The Effect of Storage Condition on the Rheological/Functional Properties of Soup Thickener *Mucuna sloanei* (Ukpo)

Nwosu, Justina

Department of Food Science and Technology, Federal University of Technology, P. M. B. 1526 Owerri
Ifytina19972003@yahoo.com

Abstract: The effect of storage conditions on the rheological/functional properties of 'Ukpo' (*Mucuna sloanei*), was studied for 12 weeks and analysed at 4 week intervals. The seeds were subjected to five different storage conditions namely refrigeration, ambient, fire place (*Ngiga),* plastic, and mud pot. Rheological analysis showed that the values of the legumes significantly decreased ($p \leq 0.05$) for viscosity, water absorption, oil absorption, foaming capacity, Emulsifying capacity, swelling index, wetability and solubility as the storage time increased from I week to 12 weeks; while there was no significant increase ($p \geq 0.05$) in gelation, and bulk density as time of storage from I week to 12 weeks. The values of gelation of "Ukpo" stored under refrigeration increased from (24.00% - 32.00%) as the storage time increased from 1 week to 12 weeks. The protein content of "Ukpo" also decreased in fire place (Ngiga) after 12 weeks of storage from (19.80%) to (17.80%).
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Key words: Storage Condition; Rheological/Functional Property; Soup Thickener *Mucuna sloanei*

1. Introduction:

Ukpo (*Mucuna slonei*) is among one of the legumes found in the tropical and sub-tropical regions of the world. It is a food thickener known to originate from Asia and was introduced into the western hemisphere via *Mauritus* (Nkpa, 2004). It is known as "horse eye bean"; and with other local names in respect to different tribes and ethnic groups. It is called 'ukpo' by Ibos; 'karasuu' by Hausas and 'Yerepe' by Yorubas (Adewale and Mozie, 2010). They belong to the legume family fabaceae. There are other species of *Mucuna* throughout tropical regions of the world including *Mucuna urensi*, *M. pruriens* and *M. veracrua* (Nkpa, 2004).

Nutritionally, the 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. They are better source of phosphorous, but only fair in their supply of iron and calcium (Okaka *et al*., 2006). Ukpo (*Mucuna sloanei*) contain 20.0 – 25.4%, crude protein, 43.5% – 49% CHO; 5.05 - 7.0% fat; 25.0 - 27.4% crude fibre, and about 6.46% - 14% moisture (Akpata and Miachi, 2001).

'Ukpo' (*Mucuna sloanei*) is used in preparing various soups as soup thickeners (Ezueh, 1997). In addition to their thickening property, Ukpo has gelation properties and imparts a gummy texture when used in soups. This is a desirable attribute for the eating of 'gari', 'fufu', pounded yam etc. As a result of increasing interest in the use of soup thickners for food preparation and industrial purposes, especially in new product development, the issue of storage conditions as it affects the rheological properties of this food thickener has become one of optimum concern. Previous work on the rheological properties of soup thickeners indicate that storage conditions affect the quality of these seeds due to attack by pests and spoilage by mico-organisms. Therefore the need for selecting the most suitable storage cannot be over emphasized.

The objective of this research work therefore is to determine the proximate composition and the rheological/functional properties of 'Ukpo' as affected by different storage conditions. It is hoped that this will provide a base for selecting an ideal storage condition for this seed.

2. Materials and Methods

'Ukpo' seeds used for this research work were purchased from a local market (Afo-oru) in Mbaise in Imo State. The chemicals used were of analytical grade and were obtained from the Department of Food Science and Technology, Federal University of Technology Owerri. The equipment and other materials were obtained from the Departments of Food Science and Technology and Crop Science and Technology, Federal University of Technology Owerri.

2.1. Sample Preparation

The seeds were sorted to remove dirts and stalks. One kilogram (1 kg) of cleaned seeds were conditioned to 25% moisture by addition of 4 liters of distilled water and held for 3 h at ambient temperature (28 ± 2^0C) with occasional stirring. This helped to ease hull removal. The conditioned sample was dried at $50 – 60^0$C in a Gallenkamp moisture extraction oven for 2h to a moisture content of 10%. The dried seeds were then

dehulled using disc attrition mill and sieved with American Standard Sieve No 40 with 435 ppm aperture. The samples were then stored for 12 weeks in five different storage conditions of refrigeration, fire place ('Ngiga'), plastic and mud pot including a control sample just kept at ambient temperature. After every 4 weeks (monthly), the samples were analysed for proximate composition and functional/rheological properties.

3. Proximate Composition Analysis

This was carried out according to the method of AOAC (1990).

3.1 Moisture Content Determination

Two grams of each of the sample was weighed into dried weighed crucible. The samples was put into a moisture extraction oven at 105^0C and heated for 3h. The dried samples was put into desiccators, allowed to cool and reweighed. The process was reported until constant weight was obtained. The difference in weight was calculated as a percentage of the original sample

$$\text{Percentage moisture} = \frac{W_2 - W_1}{W_2 - W_3} \times \frac{100}{1}$$

Where

W_1 = Initial weight of empty dish
W_2 = Weight of dish + undried sample
W_3 = Weight of dish + dried sample

3.2 Ash Content Determination

Two grams of each of the samples was weight into crucible, heated in a moisture extraction oven for 3h at 100^0C before being transferred into a muffle furnace at 550^0C until it turned white and free of carbon. The sample was then removed from the furnace, cooled in a desiccator to a room temperature and reweighed immediately. The weight of the residual ash was then calculated as

$$\text{Percentage Ash} = \frac{\text{Ash Content}}{\text{Weight of original of sample}} \times \frac{100}{1}$$

3.3 Crude Protein Determination

The micro kjeldahl method described by A.O.A.C (1990) was used. Two grams of each of the samples was mixed with 10ml of concentrated H_2SO_4 in a heating tube. One table of selenium catalyst was added to the tube and mixture heated inside a fume cupboard. The digest was transferred into distilled water. Ten millimeter portion of the digest mixed with equal volume of 45% NaOH solution and poured into a kjeldahl distillation apparatus. The mixture was distilled and the distillate collected into 4% boric acid solution containing 3 drops of methyl red indicator. A total of 50ml distillate was collected and titrated as well. The sample was duplicated and the average value taken. The Nitrogen content was calculated and multiplied with 6.25 to obtain the crude protein content.

This is given as percentage Nitrogen

$$= \frac{(100 \times N \times 14 \times VF)\ T}{100 \times Va}$$

Where

N= Normality of the titrate (0.1N)
VF= Total volume of the digest= 100ml
T= Titre Value
Va= Aliquot Volume distilled

3.4 Fat Content Determination

Two grams of the sample was loosely wrapped with a filter paper and put into the thimble which was fitted to a clean round bottom flask, which has been cleaned, dried and weighed. The flask contained 120ml of petroleum ether. The sample was heated with a heating mantle and allowed to reflux for 5h. The heating was then stopped and the thimbles with the spent samples kept and later weighed. The difference in weight was received as mass of fat and is expressed in percentage of the sample.

The percentage oil content is percentage fat

$$= \frac{W_2 - W_1}{W_3} \times \frac{100}{1}$$

Where

W_1 = weight of the empty extraction flask
W_2 = weight of the flask and oil extracted
W_3 = weight of the sample

3.5 Crude Fibre Determination

Two grams (2g) sample and 1g asbestos were put into 200ml of 1.25% of H_2S0_4 and boiled for 30 minutes. The solution and content then poured into buchner funnel equipped with muslin cloth and secured with elastic band. This was allowed to filter and residue was then put into 200ml boiled NaOH and boiling continued for 30 minutes, then transferred to the buchner funnel and filtered. It was then washed twice with alcohol, the material obtained washed thrice with petroleum ether. The residue obtained was put in a clean dry crucible and dried in the moisture extraction oven to a constant weight. The dried crucible was removed, cooled and weighed. Then, difference of weight (i.e. loss in ignition) is recorded as crucible fibre and expressed in percentage crude fibre

$$= \frac{W_1 - W_2}{W3} \times \frac{100}{1}$$

Where

W_1 = weight of sample before incineration
W_2 = weight of sample after incineration
W_t = weight of original sample

3.6 Carbohydrate Content Determination

The nitrogen free method described by A.O.A.C (1990) was used. The carbohydrate is calculated as weight by difference between 100 and the summation of other proximate parameters as

Nitrogen free Extract (NFE) percentage carbohydrate (NFE). = 100- (m + p + F + A + F_2)

Where

m = moisture

p = protein

F_1 = Fat

A = ash

F_2 = Crude fibre

4. Determination of the Functional Properties

4.1 Foaming Capacity and Stability

Foaming capacity and stability of the flour samples were studied according to the methods described by Desphande *et al* (1982). For stability, the flour sample (0.5g) was blended for 30 min in distilled water (40ml) at top speed in a blender. The whipped mixture was transferred into 100ml graduated cylinder. The blender was rinsed with 10ml distilled water and then gently added to the graduated cylinder. Foam volume in the cylinder was recorded per sample after 30 minutes standing. Triplicate measurements were taken for each sample and mean value recorded.

4.2 Emulsion Capacity

Emulsion capacity was determined according to A.O.A.C (1990). Flour sample (2g) and distilled water (100ml) were blended for 30sec at high speed (of 100rpm). After complete dispersion, peanut oil was added from a burette in streams of about 5ml. Blending continued until there appeared separation into two distinct layers (emulsion breakpoint). Emulsion capacity was expressed as grams of oil emulsified by 1g flour. Triplicate measurements will be made *and average results taken.*

4.3 Bulk Density

Bulk density of flour samples were determined by weighing the sample (50g) into 100ml graduated cylinder, tapping ten times against the palm of the hand and expressing the final volumes as g/ml.

4.4 Wettability

The method of Onwuka (2005) was used. Into a 25ml graduated cylinder with a diameter of 1cm,1g of sample was added. A finger was placed over the open end of the cylinder which was invested and clamped at a height of 10cm from the surface of a 600ml beaker containing 500ml of distilled water. The finger was removed and the rest material allowed to be dumped. The wettability is the time required for the sample to become completely wet.

4.5 Viscosity

The method of Onwuka (2005) was adopted. Ten (10) percent of the flour was suspended in distilled water and mechanically stirred for 2h at room temperature. Oswald type Viscometer was used to measure the viscosity.

4.6 Water Absorption Capacity Determination

The method of Abbey and Ibeh (1998) was adopted for determination of water absorption capacity. Flour sample (1g, dry basis) of each treatment was weighed separately (and also together with a clean, dry centrifuge tube, into which it was placed). Distilled water was mixed with the flour to make up to 10ml of dispersion. It was then centrifuged at 3500 rpm for 15 minutes. The supernatant was discarded and the tube with its contents reweighed as water absorbed per gram of sample. The gain in mass was the water absorption capacity of the flour sample.

4.7 Oil Absorption Capacity

Two grams (2g) of the composite flour samples (2g) were mixed with 20ml of oil in a blender at high speed for 30sec. Samples were then allowed to stand at 30^0C for 30 minutes then centrifuged at 1,000rpm for 30 minutes. The volume of supernatant in a graduated cylinder was noted. Density of water was taken to be 1g/ml and that of oil determined to be 0.93g/ml. Means of triplicate determinations were reported.

4.8 Swelling Index Determination

Three gram portions (dry basis) of each flour were transferred into clean, dry, graduated (50ml) cylinders. Flour samples were gently leveled and the volumes noted. Distilled water (30ml) was added to each sample; the cylinder was swirled and allowed to stand for 60 minutes while the change in volume (swelling) was recorded every 15 minutes. The swelling power of each flour sample was calculated as a multiple of the original volume as done by Ukpabi and Ndimele (1990).

4.9 Solubility Determination

The cold water extraction method, as described by Udensi and Onuora (1992), was adopted. Flour dispersion (10% w/v, db) was prepared with each of the flour samples by dispersing 1g (dry base) of flour in 5 ml distilled water and making it up to 10ml. It was left for 60 minutes while it was stirred every 10 minutes. Then it was allowed to settle for 15 minutes after which 2ml of the supernatant were weighed in a dry Petri dish, evaporated to dryness and re-weighed. The difference in mass is the total soluble solids (Udensi and Onuora, 1992). Solubility was calculated as follows:

$$\text{Solubility} = \frac{\text{TSS (\%) ((VsMe-Md)}}{2\text{Ms}} \times \frac{100}{1}$$

Where
Vs = Total supernatant/ filtrate
Md= Mass of empty, dry Petri dish
Me = Mass of Petri dish plus residual solid after evaporative drying
Ms = mass of flour sample used in the preparation of the dispersion.

4.10 Gelation Capacity

The method of Onwuka (2005) was adopted in the determination of gelation capacity. A sample suspension of 2.20% (w/v) in 5ml of distilled water was prepared in test tubes. The samples were heated for 1h in a boiling water bath followed by rapid cooling under running cold tap water. The test tubes were then cooled further for 2h at 4^0C. The gelation capacity is the least gelation concentration determined as the concentration when the sample from the inverted test tube will not fall or slip.

5. Results and Discussion

5.1 Effect of Storage Condition on Proximate Composition of "Ukpo"

For moisture, there was a significant decrease between the control sample and the one stored in plastic and fireplace. The samples stored in fireplace lost water more rapidly compared to other storage conditions. This could be attributed to the fact that heat or higher temperature causes loss of moisture in food as reported by Dengate (1984). There was no significant difference ($p \geq 0.05$) among the different storage conditions studied. As such it could be said that the storage conditions did not affect the mineral contents of the seed.

Table 1: Means Values for the Proximate Composition of 'Ukpo' As Affected By Different Storage Condition

Storage Condition Time	Moisture %	Ash %	Fat %	Protein %	Crude Fibre %	CHO %
Control 0h	13.70^{a}	5.00^{a}	5.00^{a}	19.8^{a}	7.40^{c}	49.10^{b}
12 wks						
Ambient	13.70^{a}	4.42^{a}	4.48^{b}	18.70^{c}	9.10^{b}	45.88^{c}
Refrigeration	13.00^{ab}	4.50^{a}	4.50^{b}	18.8^{b}	9.00^{b}	50.20^{ab}
Plastic	13.10^{b}	4.47^{a}	4.31^{b}	18.01^{c}	8.88^{b}	49.99^{b}
Mud pot	13.01^{ab}	4.43^{a}	4.30^{b}	18.07^{c}	10.20^{a}	49.99^{b}
Fire place	12.00^{c}	4.40^{a}	4.00^{c}	17.80^{c}	9.01^{b}	52.79^{a}
LSD	**0.404**	**0.792**	**0.292**	**0.248**	**0.578**	**1.450**

a,b,c means with the same superscript on the same column are not significantly different at ($p \geq 0.05$)

On the fat content, there was a significant reduction ($p \leq 0.05$) between the control and those stored in the other conditions. The reduction was highest among those stored over fire place. This is because the fat content of foods tends to decrease rapidly under high temperatures. This result is in agreement with the report of Pushpamma and Uma (1979) and also shows why refrigerator condition had least reduction.

The protein content of 'Ukpo' as seen in Table 1 decreased from 19.80 to 17.80 (ambient to fireplace) and there was a significant difference ($p \leq 0.05$) between them. The 'Ukpo' stored under refrigeration temperature retained more protein while that of fireplace had the least. This could be attributed to the high temperature employed in fireplace which caused protein denaturation (Pushpamma and Uma, 1979).

The crude fibre increased with mud storage temperature having the highest value of 10.20%. This was also significant from the control which had the least value of 7.40 and the other samples. There was no significant difference ($p \geq 0.05$) between the crude fibre of those stored in ambient, refrigerator, plastic and fireplace. This result is in agreement with the work of Ayozie (2010) which states that crude fibre content of legumes increases with storage.

The carbohydrate content was highest on samples stored over fireplace after 12 weeks of 52.79%. There was significant different ($p \leq 0.05$) between the control and ambient and those stored under fire place. However, the slight increase observed could be due to the effect of the decrease of the other proximate compositions under the different storage conditions after 12 weeks storage time.

Table 2: Functional Properties of Ukpo

	Wk(s)	Bulk Density (g/g)	WAC (g/g)	OAC (g/g)	Wettability (sec)	(Cp) Viscosity	Solubility (%)	Gelation (%)	Swelling Index (g/g)	Emulsion Capacity (%)	Foaming Capacity (%)
Refrigerator	1	1.77^{d}	2.20^{c}	0.03^{b}	60.00^{a}	64.00^{a}	9.90^{a}	24.00^{d}	1.89^{a}	41.70^{a}	3.00^{a}
	4	2.15^{c}	2.40^{b}	0.01^{b}	55.00^{b}	61.20^{a}	8.61^{a}	25.00^{c}	1.82^{a}	40.10^{a}	2.20^{b}
	8	2.56^{b}	2.60^{b}	0.06^{a}	51.00^{c}	55.30^{ab}	8.02^{a}	29.00^{b}	1.77^{a}	33.90^{b}	2.00^{c}
	12	2.93^{a}	3.10^{a}	0.02^{b}	45.00^{d}	50.90^{b}	7.19^{a}	32.00^{a}	1.71^{a}	30.10^{b}	1.62^{d}
Plastic	1	1.77^{b}	2.20^{a}	0.03^{a}	60.00^{a}	64.00^{a}	9.50^{a}	24.00^{d}	1.89^{a}	41.70^{a}	3.00^{a}
	4	1.75^{b}	2.00^{a}	0.03^{a}	55.00^{b}	63.10^{a}	9.45^{a}	26.00^{c}	1.85^{a}	40.10^{a}	3.00^{a}
	8	1.76^{b}	1.80^{b}	0.01^{a}	53.00^{b}	60.10^{a}	9.42^{a}	29.00^{b}	1.77^{a}	33.20^{b}	2.90^{b}
	12	1.89^{a}	1.40^{c}	0.05^{a}	53.00^{b}	55.10^{b}	9.22^{a}	31.00^{a}	1.72^{a}	30.10^{b}	2.20^{c}
Fireplace	1	1.77^{a}	2.20^{c}	0.03^{a}	60.00^{c}	64.00^{b}	9.50^{a}	24.00^{a}	1.89^{b}	41.70^{a}	3.00^{a}
	4	1.60^{b}	2.40^{c}	0.04^{a}	65.00^{b}	66.10^{b}	9.58^{a}	20.00^{b}	2.10^{b}	32.10^{b}	2.50^{b}
	8	1.35^{c}	2.72^{b}	0.05^{a}	68.00^{b}	70.10^{a}	9.68^{a}	15.00^{c}	2.59^{a}	25.70^{c}	2.10^{c}
	12	1.12^{d}	2.98^{a}	0.07^{a}	72.00^{a}	75.50^{a}	9.78^{a}	10.00^{d}	2.75^{a}	20.10^{c}	1.90^{d}
Ambient	1	1.77^{c}	2.20^{a}	0.03^{a}	60.00^{a}	64.00^{a}	9.50^{a}	24.00^{d}	1.89^{a}	41.70^{b}	3.00^{a}
	4	1.79^{c}	1.60^{b}	0.02^{a}	59.00^{a}	63.10^{a}	9.03^{a}	25.00^{c}	1.86^{a}	45.70^{ab}	2.50^{b}
	8	1.99^{b}	1.40^{b}	0.01^{a}	54.00^{b}	62.10^{a}	9.03^{a}	29.00^{b}	1.84^{a}	46.10^{ab}	2.30^{c}
	12	2.23^{a}	1.10^{c}	0.01^{a}	54.00^{b}	60.10^{a}	8.64^{a}	31.00^{a}	1.82^{a}	48.30^{a}	2.00^{d}
Mud pot	1	1.77^{b}	2.20^{a}	0.03^{a}	60.00^{a}	64.00^{a}	9.50^{a}	24.00^{d}	1.89^{a}	41.70^{a}	3.00^{a}
	4	1.81^{ab}	2.10^{a}	0.02^{a}	55.00^{b}	62.10^{a}	9.41^{a}	26.00^{c}	1.87^{a}	44.70^{a}	2.50^{b}
	8	1.93^{a}	1.70^{b}	0.01^{a}	53.00^{b}	50.10^{a}	9.40^{a}	28.00^{b}	1.85^{a}	45.20^{a}	1.40^{b}
	12	1.99^{a}	1.50^{b}	0.05^{a}	51.00^{c}	55.90^{b}	9.01^{a}	30.00^{a}	1.84^{a}	47.30^{a}	1.10^{c}
LSD		**0.116**	**0.297**	**0.316**	**3.939**	**6.144**	**2.704**	**0.695**	**0.430**	**6.687**	**0.105**

The bulk density of 'Ukpo' as shown in Table 2 had 1.77% as at the first week. After 12 weeks of storage; there was a significant increase ($p \leq 0.05$) in all the different storage conditions. The bulk densities increased more at refrigeration temperature than the other conditions. The lowest bulk density was found to be with those stored in fireplace. This is in agreement with the report of Ayozie (2010) that high temperature reduced the bulk density of legume flours.

For water absorption capacity (WAC), it was observed (Table 2) that there were increases when stored in refrigeration and fireplace; while storage under ambient, mud pot and plastics decreased the WAC. The increase in those stored at fireplace could be attributed to the high loss of water during storage at high temperatures.

The oil absorption capacity (OAC) decreased significantly ($p \leq 0.05$) in refrigeration storage while ambient and mud pot had slight decreases but no significant difference ($p \geq 0.05$) between them. There were also slight increases among those stored in plastics and fireplace though there was no significant difference ($p \geq 0.05$) between them. This could be due to the nature of the starch and possible contribution to oil absorption by the cell wall material as reported by Sathe and Salukhe (1981).

The wettability decreased significantly ($p \leq 0.05$) among the different storage conditions except for fireplace that was on the increase which was also significant. This increase could be as a result of much of the water that have been removed during storage at high temperature.

The viscosity of the different storage conditions followed the same trend with that of wettability where the increasing trend was found only in those stored at fire place. During the 12 weeks of storage, those stored under fireplace were more viscous with values ranging from 60.00Cp to 72.00Cp as against 64.00Cp to 60.10Cp for those stored at ambient. This result was in agreement with the work of Keay *et al* (1975) who reported that legume flours have high viscosity under high temperatures. This also indicates that these flours are more resistant to swelling and rupture towards shear. Higher viscosity in flours has great potential for incorporation into soups that needs high thickenings.

There was no significant difference ($p \leq 0.05$) between all the storage conditions with respect to solubility although there were slight decreases in all except fireplace where there was a slight increase with a solubility of 9.78%.

'Ukpo' had a gelation property of 24.00% at the beginning of storage and decreased to 10.00% at 12 weeks of storage in fireplace which was the least value. Gelation increased significantly in all storage conditions except for the fireplace storage which was also decreasing significantly. Gelation is related to the

protein content of the flour; and as most of the proteins have been destroyed by heat, it reduced its gelation property tremendously.

Although there were slight decreases in the swelling index among the different storage conditions, they were statistically equivalent. A slight increase which was significantly different only occurred in the fireplace storage. This increase from 1.89 – 2.75% was expected because as water is removed, the hydrophilic bonds draw nearer thereby having a higher swelling capacity.

For emulsion, ambient and mud pot storage had increased emulsion capacities which were statistically equivalent. But for the refrigeration, plastic and fireplace storages, there were significant decreases. This significant decrease ($p \leq 0.05$) only occurred from the 8th week of storage. Since the proteins have been reduced as a result of high temperature, it follows that the emulsion will decrease with those stored under high temperature of fireplace. The result of low protein also reflects the low emulsion because protein is involved for high emulsion capacities.

The foaming capacity decreased significantly from the control in all the storage conditions studied. This indicates that storing these samples in this condition is not favorable for products that will need foaming as a factor in a particular product.

6. Conclusion

From the research work, it was observed that the protein decreased as storage time increased in all the storage conditions. This also affected the ash, moisture and fat content which shows that storage for long periods reduces the quality of this seed. From the rheological properties, it was observed that keeping 'Ukpo' under fireplace storage ('Ngiga') improved most of these properties which is needed in various food formulations. Thus it is advised to store "Ukpo" in fire place conditions to improve most of this properties and its usage will help boost the production of 'Ukpo' in order not to make it go endangered.

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Correspondence to:
Dr. (Mrs.) J. N. Nwosu
Department of Food Science and Technology
Federal University of Technology
P. M. B. 1526, Owerri.
Cellular phone: 08028768070
Emails: ifytina19972003@yahoo.com

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