UNIVERSITY OF EDUCATION, WINNEBA

PROXIMATE COMPOSITION AND CONSUMERS ACCEPTABILITY OF OKRO SEED FLOUR CAKE

DENTAAH JEWEL ADU

2020

UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

PROXIMATE COMPOSITION AND CONSUMERS ACCEPTABILITY OF OKRO SEED FLOUR CAKE

BY

DENTAAH JEWEL ADU

(190000438)

A Dissertation in the Department of HOSPITALITY AND TOURISM EDUCATION Faculty of VOCATIONAL AND TECHNICAL EDUCATION, submitted to the School of Graduate Studies, University of Education, Winneba in partial fulfilment of the requirement for the award of the Master of Technology Education (Catering and Hospitality Education) degree.

JULY, 2020

DECLARATION

STUDENT'S DECLARATION

I Jewel Adu Dentaah do hereby declare that, this submission is my own work towards the award of a Master in Education Technology (M.Tech) in Hospitality and tourism Education and that no previous submission has been made here or elsewhere for the award of any other degree. However, all references made herein are fully and respectfully acknowledged in the text.

Signed……………………………………. Date……………………………….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this study was supervised in accordance with the guidelines and supervision of this thesis laid down by the University of Education, Winneba.

Supervisor's Name: Dr. Gilbert Owiah Sampson

Signed…………………………………… Date…………………………………

DEDICATION

This work is dedicated to the Almighty God and my family and friends.

ACKNOWLEDGEMENT

I wish to appreciate the Almighty God for how far He has brought me in my education especially this thesis. The success of this research has been possible through His divine assistance, ceaseless protection, direction and guidance. To Him be all the glory.

My sincere gratitude goes to Dr. Sampson Gilbert Owiah, my supervisor whose efforts contributed immensely to make this research a reality. I acknowledge his careful review, constructive suggestions throughout the work. Doctor, may the Good Lord bless you and your household abundantly. His patience to read through and ever readiness to provide vital materials for the work is greatly appreciated. Doctor, may the good Lord bless you abundantly.

My heartfelt gratitude goes to Brother Prince Ofori for assisting me throughout the study. Finally, I wish to appreciate my husband, Mr. Jerry Osei Sarfo for his support and encouragement.

ABSTRACT

This project was conducted to established the possibility of using Okra seed flour as a fortifier in the production of cakes. It was in effect to tackle the malnutrition challenges in the diet of man and as well address the post-harvest losses of soybean due to its underutilization. To this effect, the aim of the study was to evaluate the proximate composition and consumer acceptability of wheat cakes. The cakes were formulated in percentages of flour incorporation with wheat flour. Four different products were thus prepared, labeled; product XYZ, ABC, QPO and RMP, according to percentage levels of 0%, 20%, 25% and 75% respectively, been replaced with its wheat flour equivalence in each case. Prepared products were then examined for their proximate composition with the standard AACC, 2000. Sensory evaluation analysis was also conducted under the 'hedonic scale' measure of 1-7 score points. Data was analyzed win an Excel database spread sheet at $P < 0.05$ level of probability. Percentage carbohydrate decreased with increasing proportion of Okra seed flour, recording 45.50 ± 5.81 for sample XYZ at 75% Okra seed our proportion. The sensory analysis also showed no significant difference at $P < 0.05$ between the means and according to the hedonic scale evaluation, ABC, QPO and RMP composite cakes compared to XYZ, the 100% wheat flour cake were "moderately liked" and "like very much" that is, between 5.3 to 6.6 by the fifteen semi-trained panelist. In effect, Okra seed could serve as a nutrient fortification raw product component and as well, to be accepted by consumers of pastries.

TABLE OF CONTENT

Contents **Page**

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

According to FAO standards (FAO, 2015), suggestion to meet the recommended dietary allowances of infants, preschool children, adolescent girls, pregnant and lactating women, low-cost supplementary foods could be processed domestically by simple inexpensive processing technology. Okra seeds, usually unnoticed when eaten in the immature stage along with the green pod, could become a significant source of protein in many poor countries if harvested after maturity, a University of Rhode Island nutritionist has asserted.

If allowed to ripen on the plant, okra seeds become almost as big as lentils or soyabeans and contain protein that, although of somewhat lower proportion, is equivalent in quality to that of meat or milk. Okra grows on marginal land and in low rainfall regions where other high-protein crops, seldom do well. Okra, which is native to West Africa and widely known under its Bantu name of gumbo, is already grown in many poor countries that eat or export the immature pod.

The term, gumbo is often applied to soups that contain okra pods. “If they would just let the okra pods ripen instead of cutting them off green and then eat the seeds themselves, many of the underdeveloped countries would have more protein,” said Dr. Spiros M. Constantinides, professor of food and nutritional science at the University of Rhode Island. Dr. Constantinides specializes in identifying seldom used sources of protein that can be developed into significant new human foods.

Okra *(Abelmoschus esculentus L.*) is one of the most widely known and utilized species of the family *Malvaceae*. Okra is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. It is mostly grown for its green leaves and pods which is consumed as green vegetable (Naveed *et al.,* 2009). *Abelmoschus esculentus* is known by many local names in different parts of the world. It is known as lady's finger in England, gumbo in the United States of America, guino-gombo in Spanish, guibeiro in Portuguese and bhindi in India (Benchasri, 2012). Okra is suitable for cultivation as a garden crop as well as on large commercial farms (Rubatzky and Yamaguchi, 2007).

Okra fruits are a green capsule containing numerous white seeds when not matured (Jesus *et al.,* 2008) and the flowers and upright plants give okra an ornamental value (Duzyaman, 2007). The okra fruit can be classified based on the shape, angular or circular (Mota *et al.,* 2015). Nutritionally, one hundred grams (100 g) of okra contain moisture 89.6g, minerals 0.7g, protein 1.9g/100g, carbohydrates 6.4g, fat 0.2g, calcium 66 mg, fiber 1.2g, calories 35 potassium 103 mg, phosphorus 56 mg, magnesium 53.0 mg and sodium 6.9 mg (Gopalan *et al.,* 2007). Okra is abundant with several vitamins, minerals that handle the health advantages the plant provides.

Okra *(Abelmoschus esculentus L.*) has traditionally been used as an alternative treatment for diabetes. It is assumed that this effect of okra is due to the presence of large amount of soluble dietary fibers which retard glucose absorption from the gastrointestinal tract. Okra seed is known to be rich in high quality protein especially with regard to its essential amino acids relative to other plant protein sources. Seeds are rich in phenolic compounds with derivatives, catechin oligomers and hydroxycinnamic derivatives (Arapitsas, 2008; Manach *et al.,* 2005; Ngoc *et al.,* 2008).

Dried seed from okra are the richest part of the okra plant, although oil from okra seed is nutritious and significantly rich in protein, it is not only processed for oil or protein as the production of seed is limited to seedling and regeneration purposes. However large quantities of okra seeds are discarded as unfit for seedling purposes (Martin and Ruberte, 2009). A study by (Woodruff, 2007), reported that a high protein meal remains after oil extraction of okra seed similar to that of cotton seed meal. Removal of the okra seed hull from the kernel has not been sufficiently studied. Despite of the high protein and oil contents of okra seed, the potential of the seed as a new source of vegetable protein is yet to be fully exploited in Nigeria due partly to the problem of removal of the okra seed hull from the kernel and also a dearth of knowledge about the effect of variety on the nutritional status.

Therefore, attempts were made in this study to determine the influence of variety on protein and fat contents on different fractions of okra seed. In addition, some physical properties relevant for the dehulling process design were evaluated for the different varieties studied (Oyenuga, 2008). Seeds of mature okra can be roasted, ground and used as a coffee substitute in Turkey. (Calisir *et al.,* 2015). Also Okra seed can be dried, and the dried seeds are a nutritious material that can be used to prepare vegetable curds, (Moekchantuk and Kumar, 2014). The seeds can be a source of antioxidant, which is essential in maintaining health.

Okra seeds contain about 20 to 40% oil. Okra seed flour has huge potential of being used to enrich foods in order to provide adequate nutritional daily needs (Adelakun and Oyelade, 2011). Okra seed is made up of oligomeric catechins (2.5 mg/g of seeds) and flavonol derivatives (3.4 mg/g of seeds), while the mesocarp is mainly composed of hydroxycinnamic and quercetin derivatives (0.2 and 0.3 mg/g of skins). The pods and seeds are rich in phenolic compounds with important biological properties like quartering derivatives, catechin oligomers and hydroxycinnamic derivatives (Arapitsas, 2008). These properties, along with the high content of carbohydrates, proteins, glycol-protein, and other dietary elements enhance the importance of this foodstuff in human diet (Arapitsas, 2008; Manach *et al*., 2015). Okra pods can be consumed in many ways as fresh (raw), dried, cooked, frozen, fried and pickled. Okra also has industrial applications and is used in confectionary (Adetuyi *et al.,* 2011).

According to analyses carried out by Dr. Constantinides and a graduate student, Pavlos Karakoltsidis, okra seeds contain 20 per cent protein, as against 34 per cent for okra seeds. However, the okra is richer in calcium, iron, niacin and vitamin E. One major problem in making use of okra protein is overcoming food habits. Although the flavor of okra seeds when eaten alone is not disagreeable, Dr. Constantinides said, it is different from that of most well-known foods and may inhibit its use. When okra seeds are mixed with bread flour, however, the seeds' flavor is not noticeable. Therefore, this study would assess the proximate composition and consumers acceptability of okro seed flour cake.

1.2 Statement of the Problem

Many Ghanaian citizens are faced with acute economic hardship, resulting to low levels of living, and the lack of knowledge about less expensive but highly nutritional valued food crops, has consequently lead to inadequate intake of high nutritional value foods as well as poor feeding habits. This has therefore become a major challenge to the growth and better development of infants, preschool children, adolescent aged persons as well as lactating women.

Post-harvest losses of most Agricultural produce has become a predominant phenomenon that has devastating consequences on the issue of food security in the country, typically okra seed, which has over the years not been adequately utilized in the nutritional supplement of the Ghanaian populace. There is the need to evaluate and explore alternative uses for dried okra seeds based on the quality attributes. This would ultimately contribute to food and nutrition security.

1.3 Main objective

The main objective is therefore to analyze the fortifying effect of different combinations of okra seed flour in the production of Cakes.

1.3.1 Specific objective(s)

1. To evaluate consumer acceptability of the wheat-okra seed cakes.
2. To determine the proximate composition of different formulae of wheat-okra seed cakes.

1.2 Significance of Study

In tackling the PEM phenomenon while managing the low economic status of the Ghanaian populace, much knowledge about the diversity of use of seeds (Okra seed) in the production of bakery products (Cakes for example) needs to be intensified having realized its affordability and accessibility on the Ghanaian market. The study is therefore targeted at closing this gap of knowledge base of the possibility of producing "Cakes" with okra seed incorporation while evaluating its acceptability.

Also, the use of okra seed flour in the production of Cakes and per its adoptability and/or acceptability to the populace will mean a great deal to reducing the phenomenon of the predominant post-harvest losses that is hitherto realized in the Agriculture sector and with regards to seeds of which okra seed is part.

The mature seed is known to have superior composition of okra seed protein is comparable to that of nutritional quality. Okra seed is known to be rich in high nutrients, the PER is higher than that of soybean and the quality protein especially with regard to its essential amino acid pattern of the protein renders it an adequate amino acids relative to other plant protein sources. Seeds supplement to legume or cereal based diets. Okra seeds flour revealed a predominance of moisture diseases, such as atherosclerosis and cancer. The nutrients includes total carbohydrates (30.81%), protein (22.14%), These beneficial effects have been partly attributed to the oil (14.01%) and crude fiber (27.30%). K, Na, Mg and Ca compounds which possess antioxidant activity. The major were found to be the principal elements, with Fe, Zn, Mn antioxidants of vegetables are vitamins C, E, carotenoids and Ni.

Okra seed flour could also be used to fortify cereal flour. For example, supplementing maize ogi with okra meal increases protein, ash, oil and fiber content. Okra seed flour has been used to supplement corn flour for a very long time in countries like Egypt to make better quality dough. Okra seed flour has been reported to be rich in minerals and vitamins. Its addition to predominantly high -chromanoxy radical.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Taxonomy, Cytology and Botany of Okra

Okra, commonly known as lady finger, is one of the important vegetable crops in India. In world scenario, it occupies the first position in okra production (65.94% of total production) followed by Nigeria. It was sown in 5.04 lacs hectares in India during 2014-15 resulting in a production of 5.7 million metric tonnes. Okra is consumed in the form of its immature finger-like green pods. These green pods are the important constituents of diet in developing countries. Its major nutrients are 2.2% protein, 9.7% carbohydrate and 1.0% fiber. It is also a rich source of vitamin C (30 mg/100 g), calcium (90 mg/100 g) and iron (1.5 mg/100 g) content.

The stems and roots of this vegetable are used to clean cane-juice while making juggary. Because of its high mucilage content, it is beneficial in curing peptic ulcer, reducing the pains and hemorrhoid effects. In an experiment, its mucilage had been used as an alternative to blood plasma. Okra (*Abelmoschus spp.* (L.) Moench) is a dicot, belonging to the order Malvales, family Malvaceae and genus *Abelmoschus* (Schippers, 2010). Okra was previously included in the genus *Hibiscus*. Later, it was designated to *Abelmoschus*, which is distinguished from the genus *Hibiscus* by the characteristics of the calyx; spatulate, with five short teeth, connate to the corolla and caduceus after flowering (Terrell and Winters 2014; Kundu and Biswas, 2013). The section *Abelmoschus* was subsequently proposed to be raised to the rank of distinct genus by Medikus (2017).

The wider use of *Abelmoschus* was subsequently accepted in the taxonomic and contemporary literature. Although about species have been described, eight are most widely accepted (IBPGR, 2010). There is significant variation in chromosome numbers and ploidy levels in *Abelmoschus.* Different authors have variably reported the chromosome number 2n for *Abelmoschus esculentus* L. (Moench). The most frequently observed somatic chromosome number is 2n=130, although Datta and Naug (2018) suggested that the numbers 2n=72, 108, 120, 132 and 144 are in regular series of polyploids with n=12.

This makes the existing taxonomical classifications at the species level in the genus *Abelmoschus* quite unsatisfactory. There was a detailed cytogenetical study on Asian okra and related species, which have provided more evidence of the existence of amphidiploids in the genus (Siemonsma, 2012a). The nomenclature of *Abelmoschus spp* with varied chromosome numbers of both cultivated and wild species of *Abelmoschus* genus as distinctly reported involved most species of the genus. Chromosome number of 2n = 72 has been reported in *Abelmoschus moschatus* for both cultivated and wild type (Chevalier, 2010; Ford, 2018).

Van Borssum-Van Borssum Waalkes (2016) observed 2n = 130-1388 in *A. manihot sub sp tetraphyllus var tetraphyllus* for wild species. Siemonsma (2012a) reported 2n = 138 in *A.manihot sub sp tetraphyllus var pungens* for wild type; Hamon and Yapo (2016) observed 2n = 66-144 for *Abelmoschus esculentus* (cultivated type). Again, Pal *et al.* (2012) recorded 2n = 72-78 in *A. ficulneus* (wild), and 2n = 38 in *A. angulosus* (wild), 2n = 185-198 in *Abelmoschus caillei* (cultivated), and 2n = 58 in *Abelmoschus tuberculatus* (wild type) were recorded by (Singh *et al*., 2015), Joshi *et al*. (2014), and Kuwada (2017) respectively.

From these, okra can be regarded as a polytypic complex (Singh *et al*., 2015) that exhibits both high polyploidy and hybridity of which the parental wild species is yet to be determined. Aladele *et al. (*2008) collected 93 accessions of okra comprising 50 West African genotypes (*Abelmoschus caillei*) and 43 Asian genotypes (*A. esculentus*) and assessed for genetic distinctiveness and relationship using randomly amplified polymorphic DNA (RAPD), and concluded that all the thirteen primers used revealed clear distinction between the two genotypes.

There was more diversity among the Asian genotypes; possibly due to the fact that they were originally collected from six different countries in the region. Six duplicate accessions were discovered while accession TOT7444 distinguished itself from the other two okra species, an indication that it might belong to a different species. This recent study at molecular level emphasises the need for a deeper study into the variable polymorphism at chromosomal level in the genus *Abelmoschus*. Kumar *et al*. (2010) examined the possible outcome of a recombination of these species and their possible contrasting characters after a cross between Asian genotype and the West African genotype. The table below details their findings and observations.

2.2 Environmental Requirements of Okra

Okra is a warm season crop, growing best between the minimum mean temperature of 18°C and a maximum mean of 35°C (Grubben, 2017; Ezeakunne 2014). Okra is sensitive to low temperatures and develops poorly below 15°C (Marsh, 2013). In recent years there has been interest in growing it in heated greenhouses in Northern Europe (Buchholz *et al.,* 2006). It can be grown in a wide range of soil types provided the drainage is good. It is intolerant of wet and poorly drained and acidic soils (Incalcaterra and Curatolo, 2007).

Okra does not do well in tight, water logged soils, but will tolerate a soil pH range from 6.0 to 7.5 (Incalcaterra and Curatolo, 2017). The optimum soil temperature for seed germination is 24°C-32°C (Martin, 2013). Germination is poor at 20°C or below. Short day length stimulates flowering of most cultivars (Martin, 2013). Flowering starts at a very early stage of growth at day lengths of less than 11 hr. under long days, the flower buds tend to abort (Chauhan, 2012). Germination takes 5-14 days (Hamon *et al*., 2011).The vegetable is best eaten just after it has been picked but it can be stored for several days. Okra keeps for 7-10 days if stored at 45°C-50°C and a relative humidity of 90%-95% (Martin, 2013). Okra is very sensitive to ethylene gas, therefore it is not recommended to be stored with vegetables and fruits that give off ethylene gas such as apples and pears (Lutz and Hardenburg, 2016).

2.3 Varieties of Okra Cultivated in Ghana

Abelmoschus esculentus (L.) commonly known as okra is believed to be native to tropical Africa and belongs to the Malvaceae family. It is classified among the semi salt tolerant vegetable crops (Mass and Hoffman 2007). It is the only vegetable crop of economic importance in the Malvaceae family and cultivated throughout the tropics and subtropics (Kochhar 2016; Hammon and van Sloten 2009). In Ghana it is the fourth most popular vegetable after tomatoes, capsicum (peppers) and garden eggs. It is mainly produced for local consumption with a few farmers now producing for the export market in all the ecological zones (Tweneboah, 2018).

According to Sharma and Prassad (2010), the genetic divergence in Okra have widely been based on differences in the number of pods per plant, pod length, pod diameter, days to flowering and plant height. Most okra cultivars produce green pods, but a few varieties are yellow or dark in colour (Kumar, 2016). In Ghana okra accessions that have been chiefly cultivated are *Asontem, Fetri, Dikaba, Aisha*, and *Nkrumahene* (Oppong-Sekyere, 2012).

2.4 Okra Production

Okra (*Abelmoschus esculentus L.)* is a plant of the Malvacae family cultivated for its immature pods. The crop is grown in many tropical, sub-tropical and warm temperate regions around the world. The top ten major okra producing countries in the world are India, Nigeria, Iraq, Cote d'Ivoire, Pakistan, Egypt, Benin, Cameroon, Ghana and Saudi Arabia (Oyelade *et al.,* 2013; FAOSTAT, 2012). This vegetable is an important part of the diet of Africans and Indians as well as of other countries with the worldwide production of okra estimated to be close to 7 million Mt whereas that of Ghana alone is about 60,000 Mt (FAOSTAT, 2012).

The vegetable is known by several names in West and Central Africa and some of these names are Gombo (French), Miyan-gro (Hausa), La (Djerma), Layre (Fulani), Gan (Bambara), Kandia (Manding), Nkruma (Akan) and Fetri (Ewe) (Negi and Mitra, 2009). In Ghana, Brong Ahafo, Ashanti, Northern, Volta, Greater Accra and Central regions are the largest producers of okra (NARP, 2013). Okra has a huge potential as one of the foreign exchange earning crops and accounts for about 60% of the export of fresh vegetables excluding potato, onion and garlic in India (Kalloo, 2018).

In Nigeria, this vegetable is specially valued in different parts of the country for its delicious fruits and it is consumed alone or in combination with other foods. Okra reached the new world by the way of Brazil and Dutch Guinea. African slaves brought okra to North America by way of New Orleans (Bish *et al*., 2015 and Hamon *et al*., 2010). The crop is grown in many parts of the world, especially in tropical and sub-tropical countries (Kumar *et al.,* 2010; Saifullah and Rabbani 2009).

It is grown on a large scale in Africa, especially in Nigeria, Egypt, Ghana and Sudan, (Joshi *et al*., 2014). It is also very important in other tropical areas including Asia, Central and South America (FAOSTAT, 2008; Joshi *et al*., 2014). There are a number of species, both wild and cultivated. Some of these are *A. esculentus*, *A. caillei*, *A. moschatus*, *A. manihot*, *A. ficulneus* and *A. tetraphyllus*. Two main species in the genus *Abelmoschus* are cultivated; A. *manihot* L. and A. *moschatus* L. (Siemonsma, 2011 and Stevels, 2018). Okra is an amphidiploid-having a complete diploid set of chromosomes derived from each parent form (Siemonsma, 2012a) with varieties displaying a tremendous variation in plant size, shape, fruit type and colour.

Okra plant is a semi-woody, fibrous herbaceous annual with an indeterminate growth habit (Nonnecke, 2009). The plant forms a deeply penetrating taproot with dense shallow feeder roots reaching out in all direction in the upper 45 cm of the soil. The stems reach heights from 3 m in dwarf varieties to 7 m to 8 m in others (Anonymous, 2010). The seeds are dicotyledonous and they vary in shape, which is either round, kidney or spherical with epigeal germination (Ariyo, 2013; Hamon *et al., 20*11). The monoic flowers of okra are self-compatible (Hamon *et al*., 2010; Martin, 2013).

The leaves are dark green in colour (Kumar *et al.,* 2010). About 35-60 days after emergence, the plant begins to flower. The flowers are axillary and solitary, borne on a peduncle 2.0 – 2.5 cm long within the leaf axil (Valeriana, 2011). The flower usually remains open for a day. It is mostly self-fertilized; however, insects such as honeybees and bumble bees can crosspollinate. Okra is self-compatible, and passive self-pollination can take place in its hermaphrodite flowers (Al-Ghzawi *et al*., 2013). Its pollen grains are very large and echinate, 156 μm in diameter with spines over 20 μm in length (Vaissière and Vinson, 1994) so that pollination with both self-pollen and crosspollen is possibly achieved by insects (Al-Ghzawi *et al*., 2013; Hamon and Koechliu, 2011).

Anthesis takes place at dawn, and the flower remains open all morning and closes by noon or early afternoon. Cross pollination can occur in okra up to a maximum of 42.2% (Mitidieri and Vencovsky, 2014). The extent of cross-pollination in a particular place will depend upon the cultivar, competitive flora, insect population and season. (Al Ghzawi *et al.,* 2003) reported that, no significant differences were found between insect and self-pollinated plants for the number of flowers. Immature fruits of 8-9 cm long are ready for harvest 4-6 days after anthesis. Harvesting is recommended at least every other day for size and quality (Ramu, 2016).

About 35-40 days are required from anthesis to seed maturity. If fruits are allowed to mature, plant growth declines and few flowers develop, but with continuous harvesting, the plant continues to set fruit (Norman, 2012). Mature fruits should be removed and discarded as they reduce the plant growth and decrease yield (Ramu, 2016). The rate of allogamy differs according to type of variety and ecological conditions (Hamon *et al*., 2011). When ripe the fruit becomes fibrous and splits longitudinally in five parts, showing 5 rows of seeds, with 50 – 100 seeds per fruit (Norman, 2012). Okra has alternate, palmate broad leaves and the flowers have five large yellow petals with a large purple area covering the base.

The fruits, which are harvested immature, are pale green, green, or purplish and in many cultivars are ridged (Hamon *et al*., 2010). When mature, they are dark brown dehiscent or indehiscent capsules. Fruit shapes range from round to ridged and short to long (Siemonsma, 2012). The plant and fruits may have small spines on them that create allergies in some people (Ariyo, 2013; Düzyaman, 2017). Okra has several uses which include nutritional, economic and industrial. The nutritive value of okra comprises carbohydrate, protein, fat, iron, calcium, fibre, thiamine, nicotinamide, riboflavin, and ascorbic acid (Fajinmi and Fajinmi, 2010).

Mature seeds of 100 g okra contain 20% edible oil and 20.23% crude protein due to high lysine content and it is a good source of vitamin C (Berry *et al*., 2018; Siemonsma and Kouame, 2014). Okra seed oil is rich in unsaturated fatty acids such as linoleic acid (Savello *et al*., 2010), which is essential for human nutrition.Okra seeds are used as a substitute or additive in feed compounds (Purseglove, 2014). Dried okra seeds, can be used to prepare vegetable curds, or roasted and ground and used as coffee additive or substitute (Moekchantuk and Kumar, 2014).

The pods contain a mucilaginous substance which is used as plasma replacement or blood volume expander (Onunkun, 2012; Siemonsma and Kouame, 2004). It has also been reported to cure ulcers and relief pain from haemorrhoids (Adams, 2015). The roots can be used to cure syphilis (FAO, 2018). Okra is a very important soup condiment that is consumed daily in almost all homes and restaurants.

The tender pods of okra are used in stews or cut into slices, sun dried and then ground as a powder and used as a favourite Sudanese dish called "Weika" (Abdelmageed, 2010). Similarly, the older immature pods and leaves that are yet to develop fiber are also cut into slices, sun dried and ground and used in soups in the dry season when fresh fruits are scarce (Oppong-Sekyere, 2011; Siemonsma and Kouame, 2014). The mature fruit and stem of okra contain crude fibre which is used in the paper industry. Industrially, okra mucilage is usually used to glace certain papers and also useful in confectionery among other uses such as bioabsorbent (Kumar *et al.,* 2010; Adetuyi *et al.,* 2008; Savello *et al., 20*10).

2.5 West African Okra

The West African okra is photoperiod sensitive (short day) and cultivated primarily for its fresh pods and leaves. Nutritionally, okra pods contain 88 ml water, 2.1 g protein, 0.2g fat, 8g carbohydrate and 332.72mg vitamins in 100 g of edible portion (Berry *et al., 20*18). Genetic studies in West African okra are limited. There is the existence of genetic diversity in West African okra accessions as reported by (Ariyo, 2013).

Studies conducted by (Adeniji, 2013) and (Adewusi, 2011) indicated that West African okra are either pigmented or non-pigmented; pubescent or glabrous and arranged in vertical or horizontal direction. Heritability of metric characters has been identified as a genetic relationship between the parents and the offspring. These genetic components have been widely used to assess the degree to which a character is transmitted from parent to the offspring. Information on heritability could as well indicate the possibility and extent to which improvement in a character is possible.

More often in biological research, broad and narrow sense heritability is used to evaluate the proportion of heredity and environment in the expression of a character. In West African okra, high narrow sense heritability has been reported for pod length, pod width, plant height and number of seeds per pod (Adeniji, 2013). West African okra pods are consumed fresh (a maximum of 7 days after anthesis) obviously a high number of pods per plant are a desirable characteristic for genetic improvement in West African okra. West African okra (*A. caillei*), accounts for about 5% of the total world production of the crop (Siemonsma and Kouame, 2014) and very important in tropical areas of Benin, Cote d'Ivoire, Ghana, Cameroon, Nigeria and Togo.

It is also identified as an amphipolyploid species (Siemonsma, 2012) known for possessing a gene pool of variations that may be useful for okra improvement of both temperate and tropical types (Martin *et al., 20*13). *A. caillei* is gradually replacing common okra in the tropical-humid region because of its better adaptation under humid zone and tolerance to biotic stresses (Siemonsma, 2012). Indeed, under very limited and erratic rainfall in the Sudano-Sahel, earliness of *A. esculentus* (being amphidiploid) was compared with *A. caillei* (being amphipolyploid) and *A. caillei was* preferred during early domestication. In Asia, *A. caillei* has been utilized as a resistant source to breed yellow vein mosaic virus resistant common okra variety (Nerkar and Jambhale, 2015).

The inter-specific cross between *A. caillei* and *A. esculentus* is successful with the possibility of gene transfer, although partial hybrid breakdown barrier must be overcome (Fatokun, 2017). The study on geographical distribution and extent of natural outcrossing in Benin and Togo suggests that genetic integrity of these two species is not threatened (Hamon and Hamon, 2011).

2.6 Nutritional and Health Benefits of Okra

The Okra crop is of significant nutritional value. It contains a high percentage of water, averaging 85%, total fat of 0.5%, protein content of 4% and 5.4% carbohydrate. The carbohydrate is present as cellulose, starch in small quantity and sugar. It also contains non-cellulose, non-starch, polysaccharides (Fellows, 2010). Proteins play a particularly important role in human nutrition. According to Kouassi *et al*., (2013), in the region of Yamoussoukro, two varieties of okra are the most cultivated. These are *Dioula* and *Baoule* varieties.

Both varieties are rich in (Iron, Calcium, Copper and Zinc.) Beyond that they also contain significant levels of (magnesium, potassium, sodium and manganese) (Kouassi *et al*., 2013). Okra is used to promote a healthy life in pregnancy. An incredibly essential B vitamin for creating and maintaining new cells, foliate is a vital substance for optimum pregnancy. The vitamin aids in preventing birth defects just like spina bifida and enables the baby to develop completely. Vitamin C is additionally required for baby development. Okra is full of both foliate and vitamin C.

The high quantity of foliate included in the okra is helpful for the fetus while pregnant. Foliate is a vital nutrient that increases the growth and development of the fetus' brain. The high quantity of folic acid within okra performs a huge role within the neural tube formation of the fetus through the fourth to the 12th week of pregnancy (Zaharuddin *et al*., 2014). It has many medicinal applications such as stabilising the blood sugar, binding excess cholesterol, replenishing sodium in the body and as anti-oxidants among others (Adeboye and Oputa, 2016; Junji, 2014).

Studies have shown that high fiber present in okra aids in the reduction of serum cholesterol thereby decreasing the risk of cardio related issues (Ngoc *et al*., 2008). Okra is an oligo purpose crop due to its various uses of the fresh leaves, buds, flowers, pods, stems and seeds (Mihretu *et al.,* 2014). Okra is a very good source of calcium and potassium. Polysaccharides in okra lowers cholesterol level in blood and may prevent cancer by its ability to bind bile acids (Kahlon *et al.,* 2007). Okra is rich in foliate which are helpful for the fetus while pregnant.

Foliate is a vital nutrient that increases the growth and development of the fetus' brain. The high quantity of folic acid within okra performs a huge role within the neural tube formation of the fetus through the fourth to the 12th week of pregnancy (Zaharuddin *et al.,* 2014). Additionally, okra contains pectin that can help in reducing high blood cholesterol simply by modifying the creation of bile within the intestines ((Ngoc *et al.,* 2008). It is high in fiber, which helps to stabilize blood sugar by regulating the rate at which sugar is absorbed from the intestinal tract.

Okra is also high in iodine which is considered useful for the control of goiter. Okra is also used in folk medicine as antiulcerogenic, gastroprotective, diuretic agents in some countries (Gurbuz, 2013). Regular consumption of okra can improve heart health and the body's cholesterol level. The polysaccharides present in immature okra pods possessed considerable anti-adhesive properties (i.e. they help remove the adhesive between bacteria and stomach tissue, preventing the cultures from spreading).

The okra pods contains substantial amount of Vitamin A and also beta carotene that are both important nourishment for sustaining an excellent eye-sight along with healthy skin (Lengsfeld *et al.,* 2014). According to (Liu *et al.,* 2015), tests conducted in China suggest that an alcohol extract of okra leaves can eliminate oxygen free radicals, alleviate renal tubular-interstitial diseases, reduce proteinuria, and improve renal function. Also, Okra seed has blood glucose normalization and lipid profiles lowering action in diabetic condition (Sabitha *et al.,* 2011).

Okra leaves are used for the preparation of medicine to reduce inflammation. Okra can also be used to treat digestive issues. The polysaccharides that are present in immature okra pods contain considerable antiadhesive properties (i.e. they help remove the adhesive between bacteria and stomach tissue, preventing the cultures from spreading). Okra's polysaccharides were particularly effective at inhibiting the adhesion of Helicobacter pylori, a bacterium that dwells in the stomach and can cause gastritis and gastric ulcers if left unchecked.

Therefore, eating more okra can keep our stomach clean and create an environment that prevents destructive cultures from flourishing (Messing *et al.,* 2014). Okra is used to support colon health. It smoothly sails down our colon, absorbing all toxins and excess water in its path. Okra is filled with dietary fiber that is required for colon health and digestive health all together. The Okra fiber helps to cleanse the intestinal system, letting the colon to operate at higher amount of effectiveness.

In addition, the vitamin A plays a role in wholesome mucous membranes, which assists the digestive system to function adequately (Georgiadisa *et al.,* 2011). The okra fruit is a reservoir of important and valuable nutrients (Sanjeet, et al., 2010). nearly half of which is soluble fibre in the form of gums and pectins. Soluble fibre helps to lower serum cholesterol and reducing the risk of heart disease ((Sanjeet, et al., 2010). The other half is insoluble fibre which helps to keep the intestinal tract healthy, decreasing the risk of some forms of cancer, especially colorectal cancer (Sanjeet, et al., 2010).

About 10% of the recommended levels of vitamin B6 and folic acid are also present in a half cup of cooked okra (Hamon and Charrier. 2017). Okra has several health benefits, as it is rich in vitamin A, thiamin, vitamin B6, vitamin C, folic acid, riboflavin, calcium, zinc and dietary fibre (Sanjeet, et al., 2010). Okra is recommended for pregnant women, as it is rich in folic acid, which is essential in the neural tube formation of the foetus between the 4th and 12th weeks of pregnancy (Allen, 2007). It is rich in amino acids, with the likes of tryptophan, cystine and other sulphur amino acids.

It is the ideal vegetable for weight loss and is a storehouse of health benefits, provided it is cooked over low flame to retain its properties (Hamon and Charrier., 2007). Justo (2011) reported that, a 100 g edible portion of okra fruit contains 90 g water, 2 g protein, 1 g fibre and 7 g carbohydrates. Its energy value is 145 kJ/100 g and it is a good source of vitamins and minerals. It is also very rich in calcium (70-90 mg/100 g). Therefore, the consumption of okra plays an important role in human nutrition.

2.7 Other Uses of Okra

Non-food applications include use of the root and stem of okra for cleaning the cane juice from which Jaggary (brown sugar) is prepared (Chauhan, 2012). Mature fruits and stems containing crude fiber are used in the paper industry (Martin, 2012). It can also be used for biogas and fuel (Dahiya and Vasudevan, 2007). Okra is used as brightening agents in electro deposition of metals, as a deflocculant in paper and fabric production, and as a protectant to reduce friction in pipe-flow (Ndjouenkeu *et al., 20*16).

2.8 Okra Oil and Nutritional Composition

Okra seed oil is rich (60 to 70%) in unsaturated fatty acids (Savello *et al*., 2010). The proteins present in the seed have also been found to be rich in tryptophan (94 mg/g N) and also some amounts of sulfur-containing amino acid (189 mg/g N) (NAP, 2006). Okra seed protein with good protein efficiency ratio (PER) and net protein utilization (NPU) values is comparable to many cereals (except wheat) and its oil yield is comparable to most oil seed crops except oil palm and soybean (Rao, 2015). Moreover, okra seed oil has potential hypocholesterolemic effect (Rao *et al*., 2011).

2.9 Diversified Uses of Okra

Okra pods are rich in phenolic materials mostly of oligomeric catechins and flavonol derivatives, while the polyphenol profile of the epidermis is composed principally by hydroxycinnamic and quercetin derivatives (Arapitsas, 2008). The thick and slimy texture of okra water-extracts is attributed to its polysaccharide content and is of primary technological interest for various food applications (Whistler and BeMiller, 2013). The dried seed is a nutritious material that can be used to prepare vegetable curds, or roasted and ground to be used as coffee additive or substitute (Farinde *et al.*, 2011).

Tender green fruits are cooked in curry and soup, while the crop has adapted in some countries as leafy vegetable. Okra leaves may be cooked as the green.The leaves are also eaten raw in salads. Okra seeds may be roasted and ground to form a non-caffeinated substitute for coffee. In the U.S., Mexico and Japan, the young fruiting pods are the edible portion, while young leaves and mature seeds may be consumed in other countries (Duzyaman, and Vural, 2012).

The use of okra is not only restricted to the area of food. In the pharmaceutical industry, okra mucilage has been explored as a potential binder for the preparation of tablet formulation (Biswal *et al*., 2014). In the case of paper industry, the mature fruit, stem and roots are used for making ropes, fiber and are used as raw materials (Jideani and Adetula, 2013).

2.10 Okra, Pectin and Pectin Composition

Pectin, a complex mixture of polysaccharides occurring in the primary cell walls of terrestrial plants, is an important functional ingredient in many foods. It consists of a linear backbone of - (1-4)-D-galacturonic acid residues partially esterified with methanol, with periodic interruptions to L-rhamnose residues that make the backbone irregular and with some other neutral sugars present as side chains. The general makeup of the pectin content varies with the ripening of the fruit (Wilkins *et al.,* 2015). Pectin is produced commercially in the form of white to light brown powder, mainly extracted from citrus fruits and is used in food as a gelling agent particularly in jams and jellies.

It is also used in fillings, sweets, as a stabilizer in fruit juices and milk drinks and as a source of dietary fiber (Tobias *et al*., 2011). Okra contains large quantities of glycans, which are responsible for the viscosity of the aqueous suspension (Owoeye *et al., 20*10). Industrially, okra mucilage is usually used to glace certain papers and also useful in confectionery among other uses (Owoeye *et al., 20*10). Several studies have reported novel pectin usages, like biodegradable water-soluble films, bulking agents, coating agents, chelators, emulsifiers and viscosity modifiers (Kanmani *et al*., 2014).

Although pectin has long been associated with citrus fruits, it can be found in different varieties of fruits and vegetables. Thus, not only does pectin exist as a structural form of just citrus fruits but equally non-citrus fruits and vegetables in nature. According to Krishnamurthi and Giri (2013), the amount, structure and chemical composition of the pectin differs between plants, within a plant over time and in different parts of a single plant. Though Pectin occurs commonly in most of the plant tissues, the number of sources that may be used for commercial manufacture of pectin is limited. This is because the ability of pectin to form a gel depends on molecular size and the degree of esterification (DE) (Kanmani *et al*., 2014). Many investigators have studied the influence of different parameters on the pectin extraction from different sources.

2.11 Economic Importance of Okra

Okra (*Abelmoschus esculentus* (L) Moench) is an annual crop, which requires warm conditions for growth and is available in almost every market all over Africa (Kanmani *et al*., 2014). It is grown purposely for its leaves and young pods which are frequently eaten green as vegetable. Okra leaves are considered good cattle feed, but this is seldom compatible with the primary use of the plant. Okra mucilage is suitable for medicinal and industrial applications.

In the medical field, the mucilage is used as a plasma replacement or blood volume expander. Industrially, okra mucilage is usually used to glace certain papers and is also useful in confectionery among other uses (Farinde *et al.,* 2007). Worldwide production of okra as fruit vegetable was estimated at 6,000,000 tons per year. In West Africa, it was estimated at 500,000 to 600,000 tons per year (Burkill, 2007). Burkill, (2007), observed a great diversification of okra with the most important production regions localized in Ghana, Burkina Faso and Nigeria.

The West and Central Africa region accounts for more than 75% of okra produced in Africa, but the average productivity in the region is very low (2.5 t/ha) compared to East Africa (6.2 t/ha) and North Africa (8.8 t/ha) (FAOSTAT, 2006). Nigeria is the largest producer (1,039,000 t) followed by Cote d'Ivoire, Ghana and others (FAOSTAT, 2008). The three most important vegetables grown by 28% of the rural poor in Ghana include pepper tomato and okra (Diao, 2010).

According to Oppong-Sekyere *et al.* (2011), fresh okra is a vegetable that can be found in almost all markets in Ghana, during the rainy season and in a dehydrated form during the dry season, particularly in Northern Ghana due to its strong commercial value for poor women farmers and its importance as food in the diets of the inhabitants of the cities and villages.

2.12 Seed as Potential Edible oil and Flour Source

Okra seed oil is rich (60 to 70%) in unsaturated fatty acids (Rao, 2015; Savello *et al., 20*10). The seed protein is rich in tryptophan (94 mg/g N) and also contains adequate amounts of sulphur-containing amino acids (189 mg/g N). This rare combination makes okra seeds remarkably useful in reducing human malnutrition (NAP, 2006). Okra seed protein with good protein efficiency ratio (PER) and net protein utilization (NPU) values is comparable to many cereals (except wheat) and its oil yield is comparable to most oil seed crops except oil palm and soybean (Rao, 2015).

Moreover, okra seed oil has potential hypocholesterolemic effect (Rao *et al., 20*11). The potential for wide cultivation of okra for edible oil as well as for cake is very high (Rao, 2015). Okra seed flour could also be used to fortify cereal flour (Adelakun *et al.,* 2008). Okra seed flour has been used to supplement corn flour for a very long time in countries like Egypt to make better quality dough (Taha El-Katib, 2017).

2.13 Drying as a processing method

Drying is a heat and mass transfer process resulting in the removal of water moisture, by evaporation from a solid, semi-solid or liquid to end in a solid state. The drying technique is probably the oldest and the most important method of food preservation practiced by humans (Mujumdar, 2015). Most of the time the main goal in drying farm produce is to reduce the moisture content to a level which allows safe storage for a period. Under different processes, it simply becomes a pre-requisite to obtaining the desired product from an agricultural produce such as in the case of pectin extraction.

During drying many changes take place; structural and physico-chemical modifications affect the final product quality, and the quality aspects involved in dry conversion in relation to the quality of fresh products and applied drying techniques (Wankhade *et al*., 2012). Thus different drying techniques are likely to yield dried products whose characteristics can be completely different from each other. All over Ivory Coast, okra represents 24% of the vegetables consumed fresh and 41% of vegetables consumed dried (Siemonsma, 2012).

Indeed, to preserve the large-scale production (FAOSTAT, 2008), the producer and or consumer conducts its drying sliced then left untouched or powdered. The drying can be done in different forms. This include solar drying, freeze-drying, and oven drying techniques. Freeze drying is the process of dehydrating frozen foods under a vacuum so that the moisture content changes directly from solid to a gaseous form without having to undergo the intermediate liquid state through sublimation and desorption.

The process is used for drying and preserves the food product in a way that the dried product remains the same size and shape as the original frozen material and will be found to have excellent stability and convenient reconstitution when placed in water (Alexandraki *et al*., 2013). Most works including recent works (Eze and Akubor, 2012; Doymaz , 2011) conducted have centered on the relationship between drying techniques and nutrients, organoleptic properties as well as the optimization of the drying technique on okra pods but not on the pectin yield.

2.14 Okra Seeds

The okra fruit contains numerous oval, smooth, striated and dark green to dark brown seeds. Okra seeds are tiny in size and the fibrous seed coat contains high amount of crude fiber. They are power house of nutrients. Okra seeds can be dried, and the dried seeds are very nutritious and can be used to prepare vegetable curds, or roasted and ground to be used as coffee additive or substitute (Agbo *et al.,* 2008).

Nutritionally, the richest part of okra plants is the dried seed (Adelakun *et al.,* 2009) as it is very rich in protein, oil and antioxidant. Okra seeds are rich in unsaturated fatty acids such as linoleic acid (Savallo *et al., 20*10). Fiber of okra seeds is an important nutrient for intestine microorganisms. Seed mucilage of okra may be responsible for getting rid toxic substances and bad cholesterol which loads the liver.

2.15 Okra Seed Flour

Okra seed flour has been reported to be rich in minerals and vitamins and to enrich such foods with vital nutrients in addition to high carbohydrates (Oyelade

et al., 2013). Okra seed flour has been used for a very long time to complement wheat in countries like Egypt to produce better quality dough (Kumar et al., 2010). The chemical composition of okra seed flour has shown a predominance of moisture (6.96%), total carbohydrates (30.81%), protein (22.14%), oil (14.01%) and crude fiber (27.30%) (Moyin-Jesu, 2007).

2.16 Functional Properties of Flours

Functional property as applied to food ingredients can be defined as any property, aside its nutritional attributes, and that influences the ingredient's usefulness in food. Functional properties play a key role in the way foods or food ingredients behaves during their preparation, processing, or storage (Fennema, 2015).

2.16.1 Bulk density

Bulk density can be defined as the weight of many particles of a material or product divided by the total volume they occupy; it is a reflection of the load a sample would carry if allowed to sit directly on top of one another. (Ikpeme *et al.* 2010) looked at the difference between loose bulk density and packed bulk density, the minute differences according to them shows that the incorporation of taro did not cause a significant decrease in bulk densities of flour blends.

They also pointed out that smaller bulk densities are more desirable as they imply the sample would pack better during storage or distribution. High bulk density is a good physical attribute when determining the mixing quality of a particular product. Edema *et al*. (2015) discovered that their values for bulk density were generally lower (between 0.38 g/ml for commercially sold soybean flour and 0.55 g/ml for Maize soya blend) than those values obtained by (Amarjeet *et al*., 2013) for durum wheat blends (0.80 to 0.82). (Butt and Batool, 2010) also reported that the defatting process resulted in very porous texture of the defatted product that can be attributed to low bulk density. This would be an advantage in the formulation of complementary foods (Akpata and Akubor, 2009).

2.16.2 Water and oil absorption capacity

Soaking up of water is an important functional quality in foods such as sausages, custards and doughs. Oil absorption capacity is important in structure interaction in food especially in flavour retention, improvement of palatability and the extension of shelf life particularly in bakery or meat products (Adebowal & Lawal, 2014). Proteins are solely responsible for the bulk of the water uptake and to a minor extent the starch and cellulose at room temperature (Afoakwa, 2016). According to (Ikpeme *et al.* 2010) their result shows that indeed addition of taro flour affected the water absorption. In their case the taro starch actually slowed the absorption of water as the 90:10 wheat: taro blend had the highest absorption of water.

Importance of oil absorption is that oil acts as a flavour retainer and helps to increase the mouth feel of food. Protein is the main chemical component that affects the oil absorption capacity because it is composed of both hydrophilic and hydrophobic parts. Non polar amino acid side chain can form hydrophobic interactions with hydrocarbon chains of lipid (Jitngarmkusol *et al.,* 2008).

2.16.3 Swelling Volume Power and Solubility

Swelling power can be defined as a sedimented gel's wet mass divided by its dry weight (Leach et al., 2009). Temperature depends on the swelling power and solubility of the flour and starch (Loos et al. 2011). Swelling volume is the relation between sedimented gel and starch dry mass. Solubility is the percentage of starch that has leached into the supernatant when determining the volume of swelling (Singh et al., 2015).

2.16.4 Moisture content

For certain purposes, the moisture content of flour is crucial; the higher the moisture content, the lower the amount of dry solids in the flour and even flours with higher moisture content above 14 per cent are susceptible to microbial spoilage. A research found that meal with low moisture content had the highest resistance when stored to fungal growth and plague infestation (Nasir et al., 2013).

2.17 Conclusion

For its tender pods, which are used as a very common, tasty and gelatinous vegetable, the okra crop is widely cultivated. It is a powerhouse of nutrients worthy of value. Its fruit has a high content of vitamins, calcium, potassium and other minerals (Camciuc et al., 2011). The mature okra seed is a good source of oil and protein (Oyelade et al., 2003; Martin and Ruberte, 2019) and its nutritional quality has been known to be superior. Okra seed oil is rich in unsaturated fatty acids such as linoleic acid, which is important for human nutrition (Savello et al., 2010). Its mature fruits and stems contain crude fibre, used in the paper sector.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Materials

3.1.1 Sources of Raw Materials and Reagents

The okro was purchased at Offinso market and all agricultural practices including thinning; weed control and watering were carried out under controlled environmental conditions. All chemicals used were analytical grade reagents.

3.1.2 Preparation of Okra Seed Flour

Throughout the okra, contaminated and other debris were released. They have been washed out with water and cut open to extract seeds by a knife. The seeds were dried for 7 hours then by the sun. Packaged in zip-lock bags and placed in a freezer (Protech PRCF-500, China) for further analyzes, the sun-dried seeds were ground to 450 mg of polished matter powder.

A flowchart on the preparation of okra seed flour is shown in Figure 3.1.

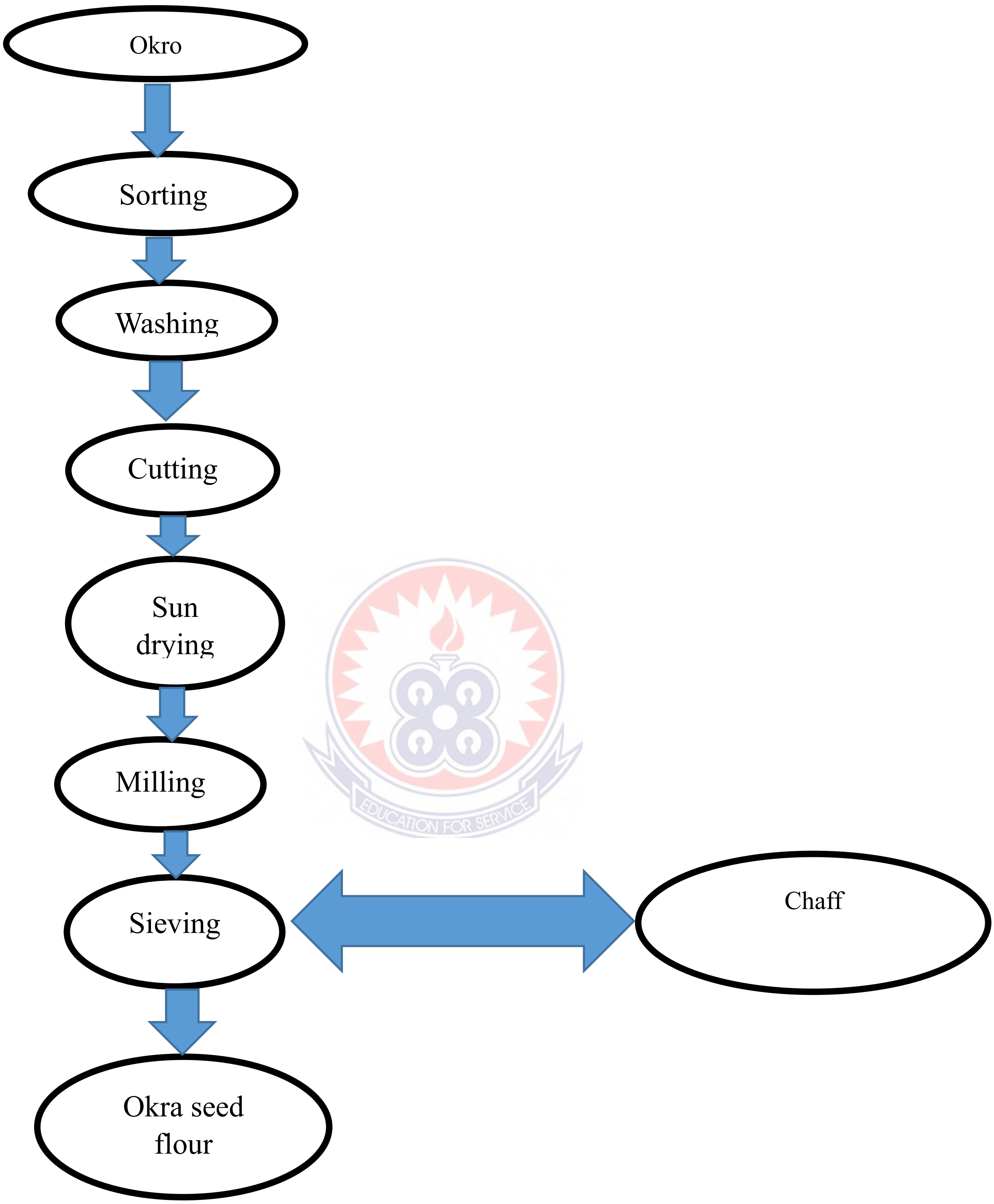


Figure 3.1: Flowchart on preparation of okra seed flour.

3.2 Methods

3.2.1 Proximate Composition

Samples of four (4) Test Treatments with labels; XYZ, ABC, QPO and RMP including the Control Sample (pure sample of wheat flour) were used and per the various percentage incorporation of both wheat flour and soybean flour as well as the other ingredients are shown in the Table 3.1 below;

Table 3.1: Formulations of full wheat and composite cakes

Product	Flour (%)		Margarine (g)	Sugar (g)	Egg	Baking powder (g)
	WF%	SF%			(1 large)	
XYZ	100	0	75	75	1 large	5
ABC	80	20	75	75	1 large	5
QPO	75	25	75	75	1 large	5
RMP	25	75	75	75	1 large	5

***XYZ = Control (100% WF) *ABC = (80% WF: 20% SF) *QPO= (75% WF: 25% SF) *RMP = (25% WF: 75% SF); WF = Wheat flour SF = Okra seed flour**

3.3. Statistical Analysis

Analysis of variance (ANOVA) was performed in the SPSS (Version 21), based on the findings obtained from experiments. In order to detect major variations between samples, two different sample tests were used for medium comparison. At the 5 percent probability level ($p<0.05$), statistical significance was accepted.

CHAPTER FOUR

RESULTS AND DISCUSSION

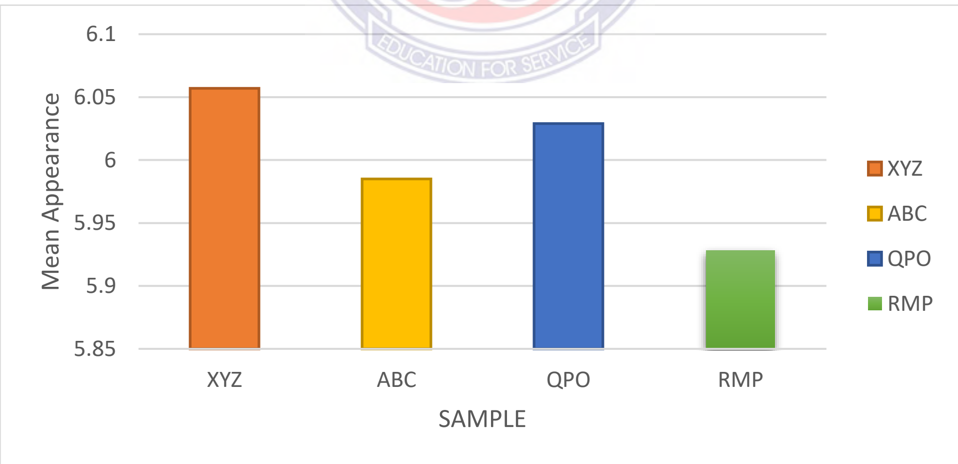
4.0 Introduction

The main objective was to analyze the fortifying effect of different combinations of okra seed flour in the production of Cakes. The analysis of the study was based on the following research objectives to determine the proximate composition of different formulae of wheat-okra seed cakes and to evaluate consumer acceptability of the wheat-okra seed cakes.

Figure 4.1 Mean values of the okra flour samples

The mean values of the samples XYZ, ABC, QPD and RMP were recorded and analysed below.

Mean appearance of Okra seed flour cake samples



The sample which recorded the highest mean appearance was sample XYZ (6.05), sample QPO (6.02) was the second highest with sample RMP (5.92) having the minimum mean texture Comparing the appearance of the samples, there was no significant difference between them with a p-value of 0.87.

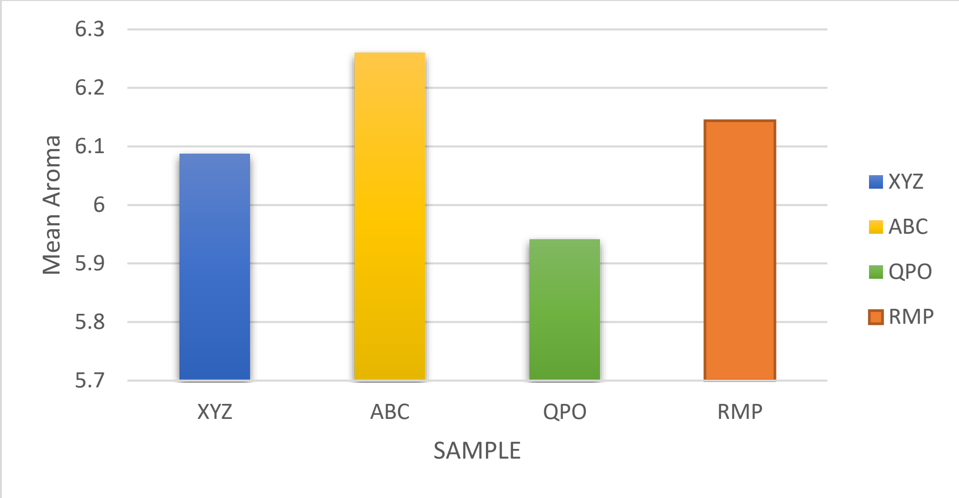


Figure 4.2: Mean aroma of okra seed flour cake samples

The sample which recorded the highest mean aroma was sample ABC (6.26), sample RMP (6.14) was the second highest with sample QPO (5.94) having the minimum mean aroma. Comparing the aroma of the samples, there was no significant difference between them with a p-value of 0.22.

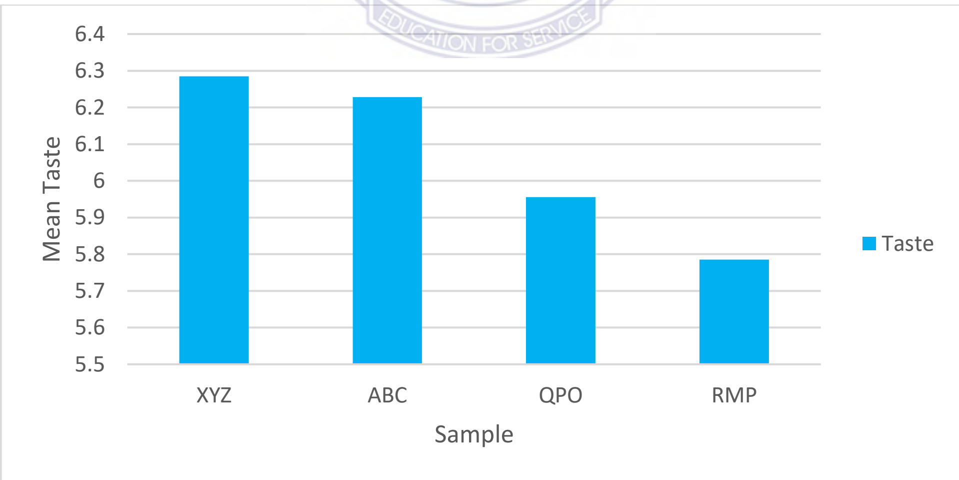


Figure 4.3: Mean taste of okra seed flour cake samples

The sample which recorded the highest mean taste was sample XYZ (6.28), sample ABC (6.22) was the second highest with sample RMP (5.78) having the minimum mean aroma. Comparing the aroma of the samples, there was no significant difference between sample XYZ and ABC, as well as sample XYZ and QPO them with a p-value of 0.98 and 0.22 respectively. However, there was a significant difference between the mean taste of sample XYZ and RMP with a p-value of 0.01 which is less than the α-value of 0.05 Also the was no significant difference between the taste of sample ABC and QPO with a p-value of 0.38, but there was a significant difference between the taste of sample ABC and RMP with a p-value of 0.04.

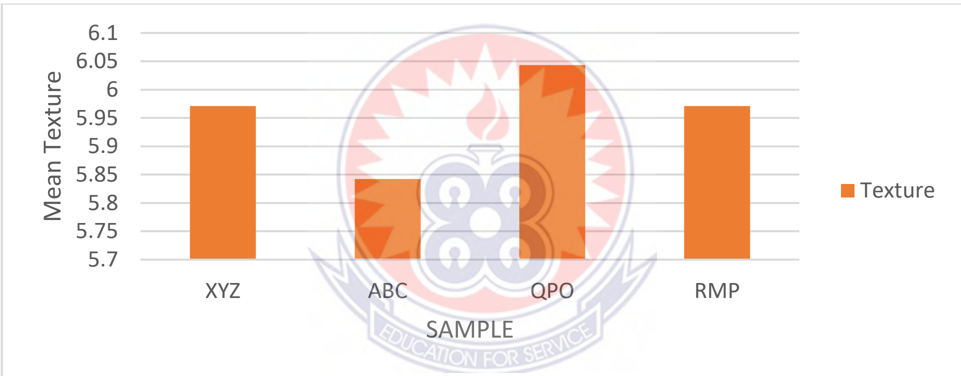


Figure 4.4: Mean texture of okra seed flour cake samples

The sample which recorded the highest mean texture was sample QPO (6.04), sample XYZ (5.97) was the second highest with sample ABC (5.85) having the minimum mean texture Comparing the texture of the samples, there was no significant difference between them with a p-value of 0.71.

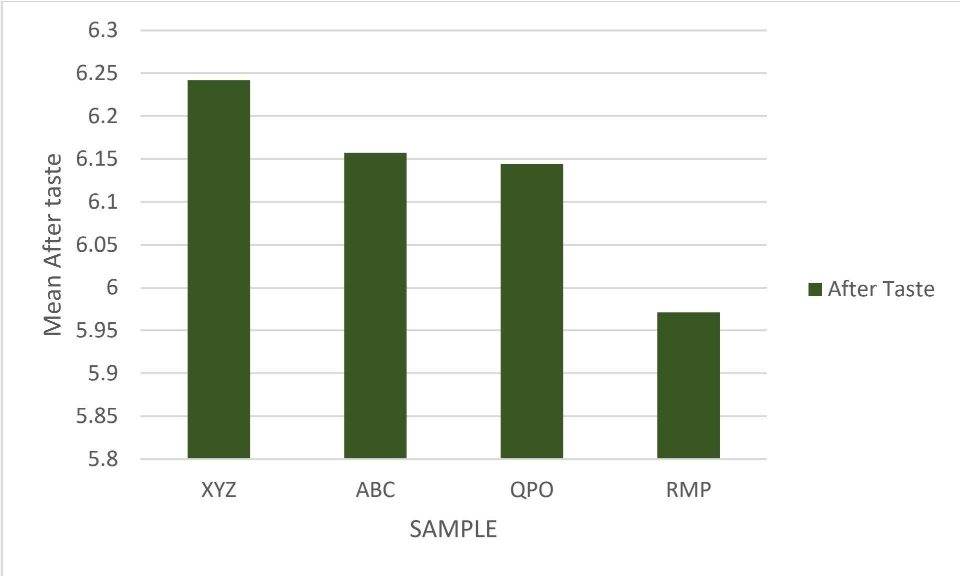


Figure 4.5: Mean after taste of okra seed flour cake samples

The sample which recorded the highest mean after taste was sample XYZ (6.24), sample ABC (6.15) was the second highest with sample RMP (5.85) having the minimum mean after taste. Comparing the after taste of the samples, there was no significant difference between them with a p-value of 0.42.

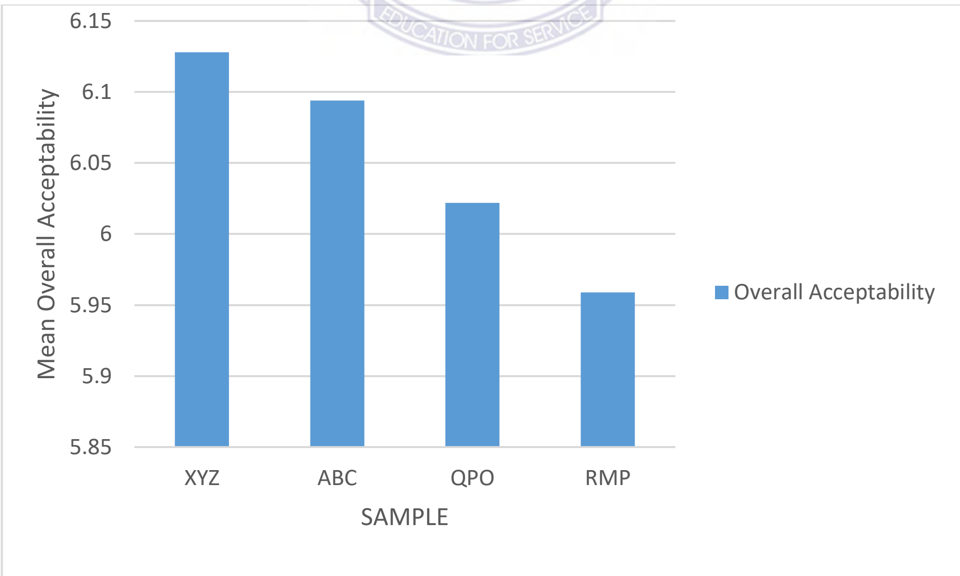


Figure 4.6: Mean overall acceptability of okra seed flour cake samples

The overall acceptability was calculated using the mean of the appearance, aroma, taste, texture and after taste. This was done in order to get the actual mean overall acceptability since some of the participants score of overall acceptability was not in accordance with the score they chose for the individual parameters of taste, color and texture. The sample with the highest acceptability was XYZ (6.13), followed by ABC (6.01), with RMP recording the least acceptability (5.95).

REFERENCES

Adebowale, Y. A. Adeyemi I. A. Osohodi A. A. (2014). Variability in the physicochemical, nutritional and antinutritional attributes of the six Mucuna species. Food Chem. 89: 37-48

Adelakun, O. E. and Oyelade O. J. (2011). "Nuts and seeds in health and disease prevention" 99, 841-846.

Adetuyi, F. O., Badejo, O. F., Ikujenlola, A. V. and Omosuli, S. V. (2009). Storage influence on the functional properties of malted and unmalted maize (Zea mays L ssp mays) and soybean (Glycine max L Merrill) flour blends. *Afr J. Food Sci,* 3(2), 056–060.

Adetuyi,, F. O. and Komolafe, E. A. (2011). "Effect of the addition of okra seed (*Abelmoschus esculentus*) flour on the antioxidant properties of plantain (*Musa paradisiacal*) flour". ARRB, 1(4), 143-152.

Adetuyi, F., Ajala, L. and Ibrahim, T. (2012). Effect of the addition of defatted okra seed *(abelmoschus esculentus)* flour on the chemical composition, functional properties and bioavailability of plantain *(musa paradisiacal linn*) flour. *JMBFS,* 2 (1), 69-82.

Afoakwa E. O. (2016). Storage Characteristics and Quality Evaluation of Cowpea-Fortified Traditional Foods. BSc Dissertation Department of Nutrition and Food Science.University of Ghana, Legon-Accra, Ghana.

Agbo, A. E., Gnakri, D., Beugre, G. M., Fondio, L. and Kouame, C. (2008). Maturity degree of four okra fruit varieties and their nutrients composition. *Elect J. Food Plant Chem.* 5, 1-4.

Akpata, M. and Akubor, P. (2009). Chemical Composition and Selected Functional Properties of Sweet Orange *(citrus sinensis)* Seed Flour. *Plant Foods for Human Nutrition*, 123-127.

Aladele, S. E., Ariyo, O. J. and Lapena, R. (2008). Genetic relationships among West African okra (*Abelmoschus caillei*) and Asian genotypes (*Abelmoschus esculentus*) using RAPD. *Indian Journal of Biotechnology,* 7(10), 1426-1431.

Amarjeet, K., Bhupendar, S. and Sindhu, J. (2013). Studies on Bread and Durum Wheat Blends. *Chem. Mikroiol,Technol.Lesbensm*, 35-40.

Allen, Y. (2007). Department of Microbiology, University of Port Harcourt, Port Harcourt department of Food Technology, University of Ibadan, Ibadan.

AOAC. (2005). Official Methods of Analysis. Association of Official Analytical Chemists, (15th ed.).Horwitz, W. and Latimer, G. W. (ed.). AOAC International. Maryland, USA

Arapitsas, P. (2008). Identification and quantification of polyphenolic compounds from okra seeds and skins. *Food Chem,* 110, 1041-1045.

Asoegwu, S., Ohanyere, S., Kanu, O. and Lwueke, C. (2006). Physical properties of Afican oil Bean (pentoncletha nacrophylla). Agriculural Engineering International; the CICR E journal, 8.

Adeboye, O.C. ad Oputa, C.O. (2016): Effect of galex on growth and fruit nutrient composition of okra (Abelmoschus esculentus). Ife Journal of Agriculture, 18(1&2), 1 – 9.

Alexandraki V, Tsakalidou E, Papadimitriou K, and Holzapfel W.,(2013). "Status and trends of the conservation and sustainable use of microorganisms in processes" www.fao.org study paper pg. 52-54

Amarjeet, D., Apea-Bah FB, Hanafi M, Dewi S, Fajriah S, Darwaman A, Artanti N, Lotulung P, Ngadymang P and Minarti B (2013). "Assessment of the DPPH and α-glucosidase Inhibitory Potential of Gambier and Qualitative Identification of Major Bioactive Compound". J. Med. Plants Res.; 3(10):736-757

Arapitsas, P. (2008). Identification and quantification of polyphenol compounds from okra seeds and skins. Food Chemistry, 110, 1041e1045

Abdelmageed, A.H.A. (2010). Mode of inheritance of pod spininess in okra (*Abelmoschus esculentus* (L.) Moench. Tropical and Subtropical Agroecosystems. 12: 405- 409.

Adelakun, O. E., Oyelade, O. J., Ade-Omowaye, B. I. O., Adeyemi, I. A., and Van de, M. (2008). Influence of pre-treatment on yield, chemical and antioxidant properties of Nigerian okra seed (*Abelmoschus esculentus* Moench) flour: DOI: 10.1016/j.fct.2008.12.023.

Adeniji, O.T. (2013). Inheritance studies in West African okra (*A. caillei*). M. Agric. Thesis. University of Agriculture. Abeokuta, Nigeria, 98p.

Al- Ghzawi, A. M., Zaittoun, S. T., Makadmeh, I. and Al –Tawaha, A.R.M. (2013). The impact of wild bee on the pollination of eight okra genotypes under semi-arid Mediterranean conditions. *International of Journal Agricultural Biology*5: 409-411.

Aladele, S. E., Ariyo, O. J. and Robert de, L. (2008). Genetic Relationship among West African Okra (*Abelmoschus caillei*) and Asian genotypes (*Abelmoschus esculentus*) using RAPD. *African Journal of Biotechnology*, 7 (10): 1426-1431.

Allen, B. (2007). Knowledge-base of Hispanic Women about Neural Tube Defects and Folic Acid Supplementation. Honors thesis. *Texas State University*. Online: https://digital.library.txstate.edu/bitstream/handle/.../fulltext.pdf.

Arapitsas, P. (2008). Identification and quantification of polyphenolic compounds from okra seeds and skins. *Journal of Food Chemistry*, 110 (4): 1041-1045.

Ariyo, O. J. (2013). Genetic diversity in West African Okra (*Abelmoschus caillei* (A.Chev.) Stevels) – Multivariate analysis of morphological and agronomic characteristics. *Genetic Resources and Crop Evolution*. 40:125-132.

Berry, S. K., Kalra, C. L. and Schyal, R. C. (2018). Quality characteristics of seeds of five okra [*A. esculentus* (L.) Moench] cultivars. *Journal of Food Science Technology* 25: 303.

Bish, I. S., Mahajan, R. K. and Rana, R. S. (2015). Genetic diversity in South Asian okra *(Abelmoschus esculentus)* germplasm collection. *Annuals Appied Biology.* 126:539-550.

Buchholz, M., Jochum, P., Zaragoza, G. and Pérez-Parra, J. (2006). Temperature and Humidity Control in the Watergy Greenhouse, International Symposium on Greenhouse Cooling, April 2006, Almeria, Spain. 211(2007) 296-303.

Burkill, H. M. (2017). The useful plant of West Tropical Africa, 2nd Edition Vol. 4, families M-R, *Royal Botanic Gardens, Kew*. United Kingdom p. 969.

Biswal B., Karna N., Patel R, (2014). "Okra mucilage act as a potential binder for the preparation of tablet formulation." Der Pharmacia Lettre 6 (3):31-39

Burkil H.M, (2007). "The useful plant of West African." 2nd edition. Vol. 4, Families M-R, Royal Botanic Garden. Kew United Kingdom pp. 969pp 27

Benchasri, S. (2012). Okra (*Abelmoschus esculentus (L.) Moench*) as a valuable vegetable of the world. Ratar. Povrt., 49, 105-112.

Beuchat, L. R. (1977). Functional and electrophoretic characteristics of succinylated peanut flour protein. Journal of Agricultural and Food Chemistry, 25, 258-261. http://dx.doi.org/10.1021/jf60210a044

Butt, M. S. and Batool, R. (2010). Nutritional and functional Properties of Some Promising Legumes Protein Isolates. *Pakistan Journal of Nutrition,* 9(4), 373-379.

Calisir, S. and Yildiz, M. U. (2015). A study on some physicochemical properties of *Pakistan Journal of Food Sciences,* 1, 16-25. Turkey okra *(Hibiscus esculenta*) seeds. *J. Food Eng,* 68, 73–78.

Chauhan, D. V. S. (2012). Vegetable production in India, Ram Prasad and Sons, India.

Chauhan, D. V. S. (2012). Vegetable Production in India, (3rd Ed.). Rata Prasad and Sons, *Agriculture.* 89pp.

Datta, P.C. and Naug, A. (2018). A few strains of *Abelmoschus esculentus* (L) Moench. Their karyological in relation to phylogeny and organ development. Beitr. *Biology of Pflanzen*.45: 113-126.

Diao, X. (2010). Economic Importance of Agriculture for Sustainable Development and Poverty Reduction: Findings from a Case Study of Ghana. (Online) URL:

www.oecd.org/dataoecd/50/2/46341169.pdf (accessed on 18th December, 2015).

Duzyaman, E. (2017). Okra: Botany and Horticulture. *Horticulture. Revised.* 21: 41-72.

Duzyaman, E. and Vural, H. (2003).Evaluation of Pod Characteristics and Nutritive Value of Okra Genetic Resources. *Acta Horticulture,* 598: 103-110.

Dabire-Binso, C. L., Ba, M. N., Some, K. and Sanon, A. (2009). Preliminary studies on incidence of insect pest on okra, *Abelmoschus esculentus (L.) Moench* in central Burkina Faso. *African J. Agric. Res,* 4, 1488-1492.

Dahiya, A. K. and Vasudevan P. (2007). Farm biomass utilization. Biological wastes 21(2): 85-91

Duzyaman, E. (2017). Okra: Botany and Horticulture. Horticulture Reviews, 21, 41-72.

Doymaz I, (2011) "Drying Of Green Bean and Okra under Solar Energy" CI&CEQ 17 (2) 199−205

Duzyaman E and Vural H (2012). Different Approaches of the improvement Procession in some local okra varieties. *Acta Horticulture* 579: 139-144.

Eze J.I and Akubor P.I (2012) Effect of Drying Methods and Storage on the Physicochemical Properties of Okra. J Food Process Technol 3:177. doi:10.4172/2157-7110.1000177

Edema, O., Sanni, O. and Sanni, I. (2015). Evaluation of Maize- Soybean Flour for Sour Maize Bread Production in Nigeria. *African Journal of Biotechnology,* 4(9), 911-918.

Ezeakunne, C. O. (2014). Large scale fruit and vegetable production in Nigeria. Short Communication. Department of Agronomy, Ahmadu Bello University, Zaria, 8pp.

Fajinmi, A. A. and Fajinmi, O. B. (2010). Incidence of okra mosaic virus at different growth stages of okra plants (Abelmoschus esculentus (L.) Moench) under tropical condition. *Journal of General and Molecular Virolog*y 2: 28-31.

FAO. (2018). Food and Agricultural Organisation of the United Nations, Conference on medicinal plants, Rome.pp.23.

FAOSTAT. (2006). Food and Agricultural Organisation (FAO) Statistical Database.

FAOSTAT. (2008). Food and Agricultural Organisation of the United Nations. On-line and Multilingual Database, http://faostat.fao.org/faostat/

FAOSTAT. (2012). Food and Agricultural Organisation (FAO) Statistical Database. http://faostat.fao.org.

Farinde, A. J., Owolarafe, O. K. and Ogungbemi, O. I. (2007). "An overview of Production, Processing, Marketing and Utilisation of Okra in Egbedore Local Government Area of Osun State, Nigeria" Agricultural Engineering International: *the CIGRE journal manuscript* No. MES 07002. Vol.IX (online)

URL:www.cigrjournal.org/index.php/Ejournal/article/view/959/1119 (accessed on13th October 2014).

Fajinmi, A. A. and Fajinmi, O. B. (2010). Incidence of okra mosaic virus at different growth stages of okra plants *(Abelmoschus esculentus (L.) Moench)* under tropical condition. *J. General Molec. Virology,* 2, 28-31.

Fennema, R. O. and Dekker, M. (2015). Technology & Engineering, 991.

FAOSTAT. (2012). Food and Agricultural Organization of the United Nations. On-line and Multilingual Database,http://faostat.fao.org/foastat/

FAOSTAT (Food and Agricultural Organization of the United Nations). (2008). On-line and multilingual database currently covering international statistics, (2008) http://faostat.fao.org/foastat/

Farinde A.j., Owlarafe O.K., and Ogungbemi O.I, (2011-2007). "An overview of production, processing, marketing, and utilization of okra in Egbedore Local Government Area of Osun State, Nigeria" Agricultural Engineering International. *The CIGR E Journal*. Vol. IX. July, 2007.

Grubben, G.J.H. (2017). *Tropical Vegetables and their Genetic Resources.* International Board for Plant Genetic Resources, Rome, FAO. 197pp.

Gulsen, O., Karagul, S. and Abak, K. (2007). Diversity and relationships among Turkish okra germplasm by SRAP and phenotypic marker polymorphism. *Biologia Bratislava*, 62: 41- 45.

Geogiadisa, N., Ritzoulisa, C., Siouraa, G., Kormezona, P, and Vasiliadoud, C. (2011) Controbution of Okra extracts to the stability and rheology of oil in water emulsions. *Food Hydrocolloids,* 25, 991-999.

Gurbuz, I. (2013). "Antiulcerogenic activity ofsome plants used as folk remedy in Tur key," *J. Ethnopharmacol,* 88 (1), 93–97.

Hamon, S. and Sloten van, D. H. (2009). Okra. In: Evolution of Crop Plants, Smartt J, Simmonds NW (eds.), John Wiley & Sons, 605 Third Avenue, New York, 350-357.

Hamon, S. and Hamon, P. (2011). Future prospect of the genetic integrity of two species of Okra (*Abelmoschusesculentus* and *A. caillei*) cultivated in West Africa. Euphytica 58:101-111.

Hamon, S. and Charrier, A. (2017). Les gombos. In*: Charrier, A., Jacquot, M. ., Hamon, S and Nicholas, D. (Editors). L'ame'lioration des plantes tropicales*, CIRAD/ORSTOM, Montpellier, France. Pp. 313-333.

Hamon, S., Charrier A., Koeklin, J. and Van Sloten, D. H. (2010). Potential contributions to okra breeding through the study of their genetic resources. *In: Report of an International workshop on okra genetic resources*. NBPGR. New Delhi, India. 133p.

Ikpeme, C., Osuchukwo, N. and Oshiele, L. (2010). Functional and Sensory Properties of Wheat (Aestium triticium) and taro flour (Colocasia esculanta)Composite Bread. *Africa Journal of Food Science,* 14(5), 248-253.

IBPGR. (2010). International Board for Plant Genetic Resources. Report on International Workshop on Okra Genetic Resources held at the National Bureau for Plant Genetic Resources, New Delhi, India. 8 – 12 October, 1990.

Incalcaterra, G. and Curatolo, G. (2007). Biodiversità di una popolazione siciliana di melone d'inverno (Cucumis melo Var .Inodorus naud.). Atti Del 3° Convegno Nazionale Biodiversità - Tecnologie - Qualità. Reggio Calibria Giugno, 16-17.

Joshi, A. B., Gadwal, V. R. and Hardas, M. W. (2014). Okra. In Hutchinson, J.B. (ed.), Evolutionary studies in world crops. Diversity and change in the Indian sub-continent*,* Ed. J B Hutchinson. Cambridge University Press. pp. 99-105.

Justo, V. P. (2011). Okra Integrated pest management, an ecological guide. National Crop Protection Center. University of the Philippines Los Baños College, *Laguna, Philippines* 4031(online) URL: www.vegetableipmasia.org/docs/ecological guide./OKRA ECO GUIDE.pdf (accessed on 18th December, 2015).

Jesus, M. M. S., Carnelossi, M. A. G., Santos, S. F., Narain, N. and Castro, A. A. (2008). Inhibition of enzymatic browning in minimally processed okra. Rev. Cienc. Agron, 39 (4), 524-530.

Jitngarmkusol, Hongsuwankul, J. and Tananuwong, K. (2008). Chemical Composition, Functional Properties and Microstructure of Defatted Macademia Nuts. *Food Chemstry,* 110. 23-30.

Jideani V.A and Adetula H.O. (2013). The potential of okra seed flour for weaning foods in West Africa. Ecology of Food and Nutrition. 29(4).

Junji, T., (2014). Health Benefits of Okra. Retrieved from: http://www.pyroenergy.com/okra-health-benefits htm, (Accessed on: 26 June, 2010).

Kanmani P, Dhivya E, Aravind J and Kumaresan K, (2014). Extraction and Analysis of Pectin from Citrus Peels:Augmenting the Yield from Citrus limon Using Statistical Experimental Design. Iranica Journal of Energy and Environment, 5 (3): 303-312

Krishnamurthi, C.R. and. Giri K.V, (2013). Preparation, Purification and Composition of Pectin from Indian Fruits and Vegetables. Brazilian Archives of Biology and Technology, 44: 476-483.

Kumar, N., (2016). Breeding of Horticultural crops. New India Publishing Agency, New Delhi, pp 173-177.

Kahlon, T. S., Chapman, M. H. and Smith, G. E. (2007). In vitro binding of bile acids by okra beets asparagus eggplant turnips green be- as carrots and cauliflower. *Food Chem,* 103, 676-680.

Kalloo, G. (2008). "Project Directorate of Vegetable Research, Varanasi. Proceedings of the National Consultation on Horticultural Research, Development and Export, 84–89.

Kasina, M. (2009). Pollination: Key to Food Security and Environmental Health. *The African Executive*. Online at URL: www.africanexecutive.com/modules/magazine/articles.php (accessed on 17th Nov.2015).

Kochhar, S. L. (2016). Tropical Crops. A textbook of Economic Botany. Macmillan Publishers Ltd. London and Basingstoke, *Macmillan Indian Ltd*. 467: 263-264.

Kumar, S., Dagnoko, S., Haougui, A., Ratnadass, A., Pasternak, D. and Kouame, C. (2010). Okra (*Abelmoschus* spp.) in West and Central Africa: Potential and Progress on its Improvement. A special review. .*African Journal of Agricultural Research*, 5(25): 3590-3598.

Lutz, J. M. and Hardenburg, R. E. (2016). The commercial storage of fruits, vegetables and florist and nursery storks, Agricultural Handbook No. 66, USDA, Washington.

Lawal, O., and Adebowale, K. (2014). Effect of Acetylation and Succinylation on Soluility Profile, Water Absorption Capacity, Oil Absorption Capacity and Emulsifying Properties of Mucuna Bena(Mucuna pruten) Protein Concentrate . *Nahrung/Food*, 48 (2), 129-136.

Leach, H. W. McCoven, L. D and Scoch, T. J. (2009). Structure of the Starch granule swelling and solubility patterns of various starches. *Cereal chemistry*, 36, 534-544.

Lengsfeld, C., Titgemeyer, F., Faller, G. and Hensel, A. (2014). Glycosylated compounds from okra inhibit adhesion of Helicobacter pylori to human gastric mucosa. *J. Agric. Food Chem,* 52, 1495-1503.

Liu, I. M., Liou, S. S., Lan, T. W., Hsu, F. L. and Cheng, J. T. (2015). Myricetin as the active principle of Abelmoschus moschatus to lower plasma glucosein streptozotocin-induced diabetic rats. *Planta Medica,* 71, 617-621.

Loos P. J., Hood, L. F. and Graham, A J. (2011). Isolation and characterization of starch from breadfruit. *Cereal Chem.,* 58, 282-286.

Madison, D. (2008). Renewing America's Food Traditions. Chelsea Green Publishing, 167.

Messing, J., Thöle, C., Niehues, M., Shevtsov, A. and Glocker, E. (2014). Antiadhesive Properties of *Abelmoschus esculentus* (Okra) Immature Fruit Extract against Helicobacter pylori Adhesion. PLOS ONE 9(1), e84836. doi:10.1371/.0084836

Mihretu, Y., Wayessa, G. and Adugna, D. (2014). Multivariate Analysis among Okra *(Abelmoschus esculentus (L.)* Moench) Collection in South Western Ethiopia. *J. Plant Sci*, 9(2), 43-50.

Moyin-Jesu, E.I. (2007). Use of plant residues for improving soil fertility pod nutrients root growth and pod weight of okra *Abelmoschus esculentum* L. Bioresour. Tech. 98, 2057-2064.

Moisture content determination, (AOAC, 2005) Journal of food engineering, 2005, volume 69(3) 275 – 279.

Mujumdar, A. S. (2015). Handbook of industrial drying (second ed.). New York: Marcel Dekker.

Marsh, L. (2013). Emergence and seedling growth of okra genotypes at low temperature. *Hortscience* 27:1310-12.

Martin, F. W. Rhodes AM, Ortiz M, and Diaz F (2013). Variation in okra. Euphytica 30:697-705.

Medikus, U. (2017). Ueber einige kinstliche geschlechter aus der Malven familie, dennder klasse der Monadelphien. Mannheim. pp. 45-46.

Moekchantuk, T. and Kumar, P. (2004). Export okra production in Thailand. Intercountry programme for vegetable IPM in South & SE Asia phase II Food & Agriculture Organization of the United Nations, Bangkok, Thailand.

National Agricultural Research Project (NARP), (2013). *Horticultural Crops*. Vol. 3, July 1993 Accra: NARP, CSIR.

Nonnecke, I. L. (2009).Vegetable Production. Van Nostrand Reinhold AVI Publishing.

Pp.608-609.

Norman, J. C. (2012). Tropical Vegetable Crops. Arthur H. Stockwell Ltd., Elms C. Francanbe, Devon. 252pp.

Ngoc T.H, Nguyen Q, Tran TVan A, and Phung Vo N. (2008) Hypolipidemic Effects from Abelmoschus esculentus on Tyloxapol-Induced Hyperlipidemic in mice. Mahidol University Journal of Pharmaceutical Sciences 2008;35(1-4):42-46.

NARP. (2013). National Agricultural Research Project, Horticultural Crops. Vol. 3 July 1993. NARP, CSIR, Accra.

Nasir, M., Butt, M. S., Faqir, M., ANJUM, Sharif, K. and Minhas R. (2013). Effect of moisture on the shelf life of wheat flour. *International Journal of Agriculture and Biology*, 05(4), 458-459.

Ndjouenkeu, R., Goycoolea, F. M., Morris, E. R. and Akingbala, J. O.(2016). Rheology of okra *(Hibiscus esculentus L.*) and dika nut *(Irvinia gabonensis*) polysaccharides. *Carbohydrate Polymer.* 29, 263-269.

Ngoc, T., Ngo, N., Van, T. and Phung, V. (2008). Hypolipidemic effect of extracts from *Abelmoschus esculentus L. (Malvaceae)* on Tyloxapol induced hyperlipidemia in mice. Warasan Phesatchasat, 35, 42–46.

Oppong-Sekyere D, Akromah R, Nyamah E. Y, Brenya E, and Yeboah S, (2012). " Evaluation of some okra (*Abelmoschus spp* L.) germplasm in Ghana" African Journal of Plant Science Vol. 6(5), pp. 166-178

Organic Farming US Department of Agriculture, Washington DC, 1994.

Owoeye AI, Caurie MC, Allagheny NN, Onyezili FN (2010). Chemical and physical parameters affecting the viscosity of mixed okra and tomato homogenate. Journal of Food Science and Agriculture 53: 283-286.

Onunkun, O. (2012). Evaluation of aqueous extracts of five plants in the control of flea beetles on okra (*Abelmoschus esculentus* (L.) Moench *Journal of Biopesticides,* 5, 62-67.

Oppong-Sekyere, D. (2011). Assessment of genetic diversity in a collection of Ghanaian Okra germplasm *(Abelmoschus spp L.)* using morphological markers. MSc. Thesis presented to the Department of Crop Science, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. pp. 42-60.

Oppong-Sekyere, D., Akromah, R., Nyamah, E.Y., Brenya, E. and Yeboah, S. (2012). Evaluation of some okra (*Abelmoschus spp* L.) germplasm in Ghana. *African Journal of Plant Science,* 6(5): 166-178.

Oyelade, O. J., Ade-Omowaye, B. I. O. and Adeomi, V.F. (2013). Influence of variety on protein, fat contents and some physical characteristics of okra seeds. *Journal of Food Engineering.* 57(2):111-114.

Pal, B.P., Singh, H.B. and Swarup, V. (2012). Taxonomic relationship and breeding possibilities of species of *Abelmoschus* related to okra (*A. esculentus*). *Bt. Gaz.* 113: 455-464.

Purseglove, J. W. (2014). Tropical Crops. Dicotyledons. Longman Singapore Publishers Ltd. pp 324.

Sabitha, V., Ramachandran, S., Naveen, K. R. and Panneerselvam, K. (2011) Antidiabetic and antihyperlipidemic potential of *Abelmoschus esculentus (L.)*

Moench. in streptozotocin-induced diabetic rats. *J. Pharm Bioallied Sci*, 3, 397-402.

Saifullah, M. and Rabbani, M. G. (2009). Evaluation and characterization of okra 6+ *(Abelmoschusesculentus L. Moench.*) genotypes. *SAARC J. Agric,* 7, 92-99.

Savello, P.A., F. Martins and W. Hull. (2010). Nutrition composition of okra seed meals. *J. Agric. Food Chem.* 28, 1163-1166.

Sanjeet, K., Sokona, D., Adamou, H., Alain, R., Dov, P. and Christophe, K. (2010). Okra *(Abelmoschus spp.)* in West and Central Africa: Potential and progress on its improvement. *African Journal of Agricultural Research,* 5(25), 3590-3598.

Singh, N., Sandhu, K. S. and Kaur, M. (2015). Physicochemical properties including granular morphology, amylose content, swelling and solubility, thermal and pasting properties of starches from normal, waxy, high amylose and sugary corn. Progress in Food Biiopolymer Research.1, 44-54.

Rao P.S, Rao P.U, and Serikeran B (2011). Serun cholesterol, triglycerides and total total fatty acid of rates in response to okra (*Hibiscus esculentus*) seed oil. JAOCA 68:433.

Rao PU (2015). Chemical compostion and biological evaluation of okra (*Hibiscus esculentus*) seeds and their kernels. Qual. Plant Food Human Nutrition, 35:389-396.

Ramu, P. M. (2016). Breeding Investigation in Okra (*Abelmoshus esculentus* (L.) Moench) *Mysore Journal of Agricultural Science*10 (1):146.

Rao, P. S., Rao, P. U. and Serikeran, B. (2011). Serun cholesterol, triglycerides and total total fatty acid of rates in response to okra (*Hibiscusesculentus*) seed oil. JAOCA 68:433.

Rao, P. U. (2015). Chemical composition and biological evaluation of Okra (Hibiscus esculentus) seeds and their kernels. *Plant Foods for Human Nutrition (Formerly Qualitas Plantarum)*, 35 (4): 389-396.

Saifullah, M. and Rabbani, M. G. (2009). Evaluation and characterization of okra (Abelmoschus esculentus L. Moench.) genotypes. *SAARC Journal of Agriculture* 7: 92-99.

Savello, P. A Martins, F. and Hull, W. (2010). Nutrition composition of okra seed meals. *Journal of Agricultural Food and Chemistry.* 28:1163-1166.

Schippers, R. R. (2010). African indigenous vegetables- An overview of the cultivated species. pp. 103-118.

Schippers, R. R. (2010). African Indigenous Vegetables: An overview of the cultivated species. Natural/ACP-EU Technical center for Agricultural and Rural Cooperation.Chathan, UK. p. 214

Sefa-Dedeh, S. (2006). Ghana's fresh produce hits the markets with increased volume, diversified and premium quality products (online) URL: www.gepcghana.com/assets/file/Sefa_Dedeh_Article.pdf (accessed on 24rd November, 2015).

Siemonsma, J. S (2011). West African okra – morphological and cytogenetical indicators for the existence of a natural amphidiploid of *Abelmoschus esculentus* (L.) and *Abelmoschus manihot* (L.) Mediks. Euphytica 31:241-252.

Siemonsma, J. S. (2012). West African okra - morphological and cytogenetical indications for the existence of a natural amphidiploid of Abelmoschus esculentus (L.).PROTA Foundation, the Netherlands, pp.76-89.

Singh, H.B., Swarap, V. and Singh, B. (2015). Three decades of vegetable research In Indian. *ICAR, Tech. Bull*., New Delhi, 36:26-27.

Sanjeet K., Sokona D., Adamou H., Alain R., Dov P., and Christophe, K. (2010). Okra (Abelmoschus spp.) in West and Central Africa: Potential and progress on its improvement. African Journal of Agricultural Research Vol. 5(25), pp. 3590-3598.

Savello P.A, Martins F. and Hull W (2010). Nutrition composition of okra seed meals. J. Agril. Food Chem., 28:1163-1166.

Sharma R.K, and Prassad K, (2010). "Classification of promising okra (*Abelmoschus esculentus)* genotypes based on principal component analysis." *Journal of Tropical Agriculture and Food Science. 38(2): 161–169*

Siemonsma J.S. (2012). Culture of okra Legume, a tropical fruit withspecial reference to the Ivory Coast (Abelmoschus spp.).Thesis, University of Wageningen (Netherlands),.

Tobias, N.E., N.V. Eke, R.I. Okechukwu, R.N. Nwoguikpe and C.M. Duru, (2011). Waste to Health: Industrial Raw Materials. Potential of Peels of Nigerian Sweet Orange (*Citrus sinensis*). African Journal of Biotechnology, 10(33): 6257-6264.

Tweneboah, C.K., (2018). Vegetable and Spices in West Africa:Co-Wood publisers, 2018.

Taha El-Katib, M. M. (2017). Value of adding cotton okra, fenugreek seed to maize flour. Nature 156:716.

Terell, E. E. and Winters, H.F. (2014). Change in scientific names for certaincrop plants. Horticultural Science 9:324-325.

Vaissière, B. E. and Vinson, B. (2014). Pollen morphology and its effect on pollen collection by honey bees, *Apis mellifera* L. (Hymenoptera: Apidae), with special reference to upland cotton, *Gossypium hirsutum* L. (Malvaceae). *Grana,* 33: 128-138.

Valeriana, P. J. (2011).Training Resource Text on Crop Development, Major Economic Practices, Disease and Insect Ecology, Insect Pests, Natural Enemies and Diseases of Okra.

Whistler, R. L., and BeMiller, J. N. (2013). Industrial gums: Polysaccharides and their derivatives. San Diego: Academic Press.

Wilkins, M.R., W.W. Widmer, R.G. Cameron and K. Grohmann, (2015.) Effect of Seasonal Variation on Enzymatic Hydrolysis of Valencia Orange Peel Waste. Proceedings of the Florida State Horticulture Society, 118: 419-422.

Yamazaki, W. T. (1953). An alkaline water retention capacity test for evaluation of cookie baking potentialities of soft winter wheat flour. *Cereal Chemistry,* 30, 242-246.

Zaharuddin, N. D., Noordin, M. I. and Kadivar, A. (2014). The Use of *Hibiscus esculentus* (Okra) Gum in Sustaining the Release of Propranolol Hydrochloride in a Solid Oral Dosage Form. *BioMed Research International.* 735891. Doi: 10.1155/2014/735891. 38