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Effect of processing methods on some product yields of selected cultivars of soup thickener seeds

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Abstract
Effect of processing methods on the percentage yield of cotyledons, flours (Full- fat and de-fatted) and gum extracts of some cultivars of soup thickener seeds were analysed. Soaking for 16 hours resulted to the highest gum extract yield (52.28%). Comparing the effect of the processing methods on the product yields, roasting for 20 min. gave the highest yield for cotyledons (92.72%) and full- fat flour (94.88%). With the exception of the cotyledons, de- hulling resulted to higher yield for all the derived products for all the samples. With respect to gum extract yield, de- hulled, soaked seeds had the highest yield (57.68%) while un-de-hulled boiled seeds had the lowest (27.25%).

Keywords: processing methods, percentage yield, de- hulling, soup thickeners, product yield

1. Introduction

Thickeners according to [1] are additives which when added to an aqueous mixture increase the viscosity, stability and improve the suspension of other added ingredients without substantially modifying other properties. The mechanisms of food products thickening involve: starch gelatinization, protein coagulation and emulsification. *Afzelia Africana* (Akparata), *Mucuna sloanei (*Ukpo*)*, *Brachystegia eurycoma* (Achi) and Detarium *microcarpum* (Ofor) are soup thickeners commonly used in the South-Eastern part of Nigeria and they belong to the same family leguminosae as well as the same sub-family caesalpiniaceae. Flours from these seeds are used as thickeners, emulsifiers and flavouring agents in traditional soups (for eating gari, pounded yam or cocoyam and cassava fufu), due to the high level of their gum contents. The gums are extracted from the seeds and serve as natural hydrocolloids, when crushed to flour and in powdered form they have the ability to swell in water and thus are able to influence the flow and consistency of the liquid [2].

Hydrocolloids or gums are diverse group of long chain polymers characterized by their property of forming viscous dispersions and/or gels in water. The presence of large number of hydroxyl groups increases their affinity for binding water molecules, and so belongs to the group of hydrophilic compounds. According to [3], they produce a dispersion, which is intermediate between a true solution and a suspension, and exhibits the properties of a colloid. Considering these two properties, they are appropriately regarded as ‘hydrophilic colloids’ or ‘hydrocolloids’. Hydrocolloids have a wide array of functional properties in foods including; thickening, gelling, emulsifying, stabilization and coating. The primary reason behind the use of hydrocolloids in foods is their ability to modify the rheology of food systems. This includes two basic properties of food systems that is, flow behavior (viscosity) and mechanical solid property (texture) which in turns affect its sensory properties.

The world hydrocolloid market which is valued at about USD 4.4 billion per annum, with a total volume of about 260,000 tonnes in the year 2000. This reflects a remarkable demand for hydrocolloids which has influenced the price and availability [4]. Sequel to the increase in the hydrocolloid market demand, it is therefore imperative to exploit some new raw materials as potential and alternative sources of food hydrocolloids and seed gums [5, 6]. Studies on the extraction of the hydrocolloids from seeds such as: *Mucuna sloanei* and *Irivingia gabonensis* and their visco-elastic properties have been reported [7]. The flours from the cotyledon of these legumes have not found much use in food systems unlike the tapioca starch which is used in numerous industrial and food applications, as thickening and gelling agents [1].

There is increasing demand for food gums because of their various applications in the food processing. This has resulted to high cost of commercially available ones. These legumes (Ofor, Ukpo, Akparata and Achi) have restricted domestic use in native soup preparation; making the crops to be under-utilized with few industrial applications. There is also lack of scientific information on the functional properties of the flour from these legumes.

The objective of the study was to investigate the effect of processing methods on the cotyledons, flours and gum extracts yields of some indigenous soup thickeners (*Afzelia Africana*, *Mucuna sloanei*, *Brachystegia eurycoma* and *Detarium microcarpum*) seeds.

2. Materials and Methods

Afzelia africana (akparata), *Mucuna sloanei* (ukpo), *Brachysteia eurycoma* (Achi) and *Detarium microcarpium* (ofor), seeds shown in Plate 1,2,3 and 4 respectively were obtained from a local market in Ihitte/ Uboma, Imo state, Nigeria. Petroleum ether, distilled water and propane-2-ol were purchased from a scientific laboratory in Owerri, Imo state, Nigeria and were of analytical grade. Other reagents and equipment/facilities were obtained from the department of Food Science and Technology of Federal University of Technology, Owerri and Imo state Polytechnic, Umuagwo. The seeds were cleaned to remove dirt. The whole and healthy seeds were weighed separately and manually cracked with the use of a wooden hammer (Mallet). They were divided into three equal portions each for toasting, boiling and soaking treatments respectively.

2.1 Processing of flour from soaked seeds
A portion of the cracked seeds were soaked in distilled water in the ratio of 1/10(w/v) at ambient temperature for 8 h, 16 h and 24 h respectively. The soaking liquor was drained at the elapse of each soaking time and the seeds divided into two equal portions. A portion was processed un-de-coated while the other portion was de-coated to obtain the seed endosperms by scraping the seed coats with a stainless steel knife. They were washed in surplus water (1/5 w/v) and separately milled using an attrition mill. The flour were dried in a moisture extraction oven (DHG- 9053 Model) at 65ºC to a constant weight, cooled to ambient temperature and sieved through a 500µm mesh-sized sieved to generate fine flour. They were packaged in airtight containers and stored at ambient conditions for further analysis and application. The processing steps are as shown in Figure 1.

2.2 Processing of Flour from Boiled Seeds
The second portion of the cracked seeds were divided into three equal portions and placed in boiling distilled water in the ratio of 1/5 (w/v) for durations of 10 min, 20 min and 30 min respectively. They were drained, allowed to cool to ambient temperature and the seeds divided into two equal portions. A portion was processed un-de-coated while the other portion was de-coated to obtain the seed endosperms by scraping the seed coats with a stainless steel knife. They were washed in surplus water (1/5 w/v) and separately milled using an attrition mill. The flour were dried in a moisture extraction oven (DHG- 9053 Model) at 65ºC to a constant weight, cooled to ambient temperature and sieved through a 500µm mesh-sized sieve to generate fine flour. They were packaged in airtight containers and stored at ambient conditions for further analysis and application. The production flow chart is as shown in Figure 2.

2.3 Processing of Flour from Toasted Seeds
The third portion of the cracked seeds were divided into three equal portions, and toasted in a pre- heated locally fabricated oven at 130ºC for 10min, 20 min and 30 min respectively, allowed to cool to ambient temperature and the seeds divided into two equal portions. A portion was processed un-de-coated while the other portion was de-coated to obtain the seed endosperms by scraping the seed coats with a stainless steel knife. They were washed in surplus water (1/5 w/v) and separately milled using an attrition mill. The flour were dried in a moisture extraction oven (DHG- 9053 Model) at 65ºC to a constant weight, cooled to ambient temperature and sieved through a 500µm mesh-sized sieve to generate fine flour. They were packaged in airtight containers and stored at ambient conditions for further analysis and application. The production steps are as shown in Figure 3.

Plate 1: Matured Seeds of *Afzelia Africana* (Akparata)

Plate 2: Matured *Mucuna sloanei* (Ukpo) Seeds

Plate 3: Matured *Brachystegia eurycoma* (Achi) Seeds

Plate 4: Matured *Detarium microcarpum* (Ofor) Seeds

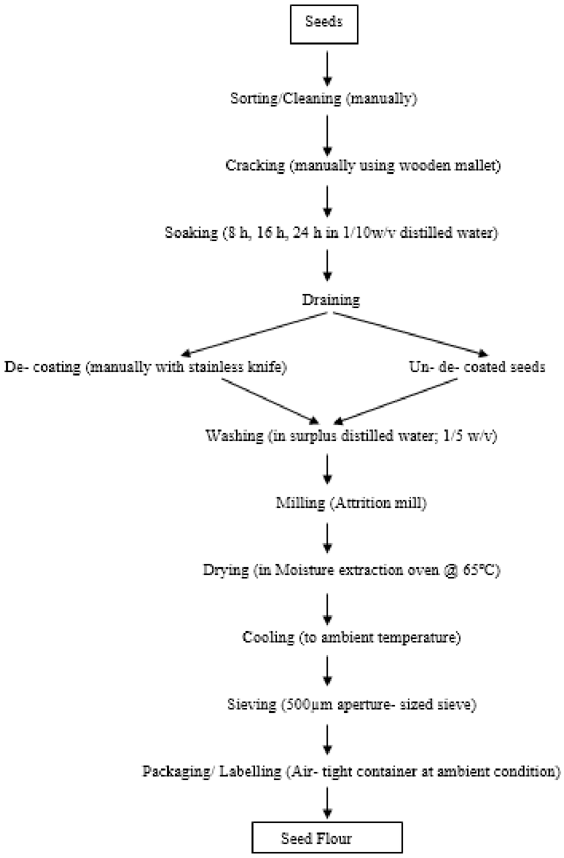

Fig 1: Flow Chart for the Preparation of Flour from Soaked Seeds

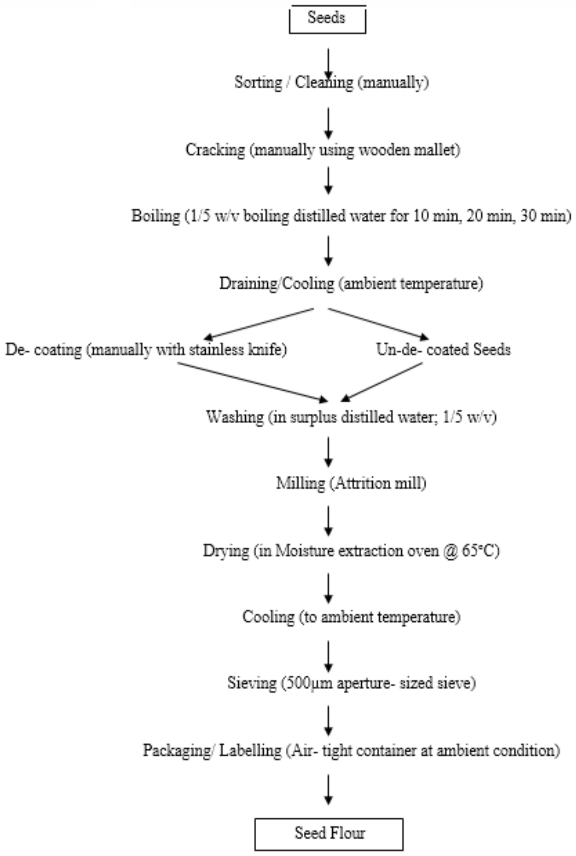

Fig 2: Flow chart for the preparation of flour from boiled seeds

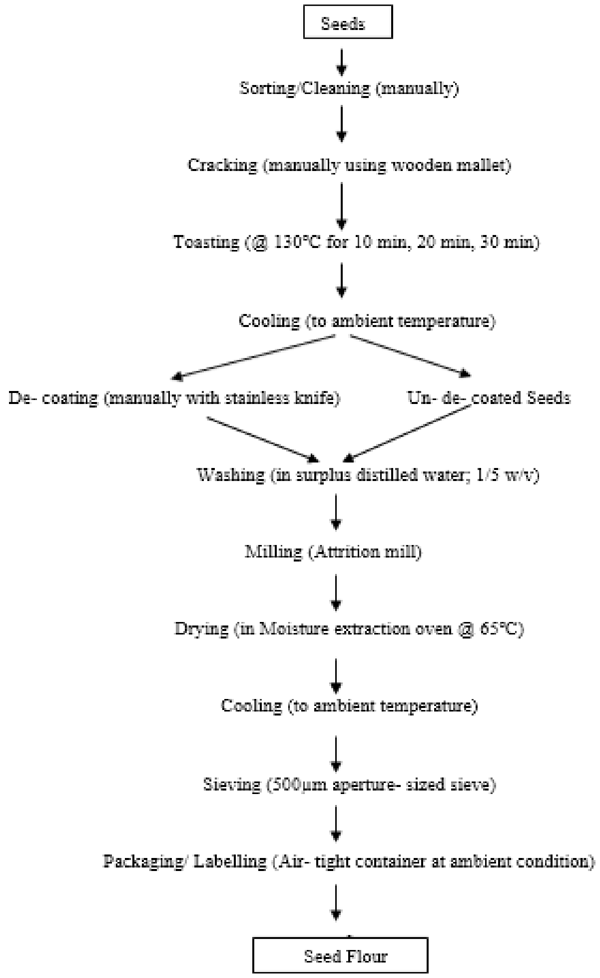

Fig 3: Flow Chart for the Preparation of Flour from Toasted Seeds

2.4 De-fatting of Seed Flour Samples
Cold (bulk) extraction method [8] was used for the de-fatting of the flours. The full-fat flour (200g) was wrapped in a white cotton fabric and soaked in 400 ml of Petroleum ether in an enclosed transparent glass jar and allow for a period of 72 hours. The wrapped flour was removed and rinsed in fresh Petroleum ether and manually squeezed to express out the entrapped solvent. The de-fatted flour was spread on a stainless tray for 4 hours to allow the trapped solvent to volatilize. The flour was sieved through a 500µm mesh sized sieve, packaged in air-tight container and stored at ambient conditions for further analysis and applications.

2.5 Seed Gum Extraction
The method of [9] was adopted for gum extraction from the de-fatted seed flours. Five (5) g of the flour samples was dispersed in 400 ml distilled water and hydrated continuously by means of a magnetic stirrer (FBI 15001, Fischer Scientific, UK) for 6h. Four hundred (400) ml of Propane -2-ol was gradually (drop by drop) added to the hydrated flour solution. The precipitated gum that spools out of the solution was gently separated from the mother liquor with the use of perforated spoon. The clear liquor was decanted while the trapped solvent was removed by filtering under suction in a Buchner funnel. The precipitates ase dried in a moisture extraction oven (DHG-9053 Model) at 60ºC till a flaky- dried gum could be easily scrapped off the drying tray. The resultant gums was cooled in desiccators to ambient temperature, pulverized using the dry section of an electric blender (Kenwood, SB266) and stored at ambient temperature in a sealed container.

2.6 Determination of percentage yield of samples
The percentage yield for the flours and the seeds gum extracts were determined as shown in equation (1).

Percentage Yield =

$$\frac{(\text{Mass of Product})}{(\text{Mass of Raw Material})} \text{X } 100\%$$

3. Result and Discussion
3.1 The percentage yield (%) of cotyledons, flours and gum extracts from soaked soup Thickeners
Effect of soaking on the percentage yield of cotyledons, full-fat flours, de-fatted flours and gum extracts from soup thickeners are shown in Table 1. From the results, the raw seeds had the highest cotyledon yield (87.37%) and this progressively reduced with increase in soaking time. The reduction was in the range of 85.32% to 80.75% for 8h and 24 h soaking respectively. The reduction in the percentage yield of cotyledon from soaked seeds could be associated with the high moisture imbibed during the soaking treatments which may have affected the easy and efficient removal of the seed coats. According to [10] increase in moisture content of seeds usually affects the seed testa and cotyledon yields.

The full- fat flour yield of the soaked soup thickeners also reduced with increase in soaking time with the raw seeds having the highest yield (94.28%) while the 24 h soaked seeds had the lowest yield (87.04%). Percentage flour yield is a function of the efficiency of size reduction equipment which is usually affected by properties of the raw materials such as moisture content. High moisture content of raw material during dry milling usually results to the production of rubbery pallets that usually clog the grinding part of machine and result to poor size reduction performance of the machine [11]. This was observed during the milling of soaked seeds which became intense as the level of pre- treatments (soaking) increased. There was no significant difference observed on the percentage yield of de-fatted flour from soaked seeds of soup thickeners. They were generally in the range of 92.12% (8h soaked) to 92.15% (2h h soaked). This implies that the level of extractable oil from the seed flours is not affected by soaking treatments used in this research.

The percentage yield of gum extracts from the soaked seeds of soup thickeners were in the range of 42.54% (raw) to 52.28% (16 h soaked). The variation in the gum yield could be associated with the initial level of the gum content in the seeds and the effect of the different levels of treatments on the extractable polysaccharides in the flour [12].

Table 1: Effect of Soaking on the Percentage Yield (%) of Cotyledons, Flours and Gum Extracts from Soup Thickeners

Soaking Time (h)	Cotyledons	Full-Fat Flour	De-fatted Flour	Gum Extracts
Raw(control)	$87.37^{a} \pm 12.82$	$94.28^{a} \pm 7.00$	$92.13^{a} \pm 4.26$	$42.54^{b} \pm 20.88$
8	$85.32^{b} \pm 14.73$	$87.81^{bc} \pm 11.77$	$92.12^{a} \pm 4.29$	$42.62^{b} \pm 21.35$
16	$83.72^{c} \pm 15.76$	$89.01^{b} \pm 10.92$	$92.14^{a} \pm 4.32$	$52.28^{a} \pm 25.78$
24	$80.75^{d} \pm 19.72$	$87.04^{c} \pm 13.04$	$92.15^{a} \pm 4.36$	$42.82^{b} \pm 21.27$
LSD	1.42	1.93	0.04	6.41

Values are represented as mean ± Standard Deviation
Means on the same column with different superscript are significantly ($p < 0.05$)

3.2 The Percentage Yield (%) of Cotyledons, Flours and Gum Extracts from Boiled Soup Thickeners
Effect of boiling on the percentage yield of cotyledons, full-fat flours, de-fatted flours and gum extracts from soup thickeners are shown in Table 2. From the results, the same trend observed in Table 1 was followed for the percentage yield of cotyledons. The yield reduced from 87.37% (raw) to 82.56% (30 min. boiled). This also could be associated with increase in moisture content of the seed as boiling time increased. According to [13], cotyledon yield of seeds is usually affected by the moisture content and level of de-attachment of seed coats from the cotyledon which in turns affect the de- hulling efficiency. De-hulling of the boiled seeds was very difficult because the seed coats were tightly adhering to the cotyledon making a reasonable proportion of the cotyledons to be tampered with during the de-hulling process.

Moreso, increase in boiling time led to reduction in the percentage yield of full-fat flour from the seeds of the thickeners studied. The results were in the range of 94.28% (raw) to 79.44% (30 min boiled). This could be attributed to the effect of the pre - treatment (boiling) on the particle size reduction of the cotyledons and flow ability of the particles after milling [11, 14]. As a result of starch gelatinization and level of moisture content imbibed during boiling, boiled samples were observed to be clogging the machine parts and had rubbery lumps during and after milling respectively. This may have resulted to reduced size reduction efficiency and low percentage yield of the flour [15, 16].

Boiling time had slight variation in the percentage yield of de- fatted flour from the seeds with no particular trend being followed as boiling time progresses. The yields were in the range of 91.71% (30 min. boiled) to 92.15% (20 min. boiled). The yield of the raw seed was 92.13%. These closely related results could mean that the level of extractable oil from the seed is not a function of level of pre- treatment (boiling) given to the seeds.

Boiling also had slight effect on the percentage yield of the gum extracted from the seeds. The gum yields were in the range of 40.80% (30 min. boiled) to 42.59 %(10 and 20 min. boiled). The raw seeds had 42.54% as the percentage yield of gum extracts.

Table 2: Effect of Boiling on the Percentage Yield (%) of Cotyledons, Flours and Gum Extracts from Soup Thickeners

Boiling Time (min.)	Cotyledons	Full-Fat Flour	De-fatted Flour	Gum Extracts
Raw(control)	87.37^{a} ±12.82	94.28^{a} ±7.00	92.13^{a} ±4.26	42.54^{a} ±20.88
10	85.33^{b} ±14.73	82.39^{b} ±9.00	92.14^{a} ±4.36	42.59^{a} ±20.88
20	84.00^{b}± 16.09	81.49^{b} ±9.29	92.15^{a} ±4.36	42.59^{a} ±20.91
30	82.56^{c} ±18.31	79.44^{b} ±11.33	91.71^{b} ±5.51	40.80^{b} ±20.07
LSD	1.44	3.59	0.34	0.20

Values are represented as mean ± Standard Deviation Means on the same column with different superscript are significantly (p< 0.05)

3.3 The Percentage Yield (%) of Cotyledons, Flours and Gum Extracts from Roasted Soup Thickeners

Effect of roasting on the percentage yield of cotyledons, full-fat flours, de-fatted flours and gum extracts from soup thickeners are shown in Table 3. Contrary to Tables 1 and 2, increase in roasting time increased percentage cotyledon yield from 87.37% (raw) to 92.72% (20 min. roasted). Since roasting is a dry-heat treatment, it tends to reduce the moisture contents of the seeds and thus make the de-attachment and de- hulling of the seeds easier and more efficient without tampering with the cotyledons. Thus these results agree with the report that the lower the moisture contents of seeds, the more efficient the de- hulling process [13].

There were no significant difference observed for the raw and roasted seeds on both their full- fat and de- fatted flour yields. They were in the ranges of 94.28% (raw) to 94.88% (20 min. roasted) and 91.93 %(30 min. roasted) to 92.13% (raw) for full- fat and de-fatted flours respectively. The result of the full-fat flour implies that both the raw and roasted cotyledons behaved alike during the size reduction process. This could be attributed to the fact that they were all at the same range of reduced moisture contents unlike the results for soaked and boiled seeds in Tables 1. and. 2 respectively. For the de-fatted flour results, since roasting did not increase the moisture content of the seeds, it means other proximate compositions such as fat may not have been significantly altered by the pre- treatment process.

Increased in roasting time caused a significant reduction in the gum extract yield. The yield reduced from 42.54% (raw) to 40.27% (30 min. roasted). The variation in the gum yield could be associated with the initial level of the gum content in the seeds and the effect of the pre- treatments on the extractable polysaccharides in the flour [12].

Table 3: Effect of Roasting on the Percentage Yield (%) of Cotyledons, Flours and Gum Extracts from Soup Thickeners

Roasting Time (h)	Cotyledons	Full-Fat Flour	De-fatted Flour	Gum Extracts
Raw(control)	87.37^{b} ±12.82	94.28^{a} ±7.00	92.13^{a} ± 4.26	42.54^{a} ±20.88
10	92.20^{a} ±9.91	94.85^{a} ±6.48	91.99^{a} ±5.36	41.36^{b} ±19.23
20	92.72^{a}±10.14	94.88^{a} ±6.53	92.00^{a} ±5.43	40.96^{bc} ±18.90
30	92.57^{a} ±10.58	94.39^{a} ±7.54	91.93^{a} ±5.64	40.27^{c} ±18.01
LSD	2.41	0.61	0.46	0.71

Values are represented as mean ± Standard Deviation

Means on the same column with different superscript are significantly (p< 0.05)

3.4 Effect of De – hulling on the Percentage Yield of Samples

The results of the effect of de-hulling on the mean percentage yield of the cotyledons, full-fat flour, de-fatted flour and gum extracts are shown in Figure 4. For all the products derived from the seeds of the thickeners, un-de-hulled samples had the highest percentage yield with the exception of the cotyledons yields which were lower for de-hulled seeds. However, the low percentage yield of other products (flour and gum extracts) for the un- de-hulled samples could be as a result of the interference of other compositions of the seed coats in the flour and gum extraction from the seeds. The low cotyledon yields for de - hulled samples could be attributed to the fact that during the de- hulling process part of the cotyledons may have been tampered with, especially for the seeds that did not imbibe sufficient moisture during the treatments and seeds that the coats are tightly attached to the cotyledons. Also, the original percentage of the seed coats in the whole seeds could also affect the percentage yield of the cotyledons. *A. africana* seeds for instance have thicker seed coats than *B. eurycoma* and *D. microcarpum.*

The percentage yields of the cotyledons were generally in the range of 99.21% (boiled un-de-hulled) to 69.81% (soaked de – hulled). The cotyledons yields with respect to de- hulling and treatments were in as follows: soaking (69.81 – 98.78) %, boiling (70.42 - 99.21) % and roasting (83.40 - 99.02) % with de-hulled samples having the lower values for each treatment. The variation on the cotyledon yield from the differently treated seeds could be associated with the effect of the different treatments on the level of de-attachment of the seed coats from the cotyledons for the different soup thickeners studied. For instance, roasting increased the level of seed coats de- attachment for most of the soup thickeners under study more than boiling and soaking.

The percentage yields for the full- fat flours were generally in the range of 98.26% (roasted de hulled) to 81.84% (boiled un-dehulled). The full- fat flour yields for the different treatments were as follows: soaking (83.19 - 95.87) %, boiling (81.84 -86.92) % and roasting (90.94-98.26) %. Roasting resulted to high flour yield while boiling resulted to low yield. This could be attributed to the effect of the treatments on the particle size reduction of the cotyledons and flow ability of the particles after milling [11, 14]. As a result of starch gelatinization and level of moisture content imbibed during boiling, boiled samples were observed to be clogging the machine parts and had rubbery lumps during and after milling respectively. This may have resulted to reduced size reduction efficiency and low percentage yield of the flour [15, 16].

The percentage yield for the de- fatted flours were in the range of 93% (boiled un-de-hulled) to 91.06% (boiled de-hulled). The yields were slightly different from each other, though no particular trend was followed on the variations on the percentage yield as regards the different treatments and de- hulling effects. Though, comparing the effect of treatments, higher yields were observed for boiled and soaked un-de-hulled samples. They were 93% and 92.95% respectively; while the de-hulled samples were 91.06% and 91.32% for boiled and soaked samples respectively. However, roasted de- hulled sample had higher yield (92.72) % than the un-de- hulled sample (91.30) %. The differences in the percentage yield of de- fatted flours could be associated with the level of oil available for extraction after the different treatments.

The percentage yield of gum extracts was generally in the range of 57.68% to 27.25% for soaked de –hulled and roasted un- de-hulled samples respectively. The gum yield for the different treatments were as follows: soaked (32.45 – 57.68) %, boiled (27.25 – 57) % and roasted (27.54 – 55.03) % with the un- de- hulled samples having the lower yield for all the treatments. Results showed that heat treatments especially dry heating generally reduced the percentage yield of gum. The differences in the gum yield of samples under different treatments can be associated with the effect of the treatments on the availability and solubility of the gum in the extracting solvent Moreover, the reduced gum yield observed in the un-de- hulled sample could be as a result of the interference of the seed coats on the extraction efficiency of both the oil and gum. According to [4], the presence of oil in the sample could interfere with the solubility of polysaccharides in extracting solvent.

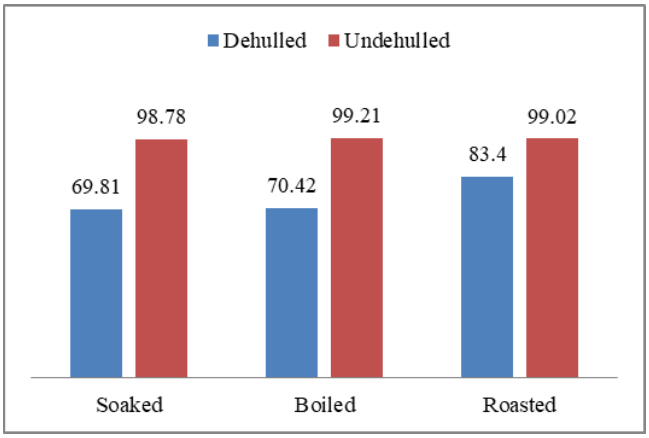

Fig 4a: Cotyledons

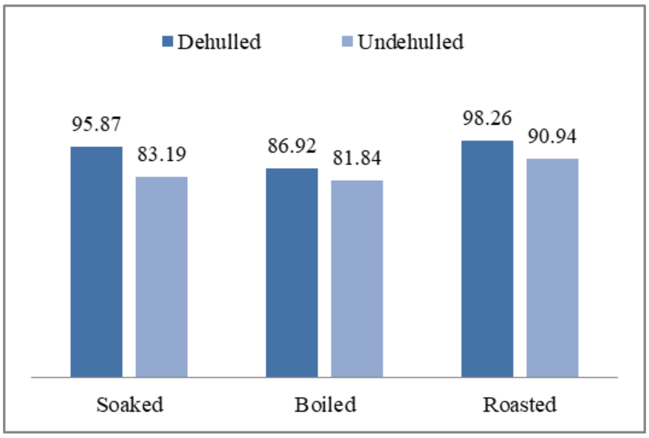

Fig 4b: Full- fat Flour

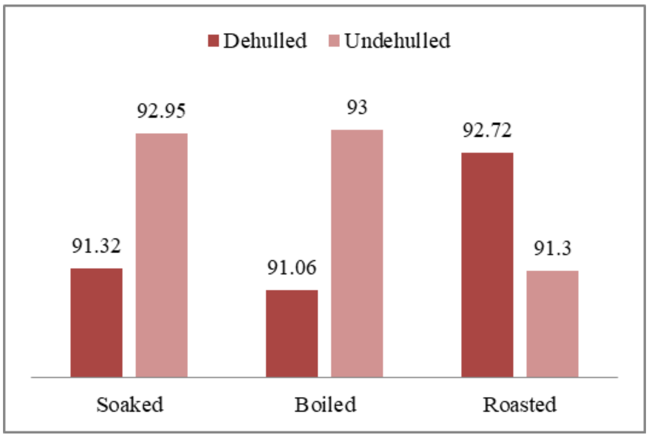

Fig 4c: De-fatted Flour

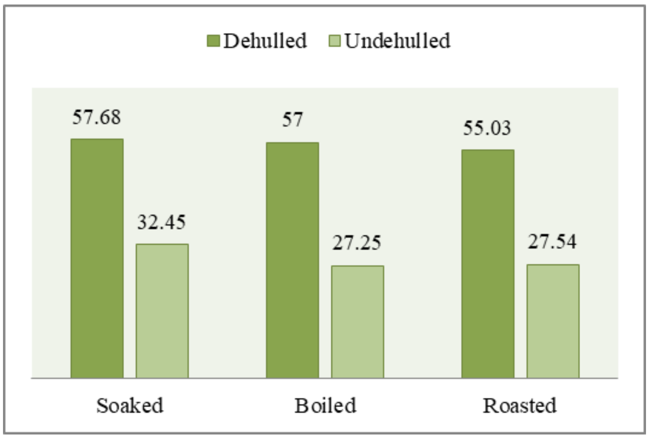

Fig 4d: Gum Extracts

Fig 4: Bar Charts for the Percentage Yield (%) of Cotyledons, Flours and Gum Extracts from Soup Thickeners

4. Conclusion

The effect of processing methods (boiling, soaking and roasting) as well as the de- hulling effects on some product yields such as cotyledons, flours (full –fat and de-fatted) and gum extracts of selected cultivars of soup thickener seeds was analysed. From the findings, the different processing methods affected the product yields differently. Though increase in roasting time resulted to reduction in percentage gum extract yields, it however produced increased percentage yield of cotyledons and full- fat flours. The different processing methods did not result to significant effect on the percentage yields of the de- fatted flours. It is therefore recommended that the time for the different processing should be regulated in order not to affect the product (flour and gum) yields from the thickeners. Also, there is no need processing the seeds un-dehulled since it resulted to lower yields of the relevant products. Soaking for 16 hours is recommended if the desired product is gum.

5. Acknowledgment
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