where weak inter associative forces result into high water binding capacity. From (Table 4.3) the values for Swelling index shows no significant difference (P>0.05) among the different levels of concentration of the chemicals (processing aid)

4.2.2.2 Water absorption capacity

The results presented in Table 4.2 show that CPA factor constitute critical determinant for Water Absorption Capacity of 'Ukpo' flour; while PAC factor did not show any significant effect (P>0.05) on the water absorption capacity. The results showed that with respect to CPA the flour resulting from Sodium bicarbonate treatment had the highest WAC of (6.47ml/g) followed by the Sodium chloride sample (5.83ml/g), the Citric acid sample (5.77ml/g), Distilled water (5.76ml/g). The high WAC of the Sodium bicarbonate sample could be due to the presence of Sodium bicarbonate in the flour sample which is a known polar compound and such will have high affinity

for water. For the Sodium chloride sample (5.83ml/g) which directly follows the Sodium bicarbonate sample its high WAC values could be due to the fact that Sodium chloride is a polar compound and water is also a polar compound, hence the reasons for its relatively high WAC value. The increase in ionic sites allows for more water biding sites within the starch molecule. Citric acid (5.77ml/g) is as well a polar substance and will support for more water binding sites within the starch molecules when compared with the Distilled water sample (5.76ml/g) which according to (Ihekoronye and Ngoddy, 1985) polar groups vary but all have some degree of attraction for water and are said to be hydrophilic.

4.2.2.3 Oil absorption capacity

Tables 4.2 and 4.3 show results of Oil Absorption Capacity of 'Upko' flour as affected by CPA and PAC respectively. It shows that only Chemical Processing Aid factor has significant effect ($P < 0.05$) with respect to the components of variation. This implies that only the CPA factor constitute critical determinant for Oil Absorption capacity of 'Ukpo' flour.

For OAC; as affected by CPA, the values ranged from 1.88ml/g-2.29ml/g. Among the CPA factor, flour of Citric Acid gave the highest OAC value of 2.29ml/g, followed by Sodium bicarbonate; 2.21ml/g, Distilled water; 2.13ml/g, and Sodium chloride; 1.88ml/g. The value of distilled water has no significant different ($P>0.05$) in terms of oil absorption capacity, though their values vary from the Table 4.2. Sodium chloride has the least OAC value (Table 4.2) this may be due to the fact that Sodium chloride is a polar compound, hence will have little or no affinity for non-polar compounds-lipids. Citric acid flour sample had the highest OAC value followed directly by Sodium bicarbonate sample (Table 4.2), though there is no significant difference ($P>0.05$) between them. The higher value exhibited by the citric acid sample could be due to the nature of the starch cell wall material as reported by Sathe and Sulukke (1981).

4.2.2.4 Bulk density

Table 4.2 and 4.3 show results of the Bulk density (BD) of 'UKPO' as affected by CPA and PAC respectively. The result shows that only CPA factor has significant effect ($P < 0.05$) with respect to the component of variation. This implies that only CPA factor constitute critical determinant for bulk density of 'UKPO' flour.

From the result on (Table 4.2) Sodium chloride treated flour sample and Sodium bicarbonate treated samples showed the highest value for Bulk density: 0.78g/ml and 0.78g/ml respectively, followed by Citric acid sample 0.76g/ml and Distilled water; 0.65g/ml. The Distilled water sample which has the least bulk density value has significant difference ($P<0.05$) in bulk Density when compared with other samples (Table 4.2). This suggests that the chemicals used in the treatment of the other flour samples contributed to their higher bulk density values; Sodium chloride and Sodium bicarbonate had the highest bulk density values. Bulk density is influenced by particle size and the density of the flour and is important in determining the packaging requirement and material handling (Karuna *et al.,* 1996) Bulk density is directly proportional to mass

and inversely proportional to volume. This statement explains why Sodium chloride and Sodium bicarbonate treated samples tend to have higher Bulk density values; sodium chloride and sodium bicarbonate have mass values greater than the other treatment chemical.

4.2.2.5 Emulsion capacity and stability

From Table 4.2 and 4.3, the results of Emulsion Capacity and Stability are shown respectively; as affected by CPA and PAC. The result shows that both CPA and PAC have significant effect ($P<0.05$) with respect to the components of variation. This implies that both

CPA and PAC constitute critical determinant for the Emulsion Capacity and Stability of 'UKPO' flour.

The Distilled water flour sample had the highest value followed by Sodium chloride flour sample, and finally Citric acid and Sodium bicarbonate samples which has no significant difference ($P>0.05$). The significant difference ($P<0.05$) that occurs between the distilled water sample and all other samples (Table 4.2) is of note. This

significant difference is owing to the fact that *M. sloanei* contains hydrophobic proteins which demonstrate superior binding characteristics with lipids (Lawal and Adewale, 2004).

Also the major chemical component affecting emulsion capacity and stability is protein, which is composed of both hydrophobic and hydrophilic parts. Non-polar amino acid side chains can form hydrophilic interactions with hydrocarbon chains of lipids (Jitrogarmkusol *et al.,* 2008).

The other samples with lesser emulsion capacity values - Sodium chloride, Citric acid and Sodium bicarbonate samples; 58.53%, 50.91% and 50.91% respectively, may be due to the dilution effect posed by the Chemical Processing Aid applied.

4.2.2.6 Foam capacity and stability

Table 4.2 and 4.3 shows the result for Foam Capacity/Stability respectively, as affected by CPA and PAC.

From the result on (Table 4.2) Distilled water sample had the highest value for Foam Capacity followed by Citric acid sample, Sodium bicarbonate, and Sodium chloride sample respectively.

The result shows that both CPA and PAC do not have significant effect ($P > 0.05$) on the Foam Capacity of the different flour samples. On the other hand only CPA shows significant effect on the foam stability of 'Ukpo' flour as affected the components of variation.

This implies that only CPA constitute critical determinant for foam stability of 'Ukpo' flour.

From the Table 4.2 the Distilled water sample has the highest Foam Stability 8.0%. The Sodium chloride sample has the least Foam stability value 4.8%. This result agrees with report that formability is related to the rate of decrease of the surface tension of the air/water interface caused by absorption of protein molecules (Sathe *et al.,* 1981). For the low foam stability value of Sodium chloride flour sample this result agrees with (Narayana and Narasinga 1984; Akintayo *et al.,* 1999) that the effect of salt on the Foam Capacity was concentration dependent, as high concentration of different salt solutions were found to depress foaming. The

beneficial effects of low concentration of salt enhance protein solubility whereas high concentrations decrease it.

4.2.3 Pasting Properties

4.2.3.1 Pasting temperature

Pasting temperature is one of the Pasting properties that provide an indication of the minimum temperature required for sample cooking, energy cost involved and other components stability (Shimelis *et al.,* 2006).

From the result shown in Tables 4.4 and 4.5 both factors CPA and PAC did not show significant effect ($P>0.05$) on the pasting temperature of the flours of Ukpo seed. This result could mean that the chemicals used in processing 'Ukpo' at their various concentrations as shown on Tables 4.4 and 4.5 had no effect on the pasting properties of the various flour samples.

4.2.3.2 Peak viscosity

The result of the Peak viscosity of the various flour samples are shown in Table 4.4 and 4.5 from the result, both CPA and PAC

factors had significant effect ($P<0.05$) on the Peak viscosity of the flours.

Among the components of the PAC factor, flour of Sodium chloride sample (559.20 RVU) attained the highest peak viscosity followed by that of the Citric Acid gave (552 RVU), Distilled water (530RVU), and lastly, the Sodium bicarbonate sample (337.20 RVU). The Distilled water, Sodium Chloride and Citric Acid show no significant difference ($P>0.05$) expect for the Sodium bicarbonate sample (337.20 RVU) which has the least Peak viscosity value. This low value could be attributed to the fact that starch molecules in this particular flours sample exhibited poor swelling ability when compared to the other samples and this consequently led to a relatively lower peak viscosity, since peak viscosity is the ability of starch to swell freely in the presence of water before their physical breakdown. The low Peak viscosity value of Sodium bicarbonate sample agrees within the result obtained for Swelling index (Table 4.2) for most of the sample. The high Peak viscosity value of Sodium chloride (559 RVU), Distilled water (553.0 RVU) and Citric Acid samples (552 RVU) when compared to other leguminous seed starch/flours example *Brachystegia eurycoma* is indicative that the

flour samples may be suitable for products requiring high gel strength and elasticity.

Peak viscosity, according to Pongsawarmanit *et al.,* (2002), is considered to present the equilibrium point between swelling and rupture of starch granules. It is closely associated with the degree of starch damage, and high starch damage results in high Peak viscosity (Sani *et al*., 2001). It is the maximum viscosity developed during the heating cycle of the sample blends.

Among the component of the PAC factor, flours of 1% concentration gave the highest PV (642.20 RVU) followed by 2.5% concentration (545.4 RVU), 5% concentration (525.8 RVU), 7.5% concentration (478.4 RVU) and 10% concentration had the least PV (418.6RVU). The 1% and 2.5% concentration samples show no significant difference ($P>0.05$), whereas 5%-10% flour samples show no significant difference ($P>0.05$), but differ significantly in value when compared with the 1% and 2.5% flour samples. The flour of sodium chloride (among the CPA factor) and the 1% concentration (among the PAC factor) are mostly favoured.

4.2.3.3 Trough viscosity

The result as shown in Table 4.4 and 4.5 revealed that variations caused by the two factors (CPA and PAC) are quite significant ($P < 0.05$). Among the components of the CPA factor, flour of the Distilled water sample showed much stability (527 RVU) than the others. This was followed by Sodium chloride sample (520.40 RVU), Citric Acid (493.40 RVU) and lastly Sodium bicarbonate sample (287.80RVU).

Among the components of the PAC factor, 1% concentration sample showed much stability to heating with viscosity of 592.40 RVU, followed by 2.5% concentration (516.40RVU), 5% concentration (489.60RVU), 7.5% concentration (457.80 RVU) and lastly 10% concentration (391.40 RVU). Trough viscosity is the minimum viscosity value in the constant temperature phase of the RVA profile, and measures the ability of paste to withstand breakdown during cooling. It is an index of starch granule stability to heating.

4.2.3.4 Final viscosity

Table 4.4 and 4.5 show that variation caused by the CPA and PAC factors are significant ($P<0.05$). Among the components of the CPA factor Distilled water sample showed the highest viscosity (1512 RVU) followed by Sodium chloride (1364RVU), Citric acid (1357 RVU) and lastly Sodium chloride (964.60 RVU). Final viscosity indicates the ability of the food material to form viscous paste or gel after cooking and cooling (Ikegwu *et al.,* 2010). It is the viscosity after holding cooked starch at 50^0C, and the most commonly used parameter to define a particular sample quality.

Among the components of the PAC factor; 1% concentration exhibited the highest viscosity value 1513.80 RVU, followed by 2.5% concentration (1436.60 RVU), 5% concentration (1350.20 RVU), 7.5% concentration (1259.80 RVU) and lastly 10% (1132.80 RVU). The high Final viscosity witnessed in distilled water and Citric Acid (Among the CPA factor), 1% 2.5% and 5% concentrations (among PAC factor) indicate that the retrogradation or precipitation of their linear molecule is very high. This tendency to retrograde suggests that the sample flours would exhibit low cooking loss, superior

eating quality and resistant to shear stress relative to the others (Bhattacharya *et al.,* 1999).

4.2.3.5 Set back viscosity

Tables 4.4 and 4.5 show that variations caused by CPA factor is significant ($P<0.05$) whereas the PAC factor did not show any significant effect. Among the components of CPA factor, the Distilled water sample showed the highest setback viscosity (985 RVU). Citric Acid (863.60 RVU) and Sodium chloride samples (843.80 RVU). Sodium bicarbonate sample showed the lowest Setback viscosity (676.20 RVU). Setback viscosity is an index of the tendency of the cooked flour to harden on cooling due to amylose retrogradation (Adeyemi, 1989). Mishra and Rai (2006) reported setback viscosity as a measure of the retrogradation phenomenon, which is closely related to the amylose content of the starch. According to Uzomah and Odusanya, (2011), it indicates how starch molecules behave after heating, cooking and cooling.

In the light of this understanding therefore the retrogradation tendency of the flour samples is as follows: for the CPA factor

Distilled water > Citric Acid > Sodium chloride > Sodium bicarbonate.

4.2.4 Sensory Evaluation

Effect of some chemical treatment of ukpo on the sensory qualities of cake prepared from composite flour of wheat and treated 'Ukpo' flour.

Table 4.6 show the result of statistical analysis conducted on the data generated from sensory panellists based on their preference for Colour, Taste, Aroma, Texture and General Acceptability of Test samples (cake).

4.2.4.1 Appearance

Samples CSB_1 (75% wheat: 25% UKPO), CSB_2 (50% wheat: 50% UKPO), CSC_3 (25% wheat: 75% UKPO), CSC_2 (50% wheat: 50% UKPO) and CSC_1 (75% wheat: 25% UKPO) show no significant difference ($P>0.05$) though they show significant difference when compared with the Control (100% wheat) ($P<0.05$) while CCA_3 (25% wheat: 75% Ukpo) CCA_2 (50% wheat: 50% UKPO), CCA_1 (75% wheat: 25% Ukpo), CSC_1, CSC_3 and CSB_1 show no significant

difference ($P>0.05$). The Control (100% wheat) is significantly different ($P<0.05$) from all the samples Control (8.12± 1.56%). The

deviation in colour from the Control may be due to the reaction of phyto-chemicals: polyphenols, L-Dopa. It has been predicted that melanin may be present in Mucuna seeds even after processing. For instance, cooking or soaking in water with sodium bicarbonate resulted in darkening, which is presumed to be due to conversion of L-Dopa into melanin (Nyirenda *et al.,* 2003).

4.2.4.2 Aroma

The Control sample (6.72), CCA_3 (6.16) (25% wheat: 75% UKPO) show no significant difference ($P>0.05$). CSB_1 (3.48), CSC_2 (3.00) show no significant difference ($P>0.05$), CSC_3 (4.50), CC1 (4.64), show no significant difference ($P>0.05$), samples CSC_3 (4.84) and CCA_1 (5.12) show no significant difference ($P>0.05$), the Control sample (6.72) is significantly different ($P<0.05$) from all the samples except sample CCA_3 (6.16). The aroma of the control was better because it was prepared from 100% wheat flour.

4.2.4.3 Flavour

The Control sample (7.36) is significantly different from all the other samples (P<0.05). This therefore implies that consumers prefer the control sample to all other samples. In terms of product flavour, sample CSB_2 (3.12) CSB_1 (3.88) show no significant difference (P>0.05); samples CSB_1 (3.88), CSC_3 (4.76), CSC_2 (4.2), CSC_1 (4.88), CCA_2 (4.2) did not show significant difference (P>0.05); samples CSC_3 (4.76), CSC_1 (4.88) and CCA_1 (5.4) show no significant difference (P>0.05). This implies that consumers will either accept or reject any of the samples in this statistical grouping based on the nine (9) point Hedonic scale rating applied in this study.

4.2.4.4 Mouth feel

From the results in table 4.6. Samples of the Control (7.8) is statistically different from all other samples (P<0.05). CSB_3 (1.2) and CSB_2 (1.68) show no significant difference (P>0.05); samples CSB_1 (4.04) and CSC_1 (4.4) show no significant difference; samples CSC_2 (2.16), CCA2 (2.56) show no significant difference (P>0.05);

samples CSC_3 (6.44), and CCA_3 (6.78) show no significant difference (P>0.05).

4.2.4.5 General acceptability

From Table 4.6 Control sample (8.35) is statistically different from all other samples ($P<0.05$). Samples CSB_3 (1.76) and CSB_2 (1.76) show no significant difference ($P>0.05$); samples CSB_1 (3.92), CSC_2 (3.12), CCA_2 (3.64) show no significant difference ($P>0.05$); samples CSC_3 (5.68), CSC_1 (5.00) and CCA_1 (5.24) show no significant difference ($P>0.05$) and lastly samples CCA_3 (6.64) and Control sample (8.35) are significantly different ($P < 0.05$).

The acceptability of the cake samples produced decreased as the level of 'Ukpo' flour increased in the blending ratios as indicated by most of the sensory properties. The above result is in agreement with Ogunsua (1987), who reported that process modification and slight change in the physical, chemical properties of ingredients in blended foods may also affect the sensory characteristics in terms of slight changes.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The result of this study shows that Chemical pre-treatment -Distilled water, Citric Acid, Sodium bicarbonate and Sodium chloride have significant effect on the Functional and Pasting properties/characteristics of 'Ukpo' flour.

Here Distilled water sample exhibited better functional properties than, Sodium chloride, Citric Acid and Sodium bicarbonate. On the other hand Distilled water sample also exhibited better Pasting properties than the other treatments.

Regarding the levels of concentration of the chemicals, the study showed that 7.5% concentration level exhibited better Functional properties than the others while 2.5% concentration level exhibited better Pasting characteristics.

Regarding the cake samples: The control samples (100% Wheat) were mostly accepted by the panellists followed by the 25% level of combination of 'Ukpo', The 50% level of combinations and the 75%

level of combination of 'ukpo' showed less acceptance. This result is applicable to all the sensory parameters considered in this study.

Conclusively, the data generated by this study has provided a guide to food processors in their choice of processing conditions, chemicals as well as their level of combination. It has also provided a form of standardization in the use of these edible chemical reagents and their level of concentration which have been studied. The results obtained from this experiment will no doubt, further guide the food processor in taking decisions on the use of this food thickener in the food and agro allied industry with a view to promoting the efficient utilization and application of the selected food thickener, which before now has been neglected and underutilized.

5.2 CONTRIBUTIONS TO KNOWLEDGE

From this study, it has been discovered that:

Dark brown edible flour can be generated from *Mucuna sloanei* seeds when boiled in Sodium bicarbonate solution of 1% w/v concentration level. This edible dark brown flour can be applied to baked products where natural browning is desired in view of the

nutritional benefits of *Mucuna sloanei* as a protein source. *Mucuna sloanei* flour will exhibit optimum physicochemical characteristics including pasting properties when processed with distilled water

than when processed with the reagents use in this experiment. Hence from this experiment boiling in distilled water is recommended for optimum results.

5.3 RECOMMENDATIONS

Further work should investigate other underutilized, and localized soup thickeners such as *Brachystegia eurycoma* and *Detarium microcarpum* to ascertain their potential use in food applications.

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APPENDIX

KEY WORDS

CPA- Chemical Processing Aid

PAC- Processing Aid Concentration

SI- Swelling Index

WAC- Water Absorption Capacity

OAC- Oil Absorption Capacity

BD- Bulk Density

EC- Emulsion Capacity

ES- Emulsion Capacity

FC- Foam Capacity

FS- Foam Stability

P_{TEMP}- Pasting Temperature

P_{TIME}- Pasting Time

PV- Peak Viscosity

TV- Through Viscosity

FV- Final Viscosity

BD- Breakdown Viscosity

LSD- Least Significant Difference

NS- No significance

CCA – Cake Citric Acid

CSB – Cake Sodium Bicarbonate

CSC – Cake Sodium Chloride

	moisture		total	mean	std
control	16.13	11.27	27.4	13.7	3.436539
c/acid	11.4	12.04	23.44	11.72	0.452548
nahco3	12.09	13.11	25.2	12.6	0.721249
nacl	11.62	12.12	23.74	11.87	0.353553

Anova: Single Factor

LSD
4.939381

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	2	27.4	13.7	11.8098
Row 2	2	23.44	11.72	0.2048
Row 3	2	25.2	12.6	0.5202
Row 4	2	23.74	11.87	0.125

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between G	4.90455	3	1.63485	0.516548	0.692918	6.591382
Within Gro	12.6598	4	3.16495			
Total	17.56435	7				

	PROTEIN		TOTAL	MEAN	std
CONTROL	21.51	18.09	39.6	19.8	2.418305
C/ACID	32.47	17.89	50.36	25.18	10.30962
NAHCO3	25.35	22.17	47.52	23.76	2.2486
NACL	26.03	20.09	46.12	23.06	4.200214

LSD
16.11979

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	2	39.6	19.8	5.8482
Row 2	2	50.36	25.18	106.2882
Row 3	2	47.52	23.76	5.0562
Row 4	2	46.12	23.06	17.6418

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between G	31.1272	3	10.37573	0.307807	0.819785	6.591382
Within Gro	134.8344	4	33.7086			
Total	165.9616	7				

	CRUDE		TOTAL	MEAN	std
CONTROL	7.91	6.89	14.8	7.4	0.721249
C/ACID	3.95	5.03	8.98	4.49	0.763675
NAHCO3	6.81	6.77	13.58	6.79	0.028284
NACL	8.81	7.89	16.7	8.35	0.650538

LSD 1.715677

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	2	14.8	7.4	0.5202
Row 2	2	8.98	4.49	0.5832
Row 3	2	13.58	6.79	0.0008
Row 4	2	16.7	8.35	0.4232

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between C	16.18295	3	5.394317	14.12679	0.013538	6.591382
Within Grc	1.5274	4	0.38185			
Total	17.71035	7				

	FATS		TOTAL	MEAN	std
CONTROL	5.93	4.07	10	5	1.315219
C/ACID	4.93	3.11	8.04	4.02	1.286934
NAHCO3	1.05	0.29	1.34	0.67	0.537401
NACL	0.79	0.13	0.92	0.46	0.46669

LSD 2.738918

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	2	10	5	1.7298
Row 2	2	8.04	4.02	1.6562
Row 3	2	1.34	0.67	0.2888
Row 4	2	0.92	0.46	0.2178

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between C	32.13055	3	10.71018	11.00569	0.021088	6.591382
Within Grc	3.8926	4	0.97315			
Total	36.02315	7				

	ASH		TOTAL	MEAN	std		
CONTROL	3.89	6.11	10	5	1.569777		
C/ACID	2.25	2.19	4.44	2.22	0.042426		
NAHCO3	3.7	3.12	6.82	3.41	0.410122		LSD
NACL	2.83	2.01	4.84	2.42	0.579828		2.392581

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	2	10	5	2.4642
Row 2	2	4.44	2.22	0.0018
Row 3	2	6.82	3.41	0.1682
Row 4	2	4.84	2.42	0.3362

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between G	9.67455	3	3.22485	4.342647	0.094969	6.591382
Within Grc	2.9704	4	0.7426			
Total	12.64495	7				

	CHO		TOTAL	MEAN	std		
CONTROL	52.01	46.19	98.2	49.1	4.115361		
C/ACID	44.59	60.11	104.7	52.35	10.9743		
NAHCO3	53.61	51.89	105.5	52.75	1.216224		LSD
NACL	57.85	49.81	107.66	53.83	5.685139		18.16246

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	2	98.2	49.1	16.9362
Row 2	2	104.7	52.35	120.4352
Row 3	2	105.5	52.75	1.4792
Row 4	2	107.66	53.83	32.3208

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between G	24.88735	3	8.295783	0.193859	0.895546	6.591382
Within Grc	171.1714	4	42.79285			
Total	196.0588	7				

ANOVA Swelling index

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2.3074	3	0.76913	5.6990	0.01159	3.49029
Columns	0.1632	4	0.04080	0.3024	0.87083	3.25916
Error	1.6195	12	0.134958			
Total	4.09012	19				

ANOVA- Water Absorption Cap.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1.7538	3	0.58459	3.43707	0.05203	3.490295
Columns	1.7915	4	0.4479	2.63324	0.08680	3.259167
Error	2.0410	12	0.1701			
Total	5.5863	19				

ANOVA- Oil Absorption Cap.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.4807	3	0.1602	8.98085	0.00215	3.490295
Columns	0.0416	4	0.0104	0.58318	0.68079	3.259167
Error	0.2141	12	0.0178			
Total	0.7364	19				

ANOVA- Bulk Density

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.0574	3	0.01913	56.6667	2.34E-	3.490295
Columns	0.0006	4	0.0002	0.46667	0.75924	3.259167
Error	0.0041	12	0.0003			
Total	0.0621	19				

ANOVA- Emulsion Cap & Stability

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1110.834	3	370.278	33.88223	3.88E-06	3.490295
Columns	23.827	4	5.95675	0.545071	0.706074	3.259167
Error	131.1406	12	10.92838			
Total	1265.802	19				

ANOVA- Foam Capacity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	15	3	5	0.718563	0.559794	3.490295
Columns	29.7	4	7.425	1.067066	0.414652	3.259167
Error	83.5	12	6.958333			
Total	128.2	19				

ANOVA- Peak Viscosity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	255997	3	853325	6.12583	0.00905	3.490295
Columns	248246	4	620615	4.45525	0.01946	3.259167
Error	167159	12	139299			
Total	671403	19				

ANOVA-Trough Viscosity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2776734	3	925578	9.0652	0.00207	3.49029
Columns	2003007	4	500751	4.9044	0.01411	3.25916
Error	1225233	12	102102			
Total	6004975	19				

ANOVA- Breakdown Viscosity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	413069	3	137689	1.78295	0.20388	3.490295
Columns	448558	4	112139	1.4521	0.27681	3.259167
Error	926709	12	77225.			
Total	178833	19				

ANOVA-Final Viscosity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1.13E+08	3	377355	6.5577	0.00712	3.49029

Columns	8388639	4	209715	3.6444	0.03635	3.25916
Error	6905180	12	575431			
Total	2.66E+0	19				

ANOVA-Setback Viscosity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	348661	3	116220	5.61294	0.0122	3.490295
Columns	224964	4	562410	2.7162	0.08047	3.259167
Error	248469	12	207057			
Total	822094	19				

ANOVA-Peak Time

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	5.8481	3	1.9493	15.5099	0.00019	3.490295
Columns	1.1872	4	0.2968	2.36144	0.11180	3.259167
Error	1.5082	12	0.1256			
Total	8.5436	19				

ANOVA-Pasting Temperature

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	75.565	3	25.188	1.01022	0.42202	3.490295
Columns	99.436	4	24.859	0.99701	0.44634	3.259167
Error	299.20	12	24.933			
Total	474.20	19				

Dependent Variable: Appearance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	572.464[a]	9	63.607	16.881	.000
Intercept	5779.216	1	5779.216	1533.762	.000
source	572.464	9	63.607	16.881	.000
Error	904.320	240	3.768		
Total	7256.000	250			
Corrected Total	1476.784	249			

Dependent Variable: Aroma

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	640.804[a]	9	71.200	35.447	.000
Intercept	4186.116	1	4186.116	2084.027	.000
source	640.804	9	71.200	35.447	.000
Error	482.080	240	2.009		
Total	5309.000	250			
Corrected Total	1122.884	249			

Dependent Variable: Flavour

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	482.724[a]	9	53.636	17.243	.000
Intercept	5503.716	1	5503.716	1769.304	.000
source	482.724	9	53.636	17.243	.000
Error	746.560	240	3.111		
Total	6733.000	250			
Corrected Total	1229.284	249			

Dependent variable: Mouthfeel

Dependent Variable: Flavour

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	482.724[a]	9	53.636	17.243	.000
Intercept	5503.716	1	5503.716	1769.304	.000
source	482.724	9	53.636	17.243	.000
Error	746.560	240	3.111		
Total	6733.000	250			
Corrected Total	1229.284	249			

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1144.356[a]	9	127.151	87.771	.000
Intercept	4656.964	1	4656.964	3214.655	.000
source	1144.356	9	127.151	87.771	.000
Error	347.680	240	1.449		
Total	6149.000	250			
Corrected Total	1492.036	249			

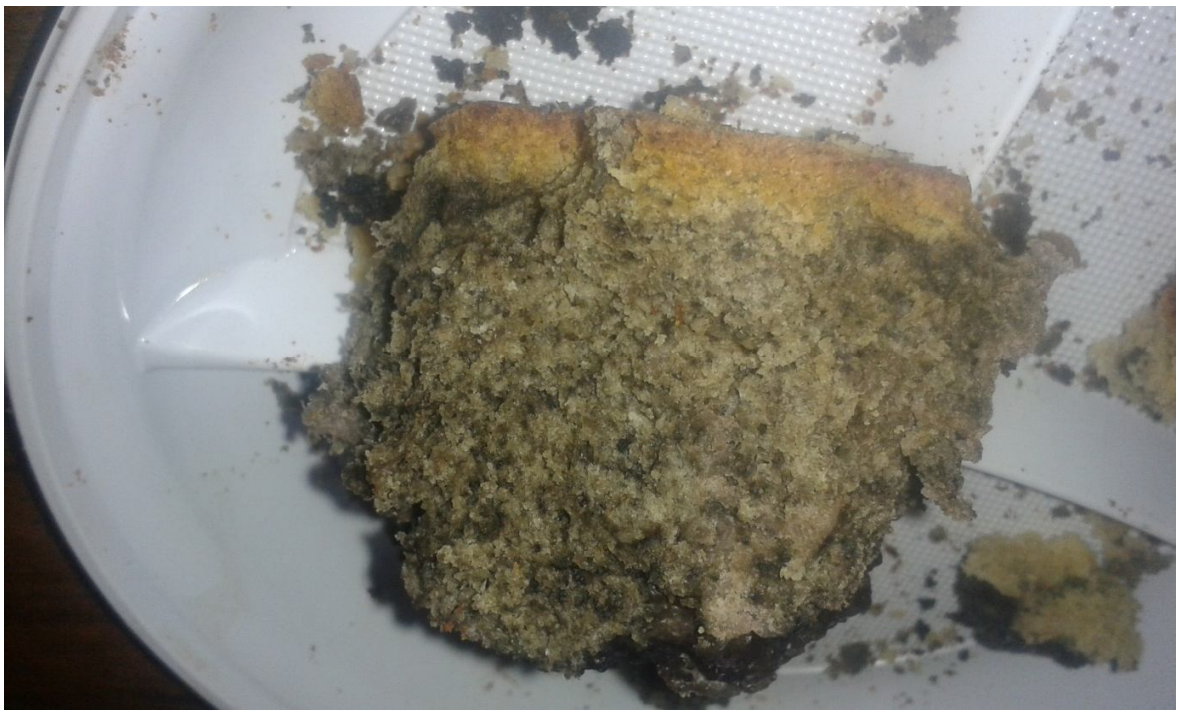
(B) Crumb

Sodium Chloride treatment- 50% Wheat : 50% Ukpo flour

Crust and Crumb

Plate Four:

Sodium Bicarbonate Treatment- 25 Wheat : 75% Ukpo flour



Crust and Crumb

Plate Five:

Sodium Chloride treatment- 75% Wheat : 25% Ukpo flour

(A) Crust

(B) Crumb

Plate Six:

Citric Acid Treatment- 50% Wheat : 50% Ukpo flour

(A) Crust

(B) Crumb

Plate Seven: Control= 100% Wheat

(A) Crust

(B) Crumb

Plate Eight: Sodium chloride Treatment- 25% wheat : 75% Ukpo flour

(B) Crust

(A) Crust

Plate Nine: Sodium bicarbonate treatment- 50% Wheat : 50% Ukpo

(B) Crumb

(A) Crust

Plate Ten: Sodium bicarbonate- 75% Wheat : 25% Ukpo

(A) Crust

Crumb

Plate Eleven: Citric Acid Treatment 25 % Wheat : 75% Ukpo

Crumb and Crust

Plate Twelve: Citric acid Treatment- 75% Wheat : 25% Ukpo

Crumb and Crust

Plate Twelve: Citric acid Treatment- 75% Wheat : 25% Ukpo