PROCESSING OPTIONS FOR FAT CONTENT REDUCTION WHILE
MAINTAINING SENSORY CHARACTERISTICS OF KOOSE

BY

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DECLARATION

This is to certify that this thesis is the result of research undertaken by SALSABILA OSMAN towards the award of the Master of Philosophy degree in Food Science in the Department of Nutrition and Food Science, University of Ghana.

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Consumer preference for low fat content foods is increasing over the years. High fat content in most fried food products is a major factor affecting consumer acceptance of fried products today. Low-fat food products are becoming more popular, due to the health risk associated with the consumption of high fatty foods. Koose is a widely consumed street food in Ghana. It is prepared either by wet or dry milling of soaked and dehulled cowpea seasoned with salt, pepper and onions. A paste is obtained and deep fried in vegetable oil until a golden-brown crispy product is obtained. It is a good source of protein for regular consumers. However, the cooking method, deep frying leads to a very high fat content with its health risk to those who eat it regularly. This research focuses on pre-drying of the paste to reduce the initial moisture content, which is a known factor in increasing fat absorption. This study revealed processing options for fat content reduction of koose. The traditional koose processing (wet and dry milled) methods were used in producing koose. For wet milled samples, 500g of cowpea was soaked for 3hrs and dehulled. It was blended with 20g of seasoning ingredients to obtain a paste. For dried milled samples the cowpeas were soaked for 3 mins and dehulled, the dehulled cowpea was dried in a hot air oven at a temperature of 70°C for 5hrs, and milled using a hammer mill with mesh screen size 1.0 mm to obtain a flour. About 200g of flour was mixed with 400 ml of water with 20g of seasoning ingredients to obtain a paste. For both processes the paste obtained was pre-dried at different temperatures (50°C, 55°C and 60°C) and times (1, 2 and 3hrs). The pre-dried and the undried (as control) cowpea paste were fried at different temperatures/time. The pre-dried paste was fried at (160°C, 170°C, 180°C / 10, 5, 1 minutes) and undried paste was fried at (160, 170, 180/ 15, 10, 5 minutes). After frying samples were presented to panellist to evaluate the sensory characteristics using a 150 mm hedonic scale from the least to the highest. Frying at a
temperature 180°C for 1mins for samples produced from the pre-dried cowpea paste and
frying at 180°C for 5mins samples produced from dry milled process, gave the least oil
absorption for both pre-dried and undried paste. Samples produced from wet milling
were spongier, soggier, and soft in appearance, for *koose* samples produced from pre-
dried and undried paste. Dry milled samples were hard and dry in appearance both for
*koose* samples produced from pre-dried and undried paste. Wet milled *koose* samples
were soft, spongier, and mushy in texture both for the pre-dried and undried samples.
Dry milled samples were dry, hard, and flaky in texture for both pre-dried and undried
samples. Wet milled *koose* samples were spongier, soggier, soft and mushy than the dry
milled *koose* samples. *Koose* produced using dry milled processing method can be used
to produce *koose* with reduced fat content. *Koose* samples produced from pre-dried paste
absorbed less oil even at a lower temperature of frying. Further studies can be done to
modify the texture of *koose* samples produced from pre-dried cowpea paste.
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1.0 INTRODUCTION

1.1 Background

Over the years, various studies have investigated how to process fried food products with low fat contents, as consumers being more health conscious are now demanding for low fat fried food products (Debnath, Bhat, & Rastogi, 2003). Frying is an old cooking method used worldwide. It has the advantage of providing the food product with distinct aroma, taste, flavour and texture. Frying involves cooking food products in hot oil, mostly at temperatures 165°C to 190°C (Hwang & Winkler-moser, 2016). Examples of fried foods include, French fries, fried plantain, fried chicken, yam, ‘koose’ or ‘akara. Frying involves heat and mass transfer of oil and moisture. High fat content in most fried food products is a major factor affecting consumer acceptance of fried products today, as low-fat food products are becoming more popular. High fatty foods are known to be the main cause of cardiovascular diseases, and high blood pressure levels (Mellema, 2003).

Reducing the fat content in fried food products while maintaining its sensory characteristics is an on-going challenge in the food industry. Various studies have focused on designing new strategies for reducing oil absorption during frying (Rahimi, Adewale, Ngadi, & Agyare, 2017). One of such techniques is pre-drying to reduce the initial moisture content of the product. This has shown to reduce the amount of oil absorbed during the frying process. The moisture content is a known factor which increases oil gain during frying (Krokida, Oreopoulou, Maroulis, & Marinos-Kouris, 2001) Krokida et al., (2000), investigated the effect pre-drying on the quality of French fries before frying, he reported that pre-dried French fries had low amount of oil as compared to non-pre-dried samples. Therefore, the quality of French fries can be determined by choosing the appropriate drying time and temperature.
Similar studies have also revealed that the amount of water lost in a food during frying is equal to the amount of oil entering the food. Therefore, the higher the initial moisture content of the food, the more oil the food will absorb during frying. This is because the frying process involves oil entering the food and water out of the food. Therefore, lowering the moisture content of the product initially could reduce the amount of oil absorbed (Mery et al., 2007). Furthermore, Debnath et al., (2003) found out that pre-fry drying of snacks produced from chickpea flour, showed low amount of oil absorbed during the frying process.

Koose is a traditional West African fried food product prepared either by wet or dry milling of soaked and dehulled cowpea, followed by addition of seasoning ingredients (onions, salt and pepper) and deep fried in vegetable oil, until a golden brown crispy product is obtained (Patterson et al., 2002). One method that has been used to lower the fat content of koose is the addition of soya flour to the formulation. However, addition of soya flour resulted in a product with a tougher and denser texture than koose made from cowpea only (Minerva, 2001).

1.2 Rationale for the study

Koose is a widely consumed street food in Ghana. It is a good source of protein for regular consumers. However, the cooking method deep frying leads to a very high fat content, with its health risk to those who eat it regularly. Previous studies such as addition of soy flour and non-removal of the seed coat during processing, has been done to reduce the amount of oil the product absorbs (Minerva, 2001). This research focuses on pre-drying of the paste to reduce the initial moisture content, which is a known factor which influences the amount of oil the product absorbs during the frying process.
Maintaining the sensory properties of this new product will be important for it to remain acceptable to consumers.

1.3 Main Objective

The main objective of this work was to evaluate processing options for fat content reduction while maintaining the sensory characteristics of koose.

1.4 Specific Objectives

1. To evaluate the effect of particle size on the viscosity of cowpea paste and oil absorption of koose.

2. To evaluate the effect of pre-drying time and temperature on frying time of koose made from cowpea paste.

3. To evaluate the effect of wet milling, dry milling and pre-drying of paste on texture, colour and sensory properties of koose.

4. To evaluate the effect of processing (wet milling, dry milling and pre-drying) on oil absorption of koose.

5. To evaluate the effect of temperature and time of frying on oil absorption of koose.
2.0 LITERATURE REVIEW

2.1 Introduction

‘Koose’ is a West African fried food product prepared by deep frying cowpea paste seasoned with onions, pepper and salt (Arubi & Gibson, 2015). Koose is considered to be one of the most consumed cowpea based product (Mofoluke, Ramota, Adeoye, Toyin, & Olusegun, 2013). In Nigeria it is consumed mostly as breakfast, lunch or supper, in Ghana it is usually consumed with millet porridge (‘Hausa koko’) or corn porridge or even as snack. The black eye cowpea cultivar is mostly used in koose preparation because, it produces a product with a light golden brown colour, which consumers find very attractive (Patterson et al., 2002). It is an inexpensive source of proteins, carbohydrate and vitamins other minerals (Mofoluke et al., 2013). Cowpea is an important grain legume in West Africa (Taiwo, 1998). It belongs to the family leguminaceae, which contains about 600 genera and 13,000 species. It can be processed in to highly nutritious cowpea based food products such as ‘koose’or ‘akara’, ‘waakye, ‘gari and beans’, ‘tubani’ ‘moimoi’ etc. (Apea-bah, Serem, Bester, & Duodu, 2017).

2.2 Cowpea (Vigna Unguiculata)

2.2.1 Chemical composition of cowpea

Cowpeas are known to be of high nutritional value due to their rich and cheap source of protein and carbohydrates, and other nutrients vitamins such as thiamine, niacin, and essential minerals such as calcium, iron potassium and phosphorous which contributes to the diet of consumers (Darfour, Wilson, Ofosu, & Ocloo, 2012). They contain about 25% proteins, 67% carbohydrates (Giami, 1993), 11% moisture, 3.9% fibre, 3.6% ash 1.3% fat which makes them the most preferred choice of legumes and contribute to their
functionality (Kerr, Ward, Mcwatters, & Resurreccion, 2001). It can be processed into highly nutritious cowpea based food products such as ‘koose’ or ‘akara’, ‘waakye’, ‘gari and beans’, ‘tubani’ ‘moimoi’ etc. (Apea-bah et al., 2017). The processing of cowpea for utilization involves mainly traditional methods such as soaking, dehulling, steaming, cooking by boiling in water.

2.2.1.1 Proteins

Foam formation of a paste depends on the proteins available in the paste, foams consist of tiny air droplets dispersed in a solution. Increased foaming capacity will result in an increased gaseous dispersed phase leading to increased air spaces in the product, producing a product which is lighter with a spongy texture. The air droplets are surrounded by layers of cohesive protein, which have sufficient mechanical strength to prevent coalescence or rupture of droplets (Arubi & Gibson, 2015).

2.2.1.2 Carbohydrate

Carbohydrates are responsible for oil, water absorption, viscosity and swelling characteristics of the paste (Prinyawiwatkul, Mcwatters, Beuchat, & Phillips, 1997). Starch contains amylose (AM) and amylopectin (AMP) chains that create inter- and intramolecular complexes in causing molecular and physical changes that influence product functionality. During processing in the presence of heat, leads to changes in water and oil absorption capacities, which result in swelling, gelatinization, retrogradation and dextrinization of food products during processing. Production of koose balls with uniform shape, colour, and texture depends upon the hydration, foam, and flow characteristics of paste (Farooq & Boye, n.d.).
2.2.1.3 Other Nutritional Factors of Cowpea

Cowpea contains other anti-nutritional substances like trypsin inhibitors, tannins as well as polyphenols which decrease protein digestibility and protein quality. These substances are found in the hulls of cowpea and thus the need to dehull to improve the quality of proteins. (Darfour et al., 2012).

2.3 Koose Processing

*Koose* is prepared traditionally by either wet or dry milling of soaked and dehulled cowpea. The beans are sorted to remove foreign materials and defective beans, followed by washing, soaking, and dehulling, addition of seasoning ingredients (onions, salt and pepper) to obtain a paste (Patterson et al., 2002). The paste is then whipped to obtain a foamed paste and deep-fried in vegetable oil by spoonful until a golden-brown crispy product is obtained. It has a spongy interior and an outer crispy crust texture (Arubi & Gibson, 2015). Soaking is done to loosen the seed coats for easy removal and soften the seeds for easy processing (Taiwo, 1998). Dehulling is done to remove the seed coat and this improves the appearance texture, cooking quality of *koose*. Whipping incorporates air in the batter giving the product a spongy interior texture (Patterson et al., 2002). A very important factor that determines the acceptability of *koose* is the texture.

Various studies have described desirable texture attributes of traditionally made *koose* as ‘spongy and tender’ whilst *koose* with undesirable texture attributes has been described as ‘dry, dense, and having a tough outer surface (Arubi & Gibson, 2015). Factors affecting foaming ability of cowpea paste include particle size, hydration time and protein content (Patterson *et al.*, 2002). Blending or milling during *koose* breaks the cowpea into fine particles for easy processing (Mofoluke *et al.*, 2013). Addition of
seasoning ingredients such as onions, pepper, salt is then gives the product a distinct flavour and colour (Taiwo, 1998).

2.3.1 Seasoning Ingredients used in koose Processing

2.3.1.1 Onions

Onion (*Allium cepa* L.) is a vegetable crop grown and consumed worldwide, it used in a different kinds of dishes due to its aroma and taste and health benefits (Beretta, Bannoud, Insani, Galmarini, & Cavagnaro, 2017). It contains flavanol quercetin, which are known for their antioxidant and health-promoting activities (Dziki et al., 2013).

2.3.1.1 Pepper

Pepper (*Capsicum annuum* L.), is consumed as pungent spice either in a dried or fresh form, it is used in a variety of dishes to enhance the aroma, colour and flavour. (Wang et al., 2017). They are known to possess some anti-oxidative, preservative and antimicrobial roles which makes it an important spice in a variety of meals or dishes (Zarai et al., 2013).

2.3.1.2 Salt

Salt is a food additive which serves as a texture flavour enhancer, contribute to food colour and fat binding capacity. Salt in food acts as a preservative and also possess antimicrobial properties due to its ability to reduce water activity of foods. Addition of salt to products improves the water retention capacity and also enhances flavour by influencing some enzyme activities (Wang et al., 2017).
2.4 The effect of particle size on paste viscosity during koose processing

Particle size is considered a major factor affecting the quality and taste of final food products (Singh et al., 2013). Particle size distribution of paste is an important factor which determines the quality of a product (Enwere, 1986).

The milling method used during koose processing affects the functionality of paste during koose processing. Wet milling produces a paste with uniform consistency, which aids in better distribution of moisture. Prinyawiwatkul et al., (1997), observed that particle size distribution of paste produced during koose processing was found to significantly affect the final quality of the product. Dry milling disrupts the protein and fibre structure of the paste and this affects the hydration and thickening properties of the paste. This affects the ability of the paste to entrap air when whipped is also affected (Minerva, 2001). Kerr et al., (2001), reported koose and moin-moin from flours milled in one pass through a 1 mm screen, they reported that the overall acceptability of products decreased as the number of passes through the mill increased, it was observed that flours used to prepare koose or moin-moin, were less hydrated, denser less spongy. Wet milling of cowpea seeds preserves the fibre structure better. Leading to good water absorption and foamability of the paste, leading to a softer and spongier koose product (Minerva, 2001).

2.5 Importance of some processing operations

2.5.1 Dehulling on koose quality

Dehulling is processing step which leads to improvement in the appearance, texture and cooking quality of food products. The dehulling step during koose processing is done to separate the seed coat from the embryo after soaking, and hence improves the appearance texture, colour, and palatability of koose. It facilitates the reduction of fibre
and tannin content by 98%. These are ant nutritional constituents which limit their full utilization and quality. Mcwatters et al., (1993) noted that koose produced from non-dehulled cowpea produced balls which dark in colour, tough and very dense while’s koose produced from decorted cowpea seeds produced koose balls which were light golden brown, spongy soft and were highly accepted by consumers.

2.5.2 Whipping of cowpea paste during koose preparation

Whipping of cowpea paste during koose processing is very crucial in developing a product with good textural characteristics. The process of whipping incorporates air in the paste leading to a product which is crispy with a soft spongy interior texture. The foamed paste consists of an aqueous continuous and a gaseous dispersed phase. Factors affecting the formability of cowpea paste include particle size, hydration time, protein solubility and high protein content (25%) of cowpea. Increased air spaces increase the pores spaces which leads to high oil absorption during frying. The process of whipping incorporates air Cowpeas contain proteins carbohydrate and fibre, which are the major ingredients and other vitamins and minerals which play significant role during processing of the product. Cowpea proteins are responsible for water absorption, foaming, viscosity, and gelatinization. According to Minerva et al., (2001), high protein content (24%) of cowpea contributes to its foaming capacity modification of the foaming capacity of the paste will modify the texture of the product. Foaming capacity, hydration properties, and flow characteristics of the paste are the most important indicators of paste functionality in koose production. Whipped cowpea paste dispenses well in hot oil and exhibits good frying characteristics.
2.6 Pre-drying of foods

Drying is considered as one the most important unit operation during food processing, (Onwude et al, 2016). Drying is done to reduce the moisture content of food to a reduced levels, thereby prolonging the shelf life of the product (Ricce et al., 2016). Previous research has shown that, the initial moisture content is a known factor which leads to high amount of oil absorption during frying of foods (Rahimi & Ngadi, 2014). Krokida et al., (2001), investigated the effect pre-drying of on the quality of French fries prior to frying, he noted that pre-dried French fries prior, had very low oil content as compared to non-pre-dried samples he noted that the quality of the French fries can be controlled by choosing the appropriate drying time fry drying of snacks produced from chickpea flour used in the production of snacks in India showed low amount of oil absorbed during the frying process (Debnath et al., 2003). Fat uptake during the frying process depends on the moisture content within the food while reducing the moisture content, frying time is also reduced (Mellema et al., 2003). The basic concept of drying is to reduce the moisture content of the product to a level that prevents deterioration within a certain period of time. The water transfer during the drying process is controlled by two types of resistance the internal resistance to the water movement inside the material and the external resistance between the solid surface and the air (Mellema et al., 2003). During frying higher temperatures surrounding the food forces water to evaporate from the product leading to a with a compact material matrix dry surface crust, drying however leads to lower moisture content leading to lower amount of oil absorbed with reduced frying time (Mery et al., 2007).
2.7 Frying of foods

Frying is a cooking process in which food is dipped in hot oil for a period of time. This cooking method is widely used in preparing different kinds of food products such as French fries, meat snacks etc. (Hwang et al., 2016). Its main purpose is to enclose the food surface giving it a golden brown colour and a crispy outer texture and a soft interior texture (Heredia et al., 2014). Frying is a heat and mass transfer, during this process moisture is lost from the food product through evaporation, this is replaced by subsequent oil absorption (Debnath et al., 2003). Various factors, affect oil absorption during deep frying this includes the quality of oil in which the food is being fried, frying temperature and time, shape of the product, initial moisture content (Debnath et al., 2003).

In a study on frying of potato slices, it was reported that the amount of oil entering the slices was equal to the amount of moisture lost, higher initial moisture content of the food, the more oil, the food will absorb during frying this is due to the fact that the frying process involves migration of oil into the food and water out of the food product through evaporation (Sandhu et al., 2013). High temperatures surrounding the food during the frying process cause starch to gelatinize and protein denature (Hwang et al., 2016). Starch gelatinization has a great influence on crust formation in most fried foods. It controls the amount of oil absorbed during frying. Mechanisms involved during this process include, evaporation of water from the food to the surface, oil absorption in the food and leaching of liquefied food components from the food (Debnath et al., 2003).

Krokida et al., (2001), noted that for many fried foods, the most important factor which determines the amount of oil absorbed in the product is the initial moisture content, reducing the initial moisture content before frying leads to lower amount of oil absorbed.
(Hwang et al., 2016). (Mellema, 2003). mostly used in frying include, (Sandhu et al., 2013).

During the frying period, the apparent density of the food product decreases, leading to pore formation, water loss and oil uptake leading to a decrease in crust formation of the food product. (Debnath et al., 2003). Krokida et al., (2001) reported that, determining the final quality of the food product (Debnath et al., 2003)

2.8 Sensory Evaluation of Foods

Sensory evaluation is a scientific discipline used to evoke measure analyse and interpret reaction to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste touch and hearing. Foods are submitted to sensory evaluation in order to provide information that can lead to product development (Analysis, 1981). Sensory attributes of quality guide the consumer in selecting of foods therefore it is used in various stages of product development. Sensory evaluation can be used to detect the differences of product from different batches. Trained and untrained panellist are used.

2.8.1 Quantitative Descriptive Analysis

Quantitative descriptive analysis provides a detailed description of a product by identifying separate attributes contributing to the formation of the overall impression of the product and their intensities assessed. Trained panellist of up to 12 are used in order to establish the description of the flavour, appearance and texture etc. During the training, the group is provided with different products that represent the range of characteristics that may be tested during the actual test sessions. The subjects are served
with a product and are advised or to write any words they want that reflect the product’s appearance, aroma, texture etc., and in the process develop a scorecard and an evaluation procedure. Products are evaluated for intensity of the characteristics on the scorecard is developed by consensus of the panel that includes all characteristics of interest in the order in which they are to be evaluated (Chapman et al., 2001). Consumer opinion is important when studying how a product will perform on the market. This test is performed, when introducing a new product on the market. (Analysis, 1981).
MATERIALS AND METHODS

3.1 Materials
The main raw material used for processing the *koose* was cowpea (Niger variety). Seasonings used were Onions, Cayenne Pepper and Salt and vegetable oil (Frytol) was used for frying. All these materials were obtained from the Madina Market, Accra.

3.2 Sample Preparation Procedures

3.2.1 Koose Preparation
The cowpea seeds were cleaned by hand picking. All extraneous materials such as stones and unwanted materials including insect attacked seeds were picked leaving whole beans before processing. The traditional *koose* processing methods (Dry and Wet milling) were used. Niger cowpea variety was used in both processes. The processing methods used are outlined in figure 3.2 1

3.2.2 Preparation of seasoning ingredient
150g of onions and 60g of pepper was washed and blended together using Waring Commercial Blender (CB15) for 3 mins using 200 ml of water.
Figure 3.2 1 Flow chart describing the traditional processing steps for both wet milled and dry milled koose processing procedure.
3.2.1.2 *Koose processing by dry milling method*

Approximately 3000g of sorted Niger cowpea variety was washed using 8.0 litres of water for 10 minutes, excess water was drained. The cowpea was then soaked in 6.4 litres of water for 3 mins and dehulled using the disc attrition mill (Model 4-E, Quaker City Mill, Philadelphia, PA. U.S. A). Dehulled beans was then spread on metal trays and dried in hot air oven at a temperature of 70°C for 5hrs. After drying, 2,097g of dried cowpea was then milled using the hammer mill with mesh size screen 1.0 mm to obtain 1,709g of flour.

3.2.4 *Preparation of Cowpea Flour*

About 3000g of sorted Niger cowpea variety was washed using 8.0 litres of water and excess water drained. It was then soaked in 6.4 litres of water for 3 mins and dehulled using the disc attrition mill (Model 4-E, Quaker City Mill, Philadelphia, PA. U.S. A). The dehulled beans were then spread on metal trays and dried in hot air oven at a temperature of 70°C for 5hrs. After drying, it was then milled using the hammer mill with mesh size screen 1.0 mm to obtain flour. Different sieve sizes with pore sizes ranging from (40µm, 45µm and 50µm) were used to separate the milled flour into the different particle sizes. The sieves were placed on a Retsch sieve shaker (Model AS200) from the biggest to the smallest and allowed to shake for 5 mins, the flour was distributed into each sieve according to particle sizes. Part of the milled flour was sieved to get flour of different particle sizes while a portion of the flour used was unsieved (control).

3.2.5 *Koose processing by wet milling method*

About 2000g of whole cowpea seeds were washed in 8.0 litres of water and excess water drained. It was then soaked in 5.6 litres of water for 3 hours and excess water drained. The soaked cowpea was dehulled in an attrition mill (model 4-E, Quaker City Mill,
Philadelphia, PA, U.S. A). 500g of cowpea each was blended to obtain a paste (Waring Commercial Model C15).

3.2.6 Particle size determination of wet milled cowpea paste

Different blender (Waring Commercial Blender Model C15) speeds 1, 2 and 3 using 300 ml of water each to obtain a paste. Different sieves with pore sizes ranging from 14 μm, 18μm, 20μm, 25μm, 30μm, 35μm were used to determine the particle sizes of paste blended at different (Waring commercial blender, Model C15) speeds 1, 2 and 3.

Sieves size 14μm retained a greater quantity of the paste for each of the blender speeds (1, 2 and 3) as shown in Table 3.1 there was no much difference in the particle size of the wet milled cowpea paste. This was due to the fact that, for the blender (Waring Commercial Blender Model C15) used, the position of the blades was not varied, the angles of the blades were the same and as a result did not produce much difference in the particle size of the paste although, the paste was blended at different blender speeds as shown in Table 3.1.
Table 3.1 Particle size Distribution of wet milled cowpea paste.

<table>
<thead>
<tr>
<th>Blender speeds</th>
<th>Quantity of flour distributed in each sieve (g)</th>
<th>Particle size of flour distributed in each sieve (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>760</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>18</td>
</tr>
<tr>
<td>Blender speed 1</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>780</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>18</td>
</tr>
<tr>
<td>Blender speeds 2</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>820</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>18</td>
</tr>
<tr>
<td>Blender speeds 3</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>35</td>
</tr>
</tbody>
</table>

3.2.6.1 Pre-drying of wet and dry milled cowpea paste at Different Temperatures and Times

About 200g of flour mixed with 400ml of water obtained from dry milled cowpea of each of the particle sizes was mixed together with 20g of seasoning ingredients to obtain a paste. Paste obtained after wet milling of 500g of cowpea with 300 ml of water for each of the blender speeds, was mixed with 20g seasoning ingredient.
For both processes, (wet and dry milling) a portion of the paste was scooped using a metallic spoon and arranged three in a row on a baking sheet in a tray. The paste was dried in a hot air oven to reduce the moisture content at different times 1 hour, 2, and 3 hours and temperatures 50°C, 55°C, 60°C.

Figure 3.2 2 Experimental Design showing Drying Temperature and Time of Cowpea Paste made from both wet and dry milled Cowpea paste
3.2.7 Frying temperature and time of dry milled cowpea paste

Both the pre-dried paste and undried paste were fried in vegetable (Frytol) oil at different temperatures (160 °C, 170 °C, and 180 °C) at different times to obtain koose samples. Part of the paste which was undried was fried at 5 minutes each for all samples. Table 3.1 shows the different frying times used for the pre-dried cowpea paste.

### Table 3.2 Frying temperature and time of dry milled pre-dried cowpea paste.

<table>
<thead>
<tr>
<th>Particle size</th>
<th>Drying temperature (50, 55, 60°C) and Time (1 hour, and 2, 3 hours)</th>
<th>Frying times (All in seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsieved cowpea</td>
<td>50°C at (1, 2 and 3 hours)</td>
<td>180, 120 and 65 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>55°C at (1, 2 and 3 hours)</td>
<td>60, 33 and 16 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>60°C at (1, 2 and 3 hours)</td>
<td>13, 16 and 10 seconds respectively</td>
</tr>
<tr>
<td>Particle size 40µm</td>
<td>50°C at (1, 2 and 3 hours)</td>
<td>180, 140 and 120 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>55°C at (1, 2 and 3 hours)</td>
<td>60, 30, 19 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>60°C at (1, 2 and 3 hours)</td>
<td>20, 16, 10 seconds respectively</td>
</tr>
<tr>
<td>Particle size 45µm</td>
<td>50°C at (1, 2 and 3 hours)</td>
<td>190, 180, 120 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>55°C at (1, 2 and 3 hours)</td>
<td>60, 35, 20 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>60°C at (1, 2 and 3 hours)</td>
<td>20, 13, 10 seconds respectively</td>
</tr>
<tr>
<td>Particle size 50µm</td>
<td>50°C at (1, 2 and 3 hours)</td>
<td>180, 130, 120 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>55°C at (1, 2 and 3 hours)</td>
<td>60, 35, 20 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>60°C at (1, 2 and 3 hours)</td>
<td>40, 16, 10 seconds respectively</td>
</tr>
</tbody>
</table>

3.2.1.6 Frying temperature and time for wet milled cowpea paste

Part of the wet milled cowpea was dried at different times and temperatures of (1 hour, 2 and 3 hours) and (50°C, 55°C, and 60°C) respectively to reduce the initial moisture content of the paste before frying. Part of the paste which was not pre-dried was fried at
5 minutes each for all particle sizes. Both dried and undried cowpea paste were fried at a temperature of 180°C as shown in Table 3.2.

<table>
<thead>
<tr>
<th>Particle size</th>
<th>Drying temperature (50, 55, 60°C) and Time (1 hour, and 2, 3 hours)</th>
<th>Frying times (All in seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blender speed 1</td>
<td>50°C at (1, 2 and 3 hours)</td>
<td>180, 150 and 130 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>55°C at (1, 2 and 3 hours)</td>
<td>130, 60 and 45 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>60°C at (1, 2 and 3 hours)</td>
<td>70, 30 and 19 seconds respectively</td>
</tr>
<tr>
<td>Blender speed 2</td>
<td>50°C at (1, 2 and 3 hours)</td>
<td>180, 150 and 19 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>55°C at (1, 2 and 3 hours)</td>
<td>80, 60 and 19 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>60°C at (1, 2 and 3 hours)</td>
<td>45, 22 and 19 seconds respectively</td>
</tr>
<tr>
<td>Blender speed 3</td>
<td>50°C at (1, 2 and 3 hours)</td>
<td>190, 140 and 60 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>55°C at (1, 2 and 3 hours)</td>
<td>80, 60 and 19 seconds respectively</td>
</tr>
<tr>
<td></td>
<td>60°C at (1, 2 and 3 hours)</td>
<td>65, 30 and 15 seconds respectively</td>
</tr>
</tbody>
</table>

### 3.2.9 Selection of koose samples for further Analysis.

*Koose* samples made from dry milled cowpea paste with particle size 45 μm at pre-drying 50°C for 1 hour and *koose* samples made from wet milled cowpea paste by at blender speeds 2 with particle size 14 μm and pre-drying 50°C for 2 hours were selected for further analysis. The selection was based on the characteristics that they exhibited as compared to the other samples. Viscosity values recorded from figure 4.5 and 4.6 from both wet and dry milled samples paste made from SS50 was thicker and more resistance to flow, this produced koose samples which was tougher, SS40 produced paste which was thin and as a result koose samples which was meaty due to high starch content, paste made using standard sieve size 45 was suitable for producing koose samples for dry
milled cowpea. For wet milled samples paste made from BS2 and BS1 produced paste which were very thin making the koose samples very soggy.

Drying time and temperature of koose samples dried at temperatures 50°C for 1 hour (dry milled) and 50°C for 2 hours (wet milled) was used because they produced paste which were moister.

3.3 Analytical methods

3.3.1 Colour Measurements

The colour of the cowpea paste, fried koose (crust and crumb) was based on the L*a*b* colour system and was determined using a Minolta Chroma Meter (Minolta CR 300 series). The colour difference (ΔE) was determined using the following formula: \[ΔE = (L^* - L)^2 + (a^* - a)^2 + (b^* - b)^2\]1/2. The standard white tile to which the samples were compared had the following colour indices: \(L^* = 97.95, a^* = -0.12, b^* = +1.64\) was calculated from values for \(L^*\) – (lightness), \(a^*\) – (redness), \(b^*\) – (yellowness). Each measurement was done in triplicate, means and standard deviations have been reported.

3.3.2 Determination of cowpea paste viscosity

The viscosities of the both wet and dry milled cowpea paste was determined after whipping (before adding peppers, onions and salt), with a Haake Viscotester D (399-0401, Thermo Scientific™, Spain). To determine the viscosity of dry milled cowpea, paste 250 ml cowpea paste were tempered to 27°C. Measurements were made at 12, 20 and 30 rpm using a T spindle (number C). Readings were taken continuously for the same sample as the spindle was immersed to a depth of 2.5 cm and returned to the surface. The readings were recorded by a recorder attached to the viscometer. The
determinations were carried out in duplicate, means and standard deviations have been reported. To determine the viscosity of wet milled cowpea, paste 500g of cowpea paste and 300 ml of water was used to determine the viscosity. Cowpea paste were tempered to 27°C. Measurements were made at 12, 20 and 30 rpm using a T spindle (number C). Readings were taken continuously for the same sample as the spindle was immersed to a depth of 2.5 cm and returned to the surface. The readings were recorded by a recorder attached to the viscometer. The determinations were carried out in duplicate, means and standard deviations have been reported.

3.3.3 Texture of Koose

Texture analysis of the koose samples were carried out using a TA. XT plus texture analyser (CX 500 series, USA). Samples were of uniform size and shape, five koose balls selected from each treatment (wet and dry milled, pre-dried and undried) were placed individually into the centre of the cell for testing. Peak heights were measured, and the force required to shear was Newton per gram (N/g). Cohesiveness, chewiness, and springiness data were obtained.

3.3.5 Determination of fat and Moisture content

Total moisture was determined by drying 2g of sample in an oven at 105°C for 24hr as described by AOAC, (2005). The crude fat determination of koose samples was done using the Soxhlet extraction method as described by AOAC (2000).
3.3.6 Statistical Analysis

All data were analysed using analysis of variance (ANOVA) procedures from the Analysis System (SAS). Mean comparisons were performed using Duncan’s Multiple Range Test (SAS 2000).

3.3.4 Sensory evaluation of koose samples.

Quantitative Descriptive Analysis (QDA®) was carried out to compare the sensory descriptive profiles of the koose. An experienced descriptive panel made up of 12 assessors from the Department of Nutrition and Food Science Sensory Evaluation Laboratory was trained to evaluate the six koose samples. The required quantity of koose to last for a three-day session was fried at least the day before the start of the evaluations and refrigerated at 4°C during the duration of the evaluations. Each koose sample was cut into four equal quarters and served in 80ml disposable clear cups labeled with three-digit product codes. Each assessor was also provided with a 9” white disposable plate, knife, tissue and crackers (to be used as a palate cleanser) to aid in their assessment of the koose. During the training period, assessors familiarized themselves with the sensory profile of different koose samples bought from the University of Ghana and its environs. They generated terms for the appearance (crust and crumb), aroma, flavour, texture in hand (crust and crumb), texture in mouth (crust and crumb) and aftertaste of the koose. A final verbal agreement of the consensus list was obtained. Assessors completed individual scoring of intensities for the different attributes on 150 mm intensity line scales, according to appearance texture, flavour, aroma and aftertaste. All products were served in a monadic sequential order according to a balanced design, using the William’s design in Compusense Saas (Compusense® Inc. Guelph, Ontario, Canada). Samples were evaluated in triplicate. Assessments were carried out in individually partitioned booths in the sensory evaluation laboratory, the laboratory has white light, noise and
odour free. Researchers had minimal contact with assessors and samples were served through a hatch from the preparation area. The environment was temperature controlled by air conditioning was maintained at 25°C ± 2.
4.0 RESULTS AND DISCUSSION

4.1 Particle size distribution

4.1.1 Particle size distribution of Flour (Dry Milled Cowpea).

Particle size distribution of the flour was determined after milling 2,097g of dried cowpea through a hammer mill with mesh screen size 1.0mm. About 1709g of flour was obtained after milling. Different sieves with pore sizes (40µm, 45µm and 50µm) respectively were used to separate the milled flour into different the particle sizes and the quantities of cowpea flour obtained is shown in table 4.1

<table>
<thead>
<tr>
<th>Sample</th>
<th>% Quantity of flour distributed in each sieve</th>
<th>Particle size of flour distributed in each sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS40</td>
<td>50</td>
<td>40 µm</td>
</tr>
<tr>
<td>SS45</td>
<td>20</td>
<td>45 µm</td>
</tr>
<tr>
<td>SS50</td>
<td>30</td>
<td>50 µm</td>
</tr>
</tbody>
</table>

Table 4.1 Quantity of flour with different particle sizes obtained from sieving dry milled cowpea on three different sieve sizes

Sieve size 40µm retained 644g of the flour, followed by sieve size 50µm retaining 309g of the sample, sieve size 45µm retained 273.6g of the sample, as shown in Figure 4.1.
4.1.2 Particle size distribution of wet milled cowpea paste

Different sieves with different pore sizes resulted in cowpea paste with particle size ranging from 14µm, 18µm, and 20µm, 25µm, 30µm, 35µm for each of the blender speeds. Figure 4.2, 4.3 and 4.4 shows the quantities of paste obtained from the different blender speeds 1, 2 and 3 for all the three blender speeds respectively.
Table 4.2 Particle size Distribution of wet milled cowpea paste.

<table>
<thead>
<tr>
<th>Blender speeds</th>
<th>%Quantity of flour distributed in each sieve (g)</th>
<th>Particle size of flour distributed in each sieve µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blender speed 1</td>
<td>45</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>Blender speeds 2</td>
<td>45</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>25</td>
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<tr>
<td></td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>14</td>
</tr>
</tbody>
</table>
Table 4.2 % Quantity of paste with different particle sizes obtained at blender speeds. For all the blender speeds, sieve size 14µm resulted in larger quantities of paste compared to the other sieve sizes. Generally, the quantities of paste increased marginally with increasing blender speeds as shown in Figures 4.2, 4.3 and 4.4. There was not much difference in the particle sizes of the wet milled cowpea paste from each of the blender speeds. This was due to the fact that for the blender (Waring Commercial Blender Model C15, US) used, the position and angles of the blades were the same and as a result did not produce much difference in the particle size of the paste, although the paste was blended at speeds.
4.2 Colour measurement of wet and dry milled cowpea paste.

Colour measurement of both wet and dry milled cowpea paste was done to determine the differences in colour of paste with different particle sizes made from wet and dry milled cowpea paste. Table 4.1 shows the colour indices of the paste.

Results from Table 4.1 shows that samples were generally creamy-white in colour. This is demonstrated in the L*, a* and b* values. L* is a colour parameter that measures the extent of lightness (a high L value indicates lightness and a low L value indicates a darker sample), a* when positive denotes redness and b* value when positive signifies yellowish colour co-ordinate. There were no significant differences in L values between paste made from SS45, and SS50, but there was a significant difference in colour between these and the unsieved sample and the paste made from SS40. Paste with particle size 40µm was the lightest as it had the highest L value. Paste made from unsieved, had the least lightness value.

Paste made by wet milling-soaked cowpea at blender speeds 3 was lightest followed by paste, followed by paste made using blender speed 1 and 2 respectively. The differences in colour of the paste may be due to differences in particle sizes.
Table 4.3 Colour of Paste made from Wet and Dry milled cowpea Paste.

<table>
<thead>
<tr>
<th>Sample</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>ΔE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Colour measurements of paste made from dry milled cowpea paste</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsieved Paste</td>
<td>81.02±0.42&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.12±0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>21.77±0.28</td>
<td>26.33±0.14&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SS40</td>
<td>85.52±0.21&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.68±0.12&lt;sup&gt;c&lt;/sup&gt;</td>
<td>20.30±0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22.64±0.17&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>SS45</td>
<td>84.50±0.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.72±0.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>20.38±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22.74±0.17&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>SS50</td>
<td>84.39±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.62±0.13&lt;sup&gt;d&lt;/sup&gt;</td>
<td>20.36±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>26.33±0.14&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Colour measurements of paste made from wet milled cowpea paste.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS1</td>
<td>86.84±0.13&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.24±0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14.16±0.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>16.78±0.05&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>BS2</td>
<td>86.39±0.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.03±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.09±0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>17.83±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>BS3</td>
<td>87.29±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.43±0.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.26±0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>15.82±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values are the average of three measurements with standard deviations. Mean values in a column not followed by the same letter are significantly different at 95% confidence interval.

Legend: Unsieved (paste produced from unsieved cowpea flour); SS40 (paste produced from cowpea flour using sieve size 40µm); SS45 (paste produced from cowpea flour using sieve size 45µm); SS50 (paste produced from cowpea flour using sieve size 50µm); BS1 (paste produced from blender speed 2 with particle size 14 µm); BS2 (paste produced from blender speed 2 with particle size 14 µm); BS3 (paste produced from blender speed 1 with particle size 14 µm).
4.4 Effect of particle size on paste viscosity of dry and wet milled cowpea during 
koose preparation.

4.3.1 Effect of particle size on paste viscosity of dry milled cowpea

![Figure 4.1 Paste viscosity of dry milled cowpea](http://ugspace.ug.edu.gh)

Viscosity is used as an indicator to determine good batter consistency, it mainly depends on the particle size distribution of flour and the amount of moisture added to it. Results from Figure 4.5 shows differences in pasting properties of cowpea paste produced from dry milled cowpea seeds, due to different particle size distribution of paste. Dry milled cowpea paste made from sieve size 50µm recorded the highest paste viscosity of 58016.3 (higher yield stress, higher flow consistency index, lower flow behaviour index), followed by the unsieved paste with viscosity of 57922, followed by paste made from sieve size 45µm (56563) and 40µm (53801) respectively. Differences in viscosity values may be due to differences in particle size distribution of the paste (Kerr et al., 2001).
4.3.2 Effect of particle size on paste viscosity of wet milled cowpea paste

![Viscosity of wet milled cowpea paste](image)

Figure 4.2 Viscosity of wet milled cowpea paste

There were differences in the viscosities of wet milled cowpea paste blended at different blender speeds, cowpea paste blended at blender speed 2 was more viscous (3,651.25) compared to cowpea paste blended at blender speed 1 (2,494.75) and 3 (2,059.85) respectively. Differences in viscosity values was due to differences in particle size distribution of the paste (Kerr et al., 2001).

4.4 Effect of pre-drying time and temperature on frying time

4.4.1 Dry milled cowpea paste.

Koose samples were fried at different pre-drying time and temperature.
Figure 4.3 Drying temperature (°C) and Time (hours) for dried milled cowpea paste

Legend: Unsieved cowpea paste; SS40: cowpea paste with particle size 40µm, SS45 cowpea paste with particle size 45µm, SS50: cowpea paste with particle size 50µm.

Results from Figure 4.3 shows increasing pre-drying time and temperature reduced the frying time of koose samples. At a lower temperature of drying, koose samples took a longer time to cook than when the drying temperature was increased as shown in figure 4.3. A possible reason for the reduced frying time of pre-dried koose samples could be due to compactness of the material matrix (reduced porosity) and increase in solids content of pre-dried whipped cowpea paste with reduced moisture content (Debnath et al., 2003).
4.4.2 Wet milled cowpea paste

Koose samples were fried at different pre-drying time and temperature.

![Bar chart showing frying time vs. drying temperature and time]

Figure 4.8 Effect of drying temperature (°C) and time (hours) on frying time

Legend: BS1 (cowpea paste with particle size 14μm made by blending soaked cowpea at blender speeds 1); BS2 (BS2 cowpea paste particle size with 14μm made by blending soaked cowpea at blender speeds 2); BS3; (BS3 cowpea paste particle size with 14μm made by blending soaked cowpea at blender speeds 2)

Results from Figure 4.4 shows that increasing pre-drying time and temperature reduces the frying time. A possible reason for the reduced drying time of pre-dried koose samples could be due to the compactness of the material matrix (reduced porosity) and increase in solids content of pre-dried whipped cowpea paste with decreased moisture (Debnath et al., 2003).
4.5 Selection of Koose samples for further Analysis

For dry milled, a sample made from cowpea paste with particle size 45µm and pre-drying temperature 50°C and for 1 hour was chosen for further analysis. For wet milled samples, koose samples made from wet milled cowpea paste at blender speeds 2 with particle size 14µm and pre-drying temperature and time of 50°C for 2 hours respectively were chosen for final analysis. According to Tinus et al. (2012) reported different particle size distribution of paste made during koose preparation has an effect on the final quality of the product. Koose samples were chosen by visual appearance based on the different particle sizes of the paste produced, samples made from paste with particle size 40µm produced a product which was dense, tough and meaty, koose produced from paste with particle size 50µm, produced a product which was very soggy and very dense, koose made from paste with particle size 45µm produced a product which was suitable because of particle size distribution of the paste. For both processing methods pre-drying temperatures 50°C and drying time 1 hour was used for dry milled samples, and for wet milled samples pre-drying temperature 50°C and drying time 2 hours was used, because at a higher pre-drying temperature and time cowpea paste became too dry. Furthermore viscosity values recorded from figure 4.5 and 4.6 from both wet and dry milled samples paste made from SS50 was thicker and more resistance to flow, this produced koose samples which was tougher, SS40 produced paste which was thin and as a result koose samples which was meaty due to high starch content, paste made using standard sieve size 45 was suitable for producing koose samples for dry milled cowpea. For wet milled samples paste made from BS2 and BS1 produced paste which were very thin making the koose samples very soggy.
4.6 Effect of wet milling, dry milling and pre-drying of paste on colour of koose samples

To determine the effect of processing on koose samples, colour measurements of the crust and crumb of both pre-dried and not dried koose samples were taken, as shown in Table 4.2 and 4.3.
Table 4.4 Colour of Outer Crust of Koose Samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>ΔE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsieved</td>
<td>47.69±0.07&lt;sup&gt;c&lt;/sup&gt;</td>
<td>13.63±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.59±0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>52.10±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>SS45</td>
<td>47.98±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.61±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.48±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>55.02±2.53&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>BS2</td>
<td>49.32±0.43&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.23±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.89±0.86&lt;sup&gt;a&lt;/sup&gt;</td>
<td>55.19±0.44&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Unsieved (pre-dried)</td>
<td>45.98±0.02&lt;sup&gt;d&lt;/sup&gt;</td>
<td>13.29±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23.24±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>55.55±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>SS40 (pre-dried)</td>
<td>45.28±0.01&lt;sup&gt;d&lt;/sup&gt;</td>
<td>12.77±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>23.69±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>55.34±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>BS2 (pre-dried)</td>
<td>46.92±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12.92±0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>23.60±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>59.07±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values are the average of three measurements with standard deviations. Mean values in a column not followed by the same letter are significantly different at 95% confidence interval.

Legend: Unsieved (*koose* produced from unsieved (undried) cowpea paste); SS45 (*koose* produced from (undried) cowpea paste using sieve size 45µm); BS2 (*koose* produced from Blender speeds 2 (undried) cowpea paste with particle size 14µm); BS2 Dried (*koose* produced from (pre-dried cowpea paste) Blender speeds 2, with particle size 14µm); SS45 Pre-dried (*koose* produced from (pre-dried) cowpea paste using sieve size 45µm); unsieved pre-dried: (*koose* produced from unsieved (pre-dried) cowpea paste).
Results from the Table 4.4 shows significance difference in L*a* b*values between 
koose samples produced from not dried cowpea paste and koose samples produced from 
dried cowpea. Results from Table 4.4 shows koose samples produced from SS45, BS2 
and unsieved cowpea paste samples (not dried) were lighter golden brown (47.98, 49.32 
and 47.69 respectively) in colour, koose samples produced from SS45, BS2 and unsieved 
cowpea pre-dried cowpea paste which were browner in colour (45.28, 46.92 and 45.98 
respectively). Koose samples produced from not dried cowpea paste had a stronger 
redness (a*) and yellowness colour (b*) indicating that they had a stronger golden yellow 
colour. The differences in colour change between koose samples produced from pre-
dried and not dried cowpea paste could be due to the fact that, for koose samples 
produced from pre-dried cowpea paste, much of the heat transfer occurs at the surface 
crust of the samples another reason could be due to increased browning reaction of koose 
samples produced from pre-dried cowpea paste (Mery et al., 2007)
Table 4.5 Colour of crumb of koose samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>∆E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsieved</td>
<td>60.12 ± 0.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.20 ± 0.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>19.02 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>41.92 ± 0.03&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>SS45</td>
<td>60.18 ± 0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.22 ± 0.02&lt;sup&gt;d&lt;/sup&gt;</td>
<td>19.05 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>41.95 ± 0.05&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>BS2</td>
<td>62.14 ± 0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.53 ± 0.42&lt;sup&gt;c&lt;/sup&gt;</td>
<td>16.97 ± 0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>39.08 ± 0.06&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Unsieved (pre-dried)</td>
<td>51.02 ± 0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.94 ± 0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>14.96 ± 0.01&lt;sup&gt;d&lt;/sup&gt;</td>
<td>49.10 ± 0.04&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SS45(pre-dried)</td>
<td>50.97 ± 0.03&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.45 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.59 ± 0.03&lt;sup&gt;d&lt;/sup&gt;</td>
<td>49.14 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>BS2(pre-dried)</td>
<td>57.70 ± 0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.780 ± 0.05&lt;sup&gt;e&lt;/sup&gt;</td>
<td>15.85 ± 0.06&lt;sup&gt;c&lt;/sup&gt;</td>
<td>42.85 ± 0.01&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values are the average of three measurements with standard deviations. Mean values in a column not followed by the same letter are significantly different at 95% confidence interval.

Legend: Unsieved (*Koose* produced from unsieved (undried) cowpea paste); SS45 (*Koose* produced from (undried) cowpea paste using sieve size 45µm); BS2 (*Koose* produced from Blender speeds 2 (undried) cowpea paste with particle size 14µm); BS2 Dried (*Koose* produced from (pre-dried cowpea paste) Blender speeds 2, with particle size 14µm); SS45 Pre-dried (*koose* produced from (pre-dried) cowpea paste using sieve size 45µm); unsieved pre-dried: (*koose* produced from unsieved (pre-dried) cowpea paste)
Results from the Table 4.5 shows significance difference in L*a* b* values between koose samples produced from not dried cowpea paste and koose samples produced from dried cowpea. Koose produced from SS45, BS2 and unsieved cowpea paste (not dried) were lighter (60.1200, 60.1200, 62.1433) respectively, followed by koose samples produced from unsieved cowpea paste, SS45, BS2 pre-dried samples (51.0167, 50.9733, 57.7033). Lower lightness colour of the crumb of pre-dried samples could be due to more browning reaction occurring in the pre-dried samples making the crumb of the koose browner (Mery et al., 2007).
4.7 Effect of wet milling, dry milling and pre-drying of paste on texture of koose samples

Textural parameters of *koose* samples were derived from force deformation curves. Results obtained showed statistically significant difference in (hardness, chewiness, springiness, and cohesiveness) of *koose* samples as shown in Table 4.6 below;

Table 4.6 Texture Profile Analysis of Koose Samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Hardness</th>
<th>Cohesiveness</th>
<th>Springiness</th>
<th>Chewiness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsieved</td>
<td>9653±643&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.41±0.06&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.39±0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1554.5±160.3&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>SS45</td>
<td>7504±672&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.49±0.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.36±0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1323.8±101.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bs2</td>
<td>4317±455&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.27±0.02&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.21±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>248.1±25.4&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Unsieved (pre- dried)</td>
<td>26843±1815&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.55±0.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.39±0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5782±423&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SS45(pre-dried)</td>
<td>26833±1804&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.51±0.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.51±0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5568±1970&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bs2(pre-dried)</td>
<td>9403±723&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.42±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.27±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1051.6±152.7&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values are the average of three measurements with standard deviations. Mean values in a column not followed by the same letter are significantly different at 95% confidence interval.

Legend: Unsieved (*Koose* produced from unsieved (undried) cowpea paste); SS45 (*Koose* produced from (undried) cowpea paste using sieve size 45µm); BS2 (*Koose* produced from Blender speeds 2 (undried) cowpea paste with particle size 14µm); BS2 Dried (*Koose* produced from (pre-dried cowpea paste) Blender speeds 2, with particle size 14µm); SS45 Pre-dried (*Koose* produced from (pre-dried) cowpea paste using sieve size 45µm); unsieved pre-dried: (*Koose* produced from unsieved (pre-dried) cowpea paste).
4.7.1 Hardness

Hardness refers to the force necessary to attain a given deformation, results from Table 4 shows, koose samples prepared from dry milled cowpea required significantly more force to shear-compress than samples processed by wet milling of cowpea seeds. BS2 both pre-dried and not dried samples had the lowest hardness (4317, 9403) respectively followed by SS45 (9653, 7504) both pre-dried and not dried koose samples respectively. Unsieved, and SS45 pre-dried samples (26843, 26833) recorded the highest hardness values. Wet milling of cowpea seeds preserves the fibre structure better than dry milled cowpea seeds, leading to good water absorption and foamability of the paste, leading to a softer and spongier product. Textural profile analysis of koose which he showed that koose made from wet-milled paste was the least hard followed by koose produced from dry milled cowpea (Minerva Adinorkie Plahar, 2001).

4.7.2 Chewiness

Chewiness is the energy required to masticate a solid food to a state ready for swallowing (Minerva Adinorkie Plahar, 2001). Results from the Table 4 shows koose made from BS2 undried (4317) and Bs2 pre-dried (9403) samples were chewier followed by unsieved (9653) and SS40 (9504) not dried samples. Koose made from unsieved (26843) and SS40 (26833) pre-dried samples had the highest chewiness values. Mofoluke et al., (2013) reported that wet milling of cowpea preserves the fibre structure better, leading to good water absorption and foamability of the paste leading to products which are soft and less chewy.

4.7.3 Springiness

Springiness is the rate at which a deformed material goes back to its undeformed condition after the deforming force is removed (Minerva Adinorkie Plahar, 2001).
Samples made from wet milling of cowpea were springier than samples prepared from dry milling. *Koose* samples prepared by BS2 (0.2732) and BS2 pre-dried (0.40518) were spongier, followed by unsieved (0.4079) and SS45 (0.4911) not dried. *Koose* samples SS45 (0.5123) and unsieved (0.5526) pre-dried samples were the least spongy it has been shown in past studies that, *koose* samples produced from dry milled cowpea do not facilitate the incorporation of air during due to disruption of the protein structure during the milling process, leading to poor air incorporation of the paste when whipped leading to product which is less springy. Kerr et al., (2001) observed that *koose* made from flour had decreased hydration which reduced the amount of air incorporated during the whipping process, this in turn led to denser and less spongy texture.

4.7.4 Cohesiveness

Cohesiveness is the extent to which a material can be deformed before it ruptures both pre-dried and not dried recorded higher cohesiveness values (0.5526, 0.4079), followed by SS40 both pre-dried and not dried (0.40518, 0.4911) and BS2 both pre-dried and not dried (0.40518, 0.2732) samples respectively. In a study by Vanchina et al., (2006), noted that change in size and shape of dry milled cowpea resulted in dense packing of particles, producing dry and dense product.
4.8 Quantitative Descriptive Analysis (QDA®)

Assessors came up with 33 descriptors to describe the appearance (crumb and crust), aroma, flavour, texture in hand (crumb and crust), texture in mouth (crumb and crust) and aftertaste of the six samples. The list of descriptors is shown in Table 4.1 below.

<table>
<thead>
<tr>
<th>Modality</th>
<th>Attribute</th>
<th>Definition</th>
<th>Anchor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance-Crust</td>
<td>Oily</td>
<td>Having an oily surface</td>
<td>Not to very</td>
</tr>
<tr>
<td></td>
<td>Blackspots</td>
<td>Black particles on the surface of the sample</td>
<td>None to many</td>
</tr>
<tr>
<td></td>
<td>Hard</td>
<td>Appearing to be hard</td>
<td>Not to very</td>
</tr>
<tr>
<td></td>
<td>Dry</td>
<td>Absence of moisture</td>
<td>Not to very</td>
</tr>
<tr>
<td>Appearance-Crumb</td>
<td>Cream colour</td>
<td>Primary colour cream</td>
<td>Not to very</td>
</tr>
<tr>
<td></td>
<td>Brown colour</td>
<td>Primary colour brown</td>
<td>Not to very</td>
</tr>
<tr>
<td></td>
<td>Black spots</td>
<td>Black particles in the sample</td>
<td>Not to very</td>
</tr>
<tr>
<td></td>
<td>Spongy</td>
<td>Giving the impression that sample will be easily compressed upon touching</td>
<td>Not to very</td>
</tr>
<tr>
<td></td>
<td>Soggy</td>
<td>Sample appearing to have absorbed oil</td>
<td>Not to very</td>
</tr>
<tr>
<td>Aroma</td>
<td>Beany</td>
<td>Characteristic aroma of freshly cooked beans</td>
<td>Not to very</td>
</tr>
<tr>
<td></td>
<td>Gari</td>
<td>Characteristic aroma of slightly dampened gari</td>
<td>Not to very</td>
</tr>
<tr>
<td></td>
<td>Koose aroma</td>
<td>Characteristic aroma of fried koose</td>
<td>Not to very</td>
</tr>
<tr>
<td></td>
<td>Oniony</td>
<td>Characteristic aroma of fried onion</td>
<td>Not to very</td>
</tr>
<tr>
<td></td>
<td>Peppery</td>
<td>Characteristic aroma of dried chilli pepper</td>
<td>Not to very</td>
</tr>
<tr>
<td>Flavour</td>
<td>Salty</td>
<td>Basic taste</td>
<td>Not to very</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Oniony</td>
<td>Characteristic flavour of fried onions</td>
<td>Not to very</td>
<td>Oniony</td>
</tr>
<tr>
<td>Texture in mouth</td>
<td>Hard</td>
<td>Not easily compressed</td>
<td>Not to very</td>
</tr>
<tr>
<td>Texture in hand</td>
<td>Soft</td>
<td>Easily compressed</td>
<td>Not to very</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture in Hand</td>
<td>Hard</td>
<td>Not easily compressed</td>
<td>Not to very</td>
</tr>
</tbody>
</table>
4.8.1 Appearance

Assessors came up with four (4) descriptors to describe the appearance of *koose* crust and five (5) descriptors for the appearance of the crumb. All descriptors for the crumb and crust appearance significantly differentiated the six samples at the 95% confidence interval. Figure 4.9 shows the crust appearance profile of the six samples.

<table>
<thead>
<tr>
<th>Aftertaste</th>
<th>Peppery</th>
<th>Lingering pepper taste</th>
<th>Not to very</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salivation</td>
<td>Production of saliva</td>
<td></td>
<td>Not to very</td>
</tr>
<tr>
<td><em>Koose</em></td>
<td>Lingering <em>koose</em> taste</td>
<td></td>
<td>Not to very</td>
</tr>
</tbody>
</table>
From Figure 4.9, BS2- undried and BS2- pre-dried were described as the oiliest samples, with BS2 undried significantly oilier than BS2 pre-dried. The other four samples (unsieved, undried, unsieved pre-dried, SS45 pre-dried and SS45 undried) were described by assessors as hard, dry and with black spots. These samples were significantly different from BS2 pre-dried and not dried in terms of these attributes.
Figure 4.10 Crumb appearance of Koose as described by panellist.
* Significant difference at 95% CI

Legend: Unsieved (Koose produced from unsieved (undried) cowpea paste); SS45 (Koose produced from (undried) cowpea paste using sieve size 45µm); BS2 (Koose produced from Blender speeds 2 (undried) cowpea paste with particle size 14µm); BS2 Dried (Koose produced from (pre-dried cowpea paste) Blender speeds 2, with particle size 14µm); SS45 Pre-dried (Koose produced from (pre-dried) cowpea paste using sieve size 45µm); unsieved pre-dried: (Koose produced from unsieved (pre-dried) cowpea paste).
Figure 4.10 shows the appearance of the *koose* crumb, BS2 undried and pre-dried were described as *soggy*, *spongy* and having a *cream colour*. BS2 undried described as spongier and soggier. The other four samples (unsieved undried, unsieved pre-dried, SS45 pre-dried and SS45 undried) were described by assessors as having a *brown colour* and *brown spots*. These samples were statistically different from BS2 undried and pre-dried.
4.5.2 Aroma

Figure 4.11 shows the aroma profile for the six samples. All the descriptors used to describe the aroma of the samples were statistically different at the 95% confidence interval.

Figure 4.11 Aroma profile of Koose as described by panellist
* Significant difference at 95% CI

Legend: unsieved (Koose produced from unsieved (undried) cowpea paste); SS45 (Koose produced from (undried) cowpea paste using sieve size 45µm); BS2 (Koose produced from Blender speeds 2 (undried) cowpea paste with particle size 14µm); BS2 Dried (Koose produced from (pre-dried cowpea paste) Blender speeds 2, with particle size 14µm); SS45 Pre-dried (Koose produced from (pre-dried) cowpea paste using sieve size 45µm); unsieved pre-dried: (Koose produced from unsieved (pre-dried) cowpea paste).
The Koose samples were described as having a peppery, oniony, beany, koose and gari aroma. BS2 pre-dried had the most oniony, and koose aroma. SS45 undried was the most beany and peppery. SS45 pre-dried had the most gari aroma.

4.12 Flavour

For flavour, there were statistically significant difference in the attributes koose, peppery, oniony, beany, umami. The term salty did not statistically differentiate the samples.

Figure 4.5 1 Flavour profile of Koose

Figure 4.12 Flavour Profile of koose as described by panellist
* Significant difference at 95% CI

Legend: unsieved (Koose produced from unsieved (undried) cowpea paste); SS45 (Koose produced from (un dried) cowpea paste using sieve size 45µm); BS2 (Koose produced from Blender speeds 2 (undried) cowpea paste with particle size14µm); BS2 Dried (Koose produced from (pre-dried cowpea paste) Blender speeds 2, with particle size14µm); SS45 Pre-dried (Koose produced from (pre-dried) cowpea paste using sieve size 45µm); unsieved pre-dried: (Koose produced from unsieved (pre-dried) cowpea paste).
From Figure 4.13, sample SS45 undried was described as the most *beany* and *peppery*, whilst BS2 pre-dried was described as the onioniest, with the most *koose* and *umami* flavour.

### 4.14 Texture in hand

Assessors came up with two (2) descriptors to describe the texture-in-hand of the crust (crust texture) and five (5) descriptors to describe the texture-in-hand of the crumb (crumb texture). The descriptors were all able to statistically differentiate the samples at the 95% confidence interval.

Figure 4.13 Texture in hand of Koose as described by panellist.

* Significant difference at 95% CI

Legend: unsieved (*Koose* produced from unsieved (undried) cowpea paste); SS45 (*Koose* produced from (undried) cowpea paste using sieve size 45µm); BS2 (*Koose* produced from Blender speeds 2 (undried) cowpea paste with particle size14µm); BS2 pre-dried (*Koose* produced from (pre-dried cowpea paste) Blender speeds 2, with particle size14µm); SS45 pre-dried (*Koose* produced from (pre-dried) cowpea paste using sieve size 45µm); unsieved pre-dried: (*Koose* produced from unsieved (pre-dried) cowpea paste).
Figure 4.13 shows the texture-in-hand profile of the koose samples BS2 pre-dried and undried were described by the attributes *mushy, soft, and oily* for their crumb texture-in-hand. They were also described as *oily* for their crust texture-in-hand. BS2 undried had a mushier, *softer*, and *oilier* crumb texture in hand and also had an oilier crust texture-in-hand. SS45 pre-dried, Control undried, Control pre-dried, and SS45 undried were described as having a *flaky* and *dry* crumb texture-in-hand whilst having a *hard* crust texture-in-hand.
4.14 Texture in mouth

Assessors came up with two (2) descriptors to describe the texture-in-mouth of the crust (crust texture) and two (2) descriptors to describe the texture-in-mouth of the crumb (crumb texture). The descriptors were all able to statistically differentiate the samples at the 95% confidence interval.

Figure 4.14 Texture in hand profile of koose as described by panellist.

* Significant difference at 95% CI

Legend: Unsieved (*Koose* produced from unsieved (undried) cowpea paste); SS45 (*Koose* produced from (undried) cowpea paste using sieve size 45µm); BS2 (*Koose* produced from Blender speeds 2 (undried) cowpea paste with particle size14µm); BS2 Dried (*Koose* produced from (pre-dried cowpea paste) Blender speeds 2, with particle size14µm); SS45 Pre-dried (*Koose* produced from (pre-dried) cowpea paste using sieve size 45µm); unsieved pre-dried: (*Koose* produced from unsieved (pre-dried) cowpea paste).
SS45 pre-dried, Control undried, Control pre-dried, and SS45 undried were described as having a *hard* and *chewy* crumb and a *hard* and *chewy* crust. These samples were statistically different from BS2 pre-dried and undried in terms of these attributes.
4.15 Aftertaste

For aftertaste, there were statistically significant difference in the attributes *peppery, and koose*. The term *salivation* did not statistically differentiate the samples.

![Aftertaste profile of koose as described by panellist.](image)

* Significant difference at 95% CI

Legend: Unsieved (*Koose* produced from unsieved (undried) cowpea paste); SS45 (*Koose* produced from (undried) cowpea paste using sieve size 45µm); BS2 (*Koose* produced from Blender speeds 2 (undried) cowpea paste with particle size 14µm); BS2 Dried (*Koose* produced from (pre-dried cowpea paste) Blender speeds 2, with particle size 14µm); SS45 Pre-dried (*Koose* produced from (pre-dried) cowpea paste using sieve size 45µm); unsieved pre-dried: (*Koose* produced from unsieved (pre-dried) cowpea paste).

BS2 undried and pre-dried were described as having a *koose* aftertaste, whilst SS45 undried was described as having a *peppery* aftertaste.
4.5.7 Principal Component Analysis

Figure 4.16 Product map showing how the koose samples are loaded in the sensory product space.

Legend: AP-Appearance; ARO-Aroma; TH-Texture-in-Hand; TM-Texture-in-Mouth; AFT-Aftertaste, FL-Flavour. Legend: unsieved (Koose produced from unsieved (undried) cowpea paste); SS45 (Koose produced from (undried) cowpea paste using sieve size 45µm); BS2 (Koose produced from Blender speeds 2 (undried) cowpea paste with particle size14µm); BS2 Dried (Koose produced from (pre-dried cowpea paste) Blender speeds 2, with particle size14µm); SS45 Pre-dried (Koose produced from (pre-dried cowpea paste using sieve size 45µm); unsieved pre-dried: (Koose produced from unsieved (pre-dried) cowpea paste).
From the PCA products map, Unsieved undried, Unsieved pre-dried and SS45 pre-dried loaded in the same quadrant. The other three samples SS45 undried, BS2 undried and BS2 pre-dried loaded in different quadrants. Assessors used *dry, hard* and *black spots* to describe the crust appearance of Unsieved (undried), Unsieved (pre-dried) and SS45 pre-dried. They were described as having *gari* aroma, they were described as having a *hard* crumb and crust (texture in hand). With their texture in mouth, they were described as having a *chewy crumb* and *hard* crust.

SS45 undried was described as having a *brown colour* for the crumb, a *peppery* and *beany* aroma, a *beany* and *peppery* flavour, a *flaky* crumb and a *peppery* aftertaste.

BS2 pre-dried was described as a *cream colour* for the crumb, a *koose* aroma, *umami* and *koose* flavour, an *oily* crumb and crust and having *salivation* and *koose* taste as after effects.

BS2 (undried) was described as having an *oily* crust appearance and a *soggy* and spongy crumb appearance, *oniony* and *salty* flavour and *mushy* and *soft* crumb (texture in hand).

**4.9 Effect of frying temperature and time on oil absorption of koose.**

To determine the effect of frying temperature and time on oil absorption, koose samples were fried at different times and temperatures of frying temperature as shown in Table 4.9 to analysis both pre-dried and not pre-dried cowpea paste was fried at different temperatures (50 °C, 55°C, and 60°C) and different times.
Table 4.9 Fat and Moisture Content of Koose Fried at different Temperatures

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fat (160°C)</th>
<th>Moisture</th>
<th>Fat (170°C)</th>
<th>Moisture</th>
<th>Fat (180°C)</th>
<th>Moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsieved</td>
<td>20.41±0.3</td>
<td>57.71±0.40^a</td>
<td>15.25±0.3</td>
<td>54.29±1.19^a</td>
<td>9.23±0.00^a</td>
<td>51.45±0.40^a</td>
</tr>
<tr>
<td>SS45</td>
<td>21.91±0.3</td>
<td>54.09±1.48^b</td>
<td>14.25±0.3</td>
<td>53.29±1.19^a</td>
<td>9.19±0.03^a</td>
<td>50.69±2.07^b</td>
</tr>
<tr>
<td>BS2</td>
<td>22.31±0.0</td>
<td>57.36±1.46^a</td>
<td>15.10±0.0</td>
<td>53.90±0.89^a</td>
<td>9.62±0.09^a</td>
<td>51.56±1.46^ab</td>
</tr>
<tr>
<td>Unsieved(pre-dried)</td>
<td>10.24±0.0</td>
<td>50.09±0.06^d</td>
<td>8.03±0.03^d</td>
<td>49.28±0.00^c</td>
<td>6.09±0.42^c</td>
<td>42.66±2.07^d</td>
</tr>
<tr>
<td>SS45(pre-dried)</td>
<td>10.03±0.0</td>
<td>50.95±3.94^d</td>
<td>8.04±0.02^d</td>
<td>50.78±0.707^b</td>
<td>7.06±0.88^b</td>
<td>45.45±1.88^c</td>
</tr>
<tr>
<td>BS2 (pre-dried)</td>
<td>13.82±0.1</td>
<td>52.28±0.19^c</td>
<td>10.82±0.1</td>
<td>50.23±0.02^b</td>
<td>9.03±0.00^a</td>
<td>50.28±1.90^b</td>
</tr>
</tbody>
</table>

Values are the average of three measurements with standard deviations. Mean values in a column not followed by the same letter are significantly different at 95% confidence interval.

Legend: Unsieved (Koose produced from unsieved (undried) cowpea paste); SS45 (Koose produced from (undried) cowpea paste using sieve size 45µm); BS2 (Koose produced from Blender speeds 2 (undried) cowpea paste with particle size14µm); BS2 Dried (Koose produced from (pre-dried cowpea paste) Blender speeds 2, with particle size14µm); SS45 Pre-dried (Koose produced from (pre-dried) cowpea paste using sieve size 45µm); unsieved pre-dried: (Koose produced from unsieved (pre-dried) cowpea paste).
4.9 Effect of frying temperature and time on oil absorption of *koose*.

Results from Table 4.9 shows fat and moisture content of *koose* samples produced from undried and pre-dried cowpea paste (wet and dry (flour)) fried at different times and temperatures. *Koose* samples were fried at different temperatures of 160°C, 170°C and 180°C at different times.

From the table 4.9, *koose* samples produced from undried cowpea paste and fried at a temperature of 160°C for 20mins, showed significant difference in fat and moisture content between unsieved, SS45 and BS2 (20.41, 21.91 and 22.3%) and (57.71, 54.09 and 57.36%) respectively.

There was no significant difference in fat and moisture content between *koose* samples produced from unsieved and SS45 pre-dried cowpea paste fried at 160°C for 10mins (10.24, 10.03%) and (8.03, 8.04%) respectively. However, the fat and moisture content of *koose* samples produced from BS2 pre-dried cowpea paste, fried at 160°C for 10mins was significantly different (13.82 and 52.28%).

*Koose* samples produced from undried cowpea paste and fried at a temperature of 170°C and time 10mins, showed significant difference in fat and moisture content between unsieved, SS45 and BS2 (15.10, 14.25, 15.25%) and (54.29, 53.29, 57.36%) respectively.

There was a no significant difference between *koose* samples produced from unsieved and SS45 pre-dried cowpea paste and fried at 170°C for 5mins (8.03 and 8.04%) respectively. However, there was a significant difference in fat and moisture content in *koose* sample produced from BS2 pre-dried cowpea paste and fried at 170°C for 5mins (10.82 and 50.23%) respectively.

*Koose* samples produced from unsieved and SS45 undried cowpea paste and fried at a temperature of 180°C and time 5mins (9.23, 9.19%) and (51.45, 50.69%) respectively.
were significantly the same, but there was a significant difference in fat and moisture content in *koose* samples produced from BS2 undried cowpea paste, fried at 180°C and time 5mins (9.62, 51.56%) respectively. *Koose* samples produced from unsieved, SS45, BS2 pre-dried cowpea paste and fried at time 1mins were significantly different (6.09, 7.06 and 9.03%) and (42.66, 45.45 and 50.28%) respectively.

These results indicate that, *koose* samples obtained from unsieved, SS45 (dry milled) cowpea paste showed less fat absorption than BS2 (wet milled) *koose* samples. According to Debnath (2003), wet milling of cowpea seeds preserves the fibre structure better than dry milling, increasing the water activity of the paste, leading to high amount of fat the product absorbs during the frying process. *Koose* samples produced from pre-dried cowpea paste showed less oil absorption even when fried at lower temperatures, this could be attributed to the fact that pre-drying of cowpea paste before frying reduced the initial water content of the paste thereby reducing the water activity of the paste making the paste, more compact (reduced porosity) with increased solid content, thereby reducing the frying time and the amount of fat the product absorbs (Debnath et al., 2003).

Generally, at lower temperatures of frying samples absorbed more oil than when the temperature was increased and at a reduced moisture content *koose* samples absorbed less oil.
5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Findings of this study shows different processing methods have an effect on the oil absorption and sensory characteristics of koose. Dry milling of cowpea into flour to produce a paste affected the ability of the paste to entrap air when whipped. Wet milled cowpea, produced paste with uniform consistency with better distribution of air and moisture.

Pre-drying of cowpea paste to reduce the moisture content, reduced the frying time of koose samples but had an effect on the texture of koose samples. Koose samples made from pre-dried cowpea paste for both wet and dry milled cowpeas were tough, flaky, chewier, drier and less spongy.

Koose samples produced from wet milled undried cowpea paste were soggier, spongy, softer, less chewy and oily, dried milled samples were drier, less spongy and flaky.

Koose samples produced from pre-dried cowpea paste for both wet and dry milled samples were browner as compared to koose samples produced from undried cowpea paste which were lighter golden brown.

Dry milling of cowpea for koose processing produced koose samples with reduced fat content than wet milling of cowpea.

Generally frying temperature and time also affected the oil absorption of the koose samples. Reduced frying temperature was found to yield samples with increased fat content because they took a longer time to cook, than when fried at a higher temperature.

Wet milled samples recorded greater oil absorption due to increasing foaming capacity of the paste, this provided a product structure that was open and porous, resulting in greater oil absorption during frying.
5.2 Recommendation

Results of this study shows pre-drying of cowpea paste before frying can be effectively used to reduce the amount of oil the product absorbs. *Koose* produced using the dry milling processing method can be used to produce *koose* with reduced fat content.

Further studies can be done to improve upon the texture of *koose* samples produced from pre-dried cowpea paste.

Effect of whipping time and addition of ingredients on oil absorption can be studied.
REFERENCES


Dziki, D., Baraniak, B., Tomilo, J., Gawlik-dziki, U., & Michal, S. (2013). Quality and antioxidant properties of breads enriched with dry onion (Allium cepa L.) skin,


Absorption, and Protein Content of The Fried Cowpea Paste (Akara) During Production, 221–225.


### APPENDIX 1

Anova Table for *koose* Descriptors

<table>
<thead>
<tr>
<th>Modality</th>
<th>Descriptor</th>
<th>Df</th>
<th>Sum of Squares</th>
<th>Mean square</th>
<th>F</th>
<th>Pr&gt;F</th>
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<td>Oily</td>
<td>5</td>
<td>639368.34</td>
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