KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

COLLEGE OF SCIENCE

DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

OKRA UTILISATION IN GHANA AND PECTIN EXTRACT AT DIFFERENT MATURITY OF OKRA FRUIT

BY

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A THESIS SUBMITTED TO THE DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY, COLLEGE OF SCIENCE IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MSc FOOD QUALITY MANAGEMENT

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DECLARATION

I hereby declare that this submission is my own work towards the MSc and that, to the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

Okra (*Abelmoschus esculentus*) is a staple vegetable in Ghana but underutilized. The mucilage or pectin content is currently of interest for various food and non-food uses. In this thesis, a survey was conducted by administering questionnaires (at least 200) in each major producing areas/regions including Northern, Upper East, Eastern, Central, Western, Brong Ahafo, Ashanti,

Volta and Greater Accra. In all a total 1560 questionnaires were administered randomly to both male and females including mostly farmers and marketers. The study was conducted between June and November 2016. The statistics showed that okra is well known (96.9%) across the country among the various ethnic groups. There are varietal differences among okra in Ghana. However, these varieties are not scientifically classified leading to different names for the various varieties across the different ethnic groups. The fruit is available all year round but abundant only in the rainy season between July to September. The results indicate that 94.7%, 22.1% and 9.6% of the respondents use okra as food, medicine and other applications, respectively. Okra is widely used as food in the form of soup (73.1%) and stew (68.7%) consumed popularly with banku (81.3%) and TZ (38.8%). Okra also had other applications in traditional medicine, pito clarification and firewood. However, a greater number of the respondents (65.2%) showed interest in new products being developed from okra. Differences in educational level, occupation and ethnic group had a significant influence on the utilization of okra in Ghana. In the medicinal utilization of okra, it was greatly used especially in the rural areas of northern Ghana for the treatment of diarrhea, boils, sores, shingles (‘ananse’), fractures and dislocations. Pectin was extracted from the Balabi okra genotype at different maturity using 0.1 M phosphate buffer at pH 6.0. The crude pectin yield obtained (11-20%) was significantly influenced by the maturity of the fruit/pod. The pectin content increased from early maturity to middle age and then decreased at late maturity when the pod texture is very hard. For Balabi okra fruit pods harvested 14-15 days after flowering produced the highest pectin yield implying the suitable maturity for harvesting the Balabi genotype if high pectin content/yield is desired.

CHAPTER ONE

1. INTRODUCTION

1.1 Background

Okra (*Abelmoschus esculentus*) is cultivated in the tropical, subtropical and warm temperate regions around the world (Chandra *et al.,* 2016). This vegetable is important in the diet of Ghanaians and several African countries. Worldwide production of okra is estimated at over 7 million MT whereas that of Ghana is over 60,000 MT (FAOSTAT, 2012). Okra is mostly found in its fresh state 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 farmers and women/marketers (Oppong-Sekyere, *et al.,* 2012). Although okra is considered a robust crop, under large scale commercial production, yield loses are very high due to the incidence of a number of biotic and abiotic stresses. Okra has considerable area under cultivation in Africa and Asia with huge socioeconomic potential. In West and Central Africa (WCA) okra is called *gombo* (French), *miyangro* (Hausa), *la* (Djerma), *layre* (Fulani), *gan* (Bambara), *Kandia* (Mandign), *fkruma* (Akan), *Fetri* (Ewe) and is among the most frequently and popularly consumed traditional vegetables (Kumar *et al.,* 2010).

Due to its local consumption and export potential, okra is considered as an important vegetable crop in Ghana. The fruit leaves and flowers buds are eaten as a source of protein, vitamins and minerals. The crop is produced in all the ten (10) regions of Ghana but the bulk of the producers comes form Brong Ahafo, Northern, Volta, Ashanti and the Greater Accra regions (NARP, 1993).

Okra has high economic value, good nutritional and functional properties and can improve food security (Kumar *et al. 2010;* Agbenorhevi *et al.,* 2015). Okro gum produces high viscosity

mucilage (pectin) even at low concentrations (Onunkwo, 2010). Pectin is a methylated ester of polygalacturonic acid which contains 1, 4-linked α-D-galacturonic acid residues (Levigne et al., 2002). Pectin has imperative nutritional and technological properties (Alba *et al.*, 2015*;* Agbenorhevi *et al.*, 2015). In terms of food applications okra pectin can be used as emulsifiers, thickeners, and stabilizers (Georgiadis *et al.*, 2011; Alba *et al.*, 2015). Okra pectin is also used for non-food applications, some of these include; brightening agent in electro deposition of metals, deflocculant in paper and fabric production, protectant to reduce friction in pipe-flow, combined with acrylamide to develop new biodegradable polymeric materials and treatment of textile wastewater (Agbenorhevi *et al.*, 2015). Aside the food and non food uses, medicinal/pharmaceutical uses of okra pectin include plasma replacement or blood volume expander, tablet binder or suspending agent. It can also be used as a treatment of gastric irritations and dental diseases as well as curing ulcers and relief from haemorrhoids (Agbenorhevi *et al.*, 2015). The source as well as the extraction method are the determinants of pectin yield and quality. The general make up of the pectin content varies with ripening of the plant and it is fairly easily brought into solution depending on the plant type (Azad *et al.*, 2014; Alba *et al.*, 2015).

1.2 Problem statement

There is limited market value for okra, this is partly due to the limited knowledge on the specific variety/genotype for other food, non-food and medicinal uses. Okra is a multipurpose crop and used as a source of nutrition, bio-medicines and industrial by-products (Khan *et al.*, 2013).The market value of okra decreases annualy due to limited use in soup/stew preparation. There is inadequate knowledge on practices to produce varieties and maximize production for specific technological application, this has led to a situation where Ghanaian farmers are at a disadvantage position. As a result of this farmers have lots of difficulty in seed storage, soil fertility management,

controlling pest and diseases and also as soon as the quantities for food are achieved value for okra drops to very low levels as there is only very limited processing by drying. Pectin is derived from the pods of the okra plants, the maturity at which the okra pods are harvested affects pectin yield since there is lignification of the cell walls of the okra pods. Okra pods should be picked while they are tender and immature. During maturation pods become tough due to thickening of fiber bundles present in the pericarp region (Ramaswamy and Ranganna, 1982; Sreeshma and Nair 2013; Noorlaila *et al*. 2015). Tough pods have less market value as well as their culinary value since they are not suitable for curry and soup preparation (Chutichudet *et al.,* 2007).

1.3 Objectives

The objectives of this study were:

- To assess okra utilization in Ghana
- To investigate okra pectin extract at different maturity of the fruit pods.

1.4 Justification

Okra has huge potential for enhancing livelihood in urban and rural areas and to several stakeholders (NARP, 1993; NAP, 2006; Kumar *et al.,* 2010; Agbenorhevi *et al., 2015*). It offers a possible root to prosperity for small scale and large scale producers alike and all those involved in the okra value chain. Notwithstanding the potentials of okra, it is underutilized in Ghana and most African countries. In the major or rainy season, okra is produced in large quantities much more than what the local populace can consume, leading to excess. Appropriate utilisation of okra is necessary to halt the wastage being experienced during the rainy season. The survey will provide information on okra utilization in Ghana and the possible areas to improve its applications. The findings on the effect of maturity on the yield of okra pectin will suggest the suitable maturity

stage to achieve high pectin yield. Ultimately, this project is expected to contribute significantly towards the effort to improve the economic value of okra.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Okra

Okra *Abelmoschus esculentus)* is an important vegetable crop of the Malvaceae family. It is one of the oldest cultivated crops and presently grown in many countries and widely distributed from Africa to Asia, southern Europe and America. It is subtle to frost; low temperature, water logging and drought conditions, and the cultivation from different countries have certain adapted distinguishing characteristics specific to the country to which they belong. Okra (as shown in Figure 1) is known by many local names in different parts of the world. It is called lady's finger in England, gumbo in the United States of America, guino-gombo in Spanish, guibeiro in Portuguese and bhindi in India (Kumar *et al*., 2013).

Figure 1: Some typical okra plants and fruits/pods

2.2 Taxonomy, cytology and origin

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 (Kundu and Biswas, 1973; Terrell and Winters, 1974). Eight out of fifty described species of okro are most widely accepted (Borssum, 1966; IBPGR, 1990). There is significant variation in the chromosome numbers and ploidy levels in Abelmoschus. The lowest chromosome number known is 2n = 56 for A. angulosus (Ford, 1938) and the highest are close to 200 for *A. caillei (*Siemonsma, 1982). Even within *A.*

esculentus, chromosome numbers 2n = 72, 108, 120, 132 and 144 are in regular series of polyploids with n = 12 (Datta and Naug, 1968). Controverting evidence exists on the geographical origin of A. esculentus. One putative ancestor (A. tuberculatus) is native to Uttar Pradesh in North India, suggesting that A. esculentus originated in India. The other evidence is based on the plants cultivation in ancient times, and the presence of another putative ancestor (A. ficulneus) in East Africa, suggesting northern Egypt or Ethiopia as the geographical origin of A. esculentus. So far A. caillei (2n = 196 to 200) has been located only in West and Central Afrca, so this region can be recognized as its origin and is believed to be amphipolyploids between A. esculentus (2n = 130 to 140) and A. manihot (2n = 60 to 68).

2.3 Domesticated species

There are four known domesticated species of Abelmoschus. Among these, *A. esculentus* (common okra) is most widely cultivated in South and East Asia, Africa, and the southern USA. In the humid zone of West and Cemtral Africa (WCA), *A. caillei* (West African okra) with a longer production cycle, is also cultivated (Siemonsma, 1982). Plants of A. manihot sometimes fail to flower and this species is extensively cultivated for leaves in Papua New Guinea (Hamon and Sloten, 1995), Solomon Islands and other South Pacific Islands (Keatinge, 2009). According to Hamon and Sloten (1995), the fourth domesticated species of okra, namely A. moschatus, is mainly cultivated for its seed, which is used for ambretee in India and several animism practices in South Togo and Benin.

2.4 Germplasm management

Okra germplasm exploration was carried out in several WCA countries from 1982 to 1986 by the Bioversity International in collaboration with the Institut de Recherche pour le Développement (IRD). Along with Asian and African collections, a core collection at ORSTOM in Montpellier,

France was established. However, active collections from this core are no longer accessible for breeding purposes (Jarvis et al., 2008). More than 3000 collections along with collections from Asia are maintained and distributed by National Plant Germplasm System (NPGS), United States. Nevertheless, the West African accessions under-represent collections from countries like Niger (3) and Chad (5). AVRDC – The World Vegetable Center, in collaboration with its partners, has initiated countrywide explorations and would like to continue exploring in unexplored regions. Between 2008–2009, 102 new accessions from Mali, Senegal, Niger and Guinea have been collected and regenerated for public use. Varietal data collected and analyzed on landraces (traditional variety) and improved cultivars used by farmers from Burkina Faso has revealed that considerable genetic diversity in the form of on-farm richness and community evenness is maintained in landraces (Jarvis *et al.,* 2008).

2.5 Genetic improvement

Through breeding a number of okra varieties have been developed in countries like USA and India. Many of these varieties have been introduced in WCA countries and are still popular (Kumar *et al*., 2013). Multivariate analysis of 14 characters (pod yield, branch per plant, leaves per plant, days to flowering, plant height at flowering and maturity, pods per plant, edible pod length and width, mature pod length, duration of flowering, life span, seeds per pod, 100 seed weight) of 30 genotypes collected from different geographical areas revealed no relationship between clustering pattern and geographical distribution of okra genotypes (Ariyo, 1987). Pod yield and several yield contributing characters lack stability due to strong environmental influence, suggesting the need for breeding for specific environment (Ariyo, 1990). Variation between the genotypes of WCA origin is attributed to the diversty in pod shape/size and flowering behaviour (Duzyaman, 1997) and scope for further gain in pod yield per plant is limited because of low phenotypic and genotypic

variability (Ariyo, 1990). A hybridizationbased breeding strategy would be ideal in order to break the yield hurdle in existing genotypes of common okra (A. *esculentus*) and breed for different market types. Although some of the WCA national agricultural research system (NARS) and private seed companies have ongoing okra improvement projects, they have never been supported through international okra research

(Kumar *et al*., 2010). Despite okra's recognized potential and significant area and consumption in the developing world in general and in West Africa in particular, it has been considered an economically minor crop (Duzyaman, 1997). Photoperiod sensitivity and cold temperatures are the main challenges hinderingcommercial okra cultivation in thetropics, these problems limit year-round availability of fresh pods; shelf-life, fiber/mucilage content, and pest resistance, especially root-knot nematodes, tomato fruit worm and begomoviruses. To overcome these challenges, a long term breeding project was warranted. Since, 2003, AVRDC – The World Vegetable Center and its partners, have been introducing, testing and promoting new cultivars. Efforts are sustained through pure line selection for high yielding cultivars with high mucilage content. Three promising lines (Sasilon, Batoumambe and Safi) are currently being promoted in Mali and The Gambia (Osawaru *et al.,* 2014). In 2007, okra improvement activities were initiated at center's outreach office that execute AVRDC/ICRISAT joint vegetable breeding project at Sadore, Niger. In the first phase, about 250 okra accessions representing collections from most parts of the world were introduced, regenerated, and characterized for morphological data. The regenerated species include: common okra (*A. esculentus*; 175), West African okra (*A. caillei*; 45) and other Albemoschus species like *A. ficulneus, A. manihot, A. manihot var. tetraphyllus, A. moschatus* and *A. tuberculatus*. Although these accessions mostly represent previous collections from WCA and South Asia, a few representative accessions from the Middle East, USA and East Africa were also introduced and maintained (Osawaru *et al.,* 2014). Efforts are being made to screen germplasm against root knot

nematode. According to Pasternak et al. (2009) there is the development of inter-specific crosses and efforts to overcome hybrid breakdown barriers is underway, to facilitate pre-breeding and broadening of genetic base due to the potential of West African (*A. caillei)* okra. A short duration Konni variety selected from a local population in Niger has been proven to be the "best bet" so far; it is being mass disseminated in the Sudano-Sahel under both rain-fed and irrigated conditions (Pasternak *et al.,* 2009).

2.6 Gene transfer between different okra species

Based on the available information on crossability, hybrids have been produced in the crosses between *A. esculentus* and *A. Caillei.* It is easy to obtain F1 plantlets irrespective of direction of crossing. It may be noted that though F1 plants were obtained in certain cases, these plants were highly sterile and it was difficult to produce subsequent generations or even to carry out backcrosses. It is more difficult to cross *A. esculentus* with wild species of the genus Abelmoschus. It is sometimes possible to obtain first-generation hybrids such as in crosses between *A. esculentus and A. tetraphyllus,* but the process is blocked at the second generation. It is almost impossible to obtain crosses with *A. moschatus* (Hamon and Yapo, 1985). Other species, because they are rarely found in collection surveys, have hardly been tested.

2.7 Reproductive biology

Growth and Development

Okra is mainly propagated by seeds and has duration of 90-100 days. It is generally an annual plant. Its stem is robust, erect, variable in branching and varying from 0.5 to 4.0 metres in height.

Leaves are alternate and usually palmately five lobed, whereas the flower is axillary and solitary. Okra plants are characterized by indeterminate growth. Although flowering is continuous, it is

vastly dependent upon biotic and abiotic stress. The first flower emerges, within one to two months after sowing (Ogunsola *et al.,* 2012). The fruit is a capsule and grows quickly after flowering, the okra pods are harvested when immature and high in mucilage, but before becoming highly fibrous. Generally the fibre production in the fruit starts from 6th day onwards of fruit formation and a sudden increase in fibre content from 9th day is observed (Nath, 1976; Ige and Eludire, 2014.). Variety, growing season and soil moisture and fertility are the predominant factors that determine whether okra plants will flower and fruit indefinitely. Itmay be necessary to harvest every day in regions where growth is especially vigorous, since regular harvesting stimulates continuous fruiting. It is at this stage that fruit is most often plucked (Tripathi *et al.*, 2011).

Floral Biology

The okra flowers are 4-8 cm in diameter, with five white to yellow petals, often with a red or purple spot at the base of each petal and the flower withers within one day. The flower structure combines hermaphroditism and self compatibility (Tripathi *et al*., 2011). Flower bud appears in the axil of each leaf, above 6th to 8th leaf depending upon the cultivar. The crown of the stem at this time bears 3-4 underdeveloped flowers but later on during the period of profuse flowering of the plant there may be as many as 10 undeveloped flowers on a single crown. As the stem elongates, the lower most flower buds open into flowers (Tiamiyu *et al.,* 2017). There may be a period of 2, 3 or more days between the time of development of each flower but never does more than one flower appear on a single stem. it takes about 22-26 days for a flower bud to develop, that is from initiation to full bloom. The style of the flower is enveloped in a staminal column which may bear more than 100 anthers. The flowers of okra are self fertile because Thakur and Arora (1986) stated that pollen comes into contact with the stigmas through a lengthening of the staminal column or through insect foraging.

Pollination and Fertilization

According to research conducted on six varieties of okra, Sulikeri and Rao (1972) concluded that flower buds are initiated at 22-26 days and the first flower opened 41-48 days after sowing. Once initiated, flowering continues for 40-60 days. Anthesis was observed between 6 a.m and 10 a.m. Anthers dehisce before flower opening and hence self pollination may occur at anthesis. The dehiscence of anthers is transverse and complete dehiscence occurs in 5-10 minutes (Purewal and Randhawa, 1947). Srivastava, (1964) indicated that pollen fertility is maximum in the period between an hour before and an hour after opening of the flower, pollen stored for 24 hours at room temperature (27° C) and 88% relative humidity was not viable. The stigma of the flower was most receptive on the day of flowering (90-100%). 50-70% and 1-15% stigma receptivity was observed the day before flowering and the day after flowering. Flowers open only once in the morning and close after pollination on the same day. The following morning the corolla withers.Okra has perfect flowers (male and female reproductive parts in the same flower) and is self-pollinating. If okra flowers are bagged to exclude pollinators, 100% of the flowers will set seed. It has been found experimentally that there is no significant difference in fruit set under open-pollinated, self-pollinated (by bagging alone) and self-pollinated (hand pollination of bagged flowers), indicating that it is potentiallya self-pollinated crop (Purewal and Randhawa, 1947). Although insects are unnecessary for pollination and fertilization in case of okra, the flowers are very attractive to bees and the plants are cross-pollinated. The cross pollination upto the extent of 4-19% (Shalaby, 1972) with maximum of 42.2% (Mitidieri and Vencovsky, 1974) Cultivar, competitive flora, insect population and growing season determines the extent of crosspollination(Tripathi *et al.*, 2011).

Seed Dispersal

During maturity okra fruits explode and shoot the seeds several feet away from the mother plant, thus okra belongs to a category of crops called explosive spreaders. The seeds of okra may spread upto 2-3 metres upon shattering (Tripathi *et al.*, 2011).

2.8 Methods of Reproductive Isolation

Okra is a self-pollinating crop that requires a considerable degree of separation between varieties to maintain purity. The observation that a plant is capable of self-pollination has sometimes been made into an argument that isolation of self-pollinators is not necessary. On the contrary, the ability to self-pollinate often has little to do with the amount of cross-pollination that can occur naturally (McCormack, 2004). As indicated earlier, research available on amount of natural cross-pollination in okra have shown that there is a considerable amount of cross-pollination. An isolation distance of 400 meters is required for production of foundation seeds of varieties/hybrids in case of okra as per Indian minimum seed certification standards (Tunwar and Singh, 1988). 400 meters as the isolation distance for conducting confined field trial of genetically engineered okra varieties/ hybrids has been adopted (Tripathi *et al.*, 2011).

2.9 Ecology

Climatic requirements

Okra requires a long, warm and humid growing period. It can be successfully grown in hot humid areas. It is sensitive to frost and extremely low temperatures. For normal growth and development a temperature range of 24°C - 28°C is required. At 24°C the first flower bud may appear in the third leaf axil while at 28°C it may appear in sixth leaf axil. This higher position is not necessarily accompanied with a delay in time because at higher temperatures the plants grow faster and the higher position is reached earlier **(**Tripathi *et al.,* 2011**)** Forfaster plant growth constant higher

temperature helps though it delays the fruiting. Flowers may desiccate and drop, causing yield losses, when tempreture exceeds 40^0C. A temperature range of 25°C to 35°C is needed for seed germination and optimum soil moisture, however fastest germination is observed at 35°C. Beyond this range the germination will be delayed and weak seeds may not even germinate **(**Tripathi*et al*., 2011)

Soil requirement

Okra thrives naturally in the low land rainforest soils, high in moisture and temperature(Adebayo *et al.,* 2013). It is usually grown on sandy to clay soils but due to its well developed tap root system, relatively light, well-drained, rich soils can also be used. A pH of 6.0–6.8 is ideallysuited.Before sowing all soils need to be pulverized, moistened and enriched with organic matter **(**Tripathi *et al*., 2011).

Biotic stresses

Although okra is considered a robust crop, under large-scale commercial production, yield losses are very high due to the incidence of a number of biotic. The most relevant biotic stress of okra is pest and disease.

Pests and Diseases of Okra

One of the most limiting factor hindering for the yield potential of okra is insect pest infestation. The cropis prone to damage by various insects, fungi, nematodes and viruses, although there is wide variability intheir degree of infestation. Fruit and shoot borer, aphids, jassids white flies, ants are some of the important insects affecting okra (Tiamiyu et al., 2012), tomato fruit worm (TFW) (*Helicoverpa armigera*) is the most destructive pest of okra. The TFW may be controlled by trap cropping using pigeon-pea borders (*Youm et al.,* 2005). Such an approach is being followed on okra in Niger, where the small size of okra fields and the farmer practice of planting borders of

other crops (example, sesame, roselle etc.) are assets for the adoption of such a technique (Ratnadass *et al.,* 2010).Aside the damage these insects causethey also serves as transmitting agents for several diseases. Okra is also prone to the attack of many diseases causing pathogens affecting leaves, flowers and fruits. The one particular serious disease of okra is yellow vein mosaic virus (YVMV) caused by YVM virus. (Tripathi *et al*., 2011), leaf curl disease caused by the begomovirus (Okra leaf curl virus, OLCV) transmitted by the white fly *(Bemisiatabaci*). OLCV disease has been found to be more prevalent in the savannah area than in the tropical-forest region (N'Guessan *et al.,* 1992). This viral disease is followed by root-knot nematodes (Meloidogyne spp.) which are major production hurdles, not only in the WCA but also in Middle-East Asia (Atiri and Fayoyin 1989).

Abiotic stresses

Unlike most vegetables, okra is traditionally cultivated as a rain-fed crop in the region. However, optimum soil moisture is required for good crop establishment especially during the initial one month after sowing. Drought and salinity are major abiotic factors adversely affecting okra production in the region (Adebayo et al., 2013).

2.9 Production of okra

Several varieties of okra are grown all over the world, various botanical species available are *Abelmoschus esculentus L*., *Moench Abelmoschus maschatus Medicus* and *Abelmoschus manihot* (Babarao *et al.,* 2014). It is one of the most widely known and utilized species of the family Malvaceae. In West and Central Africa (WCA), okra is called Gombo (French), Miyan-gro (Hausa), La (Djerma), Layre (Fulani), Gan (Bambara), Kandia (Manding), Nkruma (Akan), Fetri (Ewe) and is among the most frequently and popularly consumed traditional vegetables (Kumar *et al.,* 2010). Physically, okra has cylindrical shape and conical extremity, sup- ported by a

peduncle. It has a complex inside structure. The cut, from the outside to inward, shows a thick skin, then a spongy material in the center. Between both, there are alveoli, creating cavities which accommodate spherical seeds. These three materials have different structures (Ouoba *et al.*, 2010). Most okra cultivars require about 4 months from sowing to harvest, though some early maturing varieties can produce fruits after 50 days in the tropics (Olivera *et al.*, 2012).Okra is suitable for cultivation as a garden crop as well as on large commercial farms (Milton Abigael, 2015).

2.10 Production statistics and cropping systems

Out of the total world production of 4.8 million ton pod yield of okra, India has the major share of 70%, Nigeria 15%, Pakistan 2%, Ghana 2%, Egypt 1.7% and Iraq 1.7% (Gulsen *et al.*, 2007). Home to about 100 million of the world's poorest people, West and Central Africa has the world's most fragile ecosystem for agriculture, yet about 80% population depend on agriculture for their livelihoods. The WCA region accounts for more than 75% of okra produced in Africa, but the average productivity in region is very low (2.5 t/ha) compared to East (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). In the region, okra is traditionally cultivated as a rainy season crop by women, often on most marginalized lands easily accessible to them. The region's soil is low in organic matter and land degradation is a critical task that needs to be addressed. Rapid urbanization and population growth has caused an increase marketoriented okra production in peri-urban zones (Attigah *et al.*, 2013). Okra is now cultivated as an irrigated crop during the dry season, where it is often produced in mixed cropping with other crops. On degraded lands, okra has proven to be an important rain-fed crop along with roselle (Pasternak *et al.*, 2009).

2.11 Production Considerations

Cultivar selection

Maximum plant height, maturity period, and yield potential vary among okra cultivars. Fruit (pods) may be smooth or ridged while shape can be fat or slender. Pod color may be green, red, or nearly white, some cultivars produce pods that remain tender to a larger size(Chandra et al., 2016). Spineless cultivars have fewer spines on leaves and stems, making them less irritating to harvest. Consideration needs to be given to regional preferences, as well as whether to grow hybrids and/or heirloom cultivars. Growers should select only adapted varieties that have the qualities in demand for the intended market (Onwu *et al*., 2014).

Site selection and planting

Well-drained, fertile, silt loam soils are most desirable; however, okra will grow on a wide range of soil types as long as the site is well- drained. Okra is a hot weather plant and should be seeded only after the soil has warmed up (Makinde and Ayoola, 2012). Okra is usually planted at stake or in situ but can also be transplanted to the field, which will potentially provide an earlier harvest. Very high yields have been obtained with transplanted okra using black plastic mulch and drip irrigation(Attigah *et al.*, 2013).

Pest management

Okra is highly susceptible to root knot nematodes. Other common diseases include fungal wilts (Verticillium and Fusarium) and fruit rots. These diseases are controlled primarily by following proper cultural practices, including crop rotation (Farinde *et al.*, 2007).Inspection should be carried out to monitor insect populations can help farmers determine when and how often insecticides should be applied. Weeds are controlled mechanically through cultivation or chemically with herbicides.

2.12 Harvest and storage

Pods are cut from plants while they are still tender (typically 2 to 3½ inches long) and are graded according to size. During rapid growth periods, pods must be picked, at a minimum, of every day or every other day(Ogunsola *et al.*, 2012). It is very important that farmers have labour on hand to harvest on timely bases, since pods that are allowed to stay on the plant will become too large for commercial sales. During hot weather the difference between having a profitable harvest and having pods that are too large to be sold can just be a few days(Uka *et al.*, 2013). Although okra can be harvested over several weeks of time, harvesting should be done on a regular basis to increase yields. Yields average 8,000 to 10,000 pounds per acre. Okra may be stored for up to 10 days under the proper conditions (Uka *et al.*, 2013).

2.13 Uses and Economic importance of okra

Okra is grown mainly for its pods which are used either, fresh, canned or dried and ground as powder. Okra contains carbohydrate, proteins and vitamin C in large quantities. The essential and non-essential amino acids that okra contains are comparable to that of soybean. Hence it plays a vital role in human diet (Farinde *et al.*, 2007). For consumption, young immature fruits are important fresh fruit vegetable that can be consumed in different forms. They could be boiled, fried or cooked. In Nigeria, okra is usually boiled in water resulting in slimy soups and sauces, which are relished. The fruits also serve as soup thickeners. The leaves buds and flowers are also edible. Okra seed could be dried. 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.Okra leaves are considered good cattle feed, but this is seldom compatible with the primary use of the plant (Farinde *et al.*, 2007). Young leaves and pod of are edible and have been consumed in many

societies(State, 2013). Okra roots and stem are also used as cleaning agent for cane juice (Chauhan, 1972).

2.14 Potential of okra in improving livelihood

Okra has huge potential for enhancing livelihoods in urban and rural areas and to several stakeholders. It offers a possible route to prosperity for small-scale and large-scale producers alike and all those involved in the okra value chain, including women producers and traders (NARP, 1993; Kumar *et al.,* 2010; Agbenorhevi *et al., 2015).*

2.15 Pectin

Pectins are described as acidic heteropolysaccharides composed mainly of **α**(1-4) linked **α**-Dgalacturonic acid (GalA) residues. Three major structural units of pectic polysaccharides are recognised, all containing various amounts of GalA residues (Alba *et al.*, 2015).It is generally found in the cell walls and middle lamellae of higher plants. The pectins of a plant can be watersoluble, chelator soluble, or protopectins. Pectin can be obtained from many sources with a variation in the percentage yield (Ismail *et al.*, 2012). Commercial pectin extraction is mainly from citrus peel and apple pomace, but several other sources exist such as sugar beets and sunflower heads. Pectin form gels under certain circumstances, the gelling mechanism is highly dependent on the degree of methoxylation (DM). Conventionally, pectin is divided into high methoxy (HM) pectin with DM > 50% and low methoxy (LM) pectin with DM < 50%. Pectin with DM > 50% forms gels in the presence of high sugar concentration, usually sucrose or fructose and low pH; whereas pectin with DM < 50% forms gels in the presence of divalent ions(Castillo-Israel et al., 2015). The viscoelastic properties of pectins are the base of their broad use as a gelling agent and stabilizer in food products. The suitability of pectins for different purposes is determined by their character namely, anhydrouronic acid content, methoxyl content and degree of esterification

(Girma and Worku, 2016). Pectin is usually used in jams and jellies as a gelling agent and also used for fruit preparations, fruit drink concentrates, fruit juice, desserts and fermented dairy products. Pectin extraction is usually accomplished with water, mineral acids, hydrochloric acid, nitric acids, sulphuric acids and phosphoric acid. In a broad sense two types of pectin are available in nature including high methoxyl pectin (greater than
50% degree of esterification) and low methoxyl pectin (below 50% degree of esterification) (Azad *et al.*, 2014).

2.16 Extraction of pectin

Extracted pectin can be categorized into two major categories depending on the percentage of galacturonic acid residues that are esterified with methanol. A degree of methoxylation (DM) greater than 50% is considered high methoxyl pectin and a DM below 50% is considered low methoxyl pectin (Braddock, 1999). A subset of low methoxyl pectin exists called amidated pectin that is produced through de-esterification of high methoxyl pectin with ammonia (Braddock, 1999). These types of pectin can be used for a wide range of end uses as their structures will yield a variety of gelling and texturizing abilities under differing conditions.An extraction process is the most important operation to obtain pectin from vegetal tissue(Devi et al., 2014). Pectin extraction is a multiple-stage physical–chemical process in which hydrolysis and extraction of pectin macromolecules from plant tissue and their solubilisation take place under the influence of different factors, mainly temperature, pH and time (Devi *et al.*, 2014).

Extraction conditions vary and are dependent on the pectin source. The most common extraction method used is the dilute mineral acid method. In this method hydrochloric, sulfuric, or nitric acid is used. The material that contains pectin is added to hot water and a dilute mineral acid is added for extraction. Sufficient time elapses to allow extraction to occur and then the solids are separated

from the pectin containing liquid through filtration or centrifugation. The remaining solution is concentrated and mixed with an alcohol for pectin precipitation. The precipitated pectin is separated and washed with alcohol to remove impurities. The pectin is dried, ground to a powder, and blended with other additives, if necessary. Laboratory scale extractions have been conducted to determine optimal pectin extraction conditions and the feasibility of pectin extraction from a number of different plant materials. The optimum extraction condition including extraction time of 4.94 h, extraction temperature of 94.97 ◦C, number of extraction of 4, and the ratio of water to raw material of 21.74 has been suggested by Samavati (2013).

2.17 Uses of pectin

Pectin is capable of forming gels with sugar and acid, because of this gelling ability one of the well-known uses of pectin is in high sugar jams and confectionery jellies. Because it is a natural additive for foods, pectin is being considered for a number of applications beyond the traditional jams and jellies. Pectins are now used as thickeners, water binders, and stabilizers. It is used in yogurts and pastry glazes and as a stabilizer in drinkable yogurts and blends of milk and fruit juices. Pectin is also being used as a texturizing fat replacer to mimic the mouth-feel of lipids in low-calorie foods and shorter chain galacturonic acids have been considered as clarification agents in fruit juices (Braddock, 1999). Pectin has also been investigated for its usefulness in the pharmaceutical industry. Among other uses it has been considered in the class of dietary fibers known to have a positive affect on digestive processes and to help lower cholesterol (Braddock, 1999). It also is utilized to stabilize liquid pharmaceutical emulsions and suspensions (Ghori *et al., 2015)*..

2.18 Okra mucilage and its potential

Mucilage is a plant hydrocolloid which is a polymer of a monosaccharide or mixed monosaccharide (Deogade *et al.,* 2012). Polysaccharide mucilage is a highly hydrophilic substance with high molecular weight molecules. The polysaccharides are soluble and dispersible in water due to their ability to interact with water and swell (Noorlaila *et al.,* 2015). The swelling properties are characterized by the entrapment of large amount of water between the polymer chains and branches. Okra mucilage refers to the thick and slimy substance found in fresh as well as dried pods. Mucilaginous substances are usually concentrated in the pod walls

(not in seeds) and are chemically acidic polysaccharides associated with proteins and minerals (Woolfe *et al.,* 1977). Although nature of the polysaccharides varies greatly, neutral sugars rhamnose, galactose and galacturonic acid have been reported often (Hirose *et al*., 2004; Sengkhamparn *et al..*, 2009). The okra mucilage can be extracted as a viscous gum using various procedures. Such diversity in the extraction procedures seems to contribute to the observed variability in the mucilage chemical composition (Ndjouenkeu *et al*., 1996). Okra mucilage is a renewable and inexpensive source of biodegradable material. Its physical and chemical

properties include high water solubility, plasticity, elasticity and viscosity (BeMiller et al., 1993). Okra pectin obtained by sequential extraction are described as acidic random coil heteropolysaccharides containing **α**(1-2) rhamnose and **α**(1-4) galacturonic acid residues with disaccharide side chains composed of galactose attached to O-4 of half of the rhamnose residues It has been also reported that okra extracts contain high amounts of RG-I segments and acetylation on rhamnose residues something that is uncommon for pectin from other sources (Sengkhamparn *et al.,* 2009). Most physical and chemical properties are influenced by factors such as temperature, pH, sugar and salt contents, and storage time (Woolfe *et al.,* 1977). Okra mucilage has potential for use as food, non-food products, and medicine. Food applications include use as a whipping

agent for reconstituted egg whites, as an additive in the formulation of flour-based adhesives, and as an additive in India for clarifying sugarcane juice. Non-food applications include 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 (BeMiller *et al.,* 1993; Ndjouenkeu *et al.,* 1996). Polysaccharides can be combined with acrylamide to develop new biodegradable polymeric materials (Mishra et al., 2008). Potential of mucilage for medicinal applications includes uses as an extender of serum albumin (BeMiller et al., 1993), as tablet binder (Ofoefule *et al.,* 2001) and as suspending agent in formulations (Kumar *et al.,* 2009). Okra mucilageis used in Asian medicine as a protective food additive against irritating and inflammatory gastric diseases (Lengsfelf *et al.,* 2004).

2.19 Chemical and nutritional composition of okra

Okra just like any other vegetable, okra contains a lot of chemicals/minerals and nutrients (Table 1). Okra seeds contain 40% oil contents which can be an alternative source of edible oil. The young pods constitute mucilage (a mixture of carbohydrates and pectin) which is used as a thickener in food industries (Woolfe *et al.,* 1977). K, Na, Mg and Ca are the principal elements in pods, which contain about 17% seeds. Fresh pods are low in calories (20 per 100 g), practically no fat, high in fiber, and have several valuable nutrients, including about 30% of the recommended levels of vitamin C (16 to 29 mg), 10 to 20% of folate (46 to 88 g) and about 5% of vitamin A (14 to 20 RAE) (NAP, 2006). Both pod skin (mesocarp) and seeds are excellent source of zinc (80 g/g) (Glew, 1997; Cook et al., 2000). Okra seed is mainly composed of oligomericcatechins (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) (Kumar *et al.,* 2010). Pods and seeds contains phenolic compounds with important biological properties like quartering

derivatives, catechin oligomers and hydroxycinnamic derivatives (Arapitsas, 2008). Fresh okra pods are the most important vegetable source of viscous fiber, an important dietary component to lower cholesterol (Kmoyinl and Jenkins, 2004). Like soybean oil, okra seed oil is rich (60 to 70%) in unsaturated fatty acids (Savello et al., 1980; Rao, 1985). Seed protein is rich in tryptophan (94 mg/g N) and also contains adequate amounts of sulfur-containing amino acid (189 mg/g N) — a rare combination that makes okra seeds exceptionally useful in reducing human malnutrition (NAP, 2006). Okra seed protein has 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, 1985). Moreover, okra seed oil has potential hypocholesterolemic effect (Rao et al., 1991).

Table 1: Nutritional value of raw Okra per 100g

Energy	33kcal
Carbohydrates	7.45 g (140 kj)
Sugars	1.48 g
Dietary fibers	3.2 g
Fat	0.19g
Protein	2g
Water	90.19g
Vitamin A	36µg(7%)
Thiamine(B1)	0.2 mg (17%)
Riboflavin(B2)	0.06mg (5%)
Niacin (B3)	1mg (7%0
Vitamin C	23mg (28%)
Vitamin E	0.27 mg (2%)
Vitamin K	31.3 µg (30%)
Calcium	82mg (8%)
Iron	0.62 mg (5%)
Magnesium	57 mg (16%)
Potassium	299mg (6%)
Zinc	0.58 mg (6%)

2.20 Seed as potential edible oil and flour source

Like soybean oil, okra seed oil is rich (60 to 70%) in unsaturated fatty acids (Crossly and Hilditech, 1951; Savello *et al*., 1980; Rao, 1985). Seed protein is rich in tryptophan (94 mg/g N) and also contains adequate amounts of sulfur-containing amino acid (189 mg/g N) — a rare combination that makes okra seeds exceptionally 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, 1985). Moreover, okra seed oil has potential hypocholesterolemic effect (Rao *et al.,* 1991). The potential for wide cultivation of okra for edible oil as well as for cake is very high (Rao, 1985). Okra seed flour could also be used to fortify cereal flour (Adelakun *et al.,* 2008). For example, supplementing maize ogi with okra meal increases protein, ash, oil and fiber content (Akingbala *et al.,* 2003).

2.21 Health benefits of okra

Okra is a vegetable that has a lot of stored nutrients. There are two kinds of fibers that you can get from Okra, the soluble and the insoluble fibers. Soluble fibers helps in lowering cholesterol serum and the risk of having a heart disease, while insoluble fibers are good for the intestines as it makes sure that the intestinal track stays healthy. It also helps in avoiding any cancer diseases specially the colorectal cancer (Osawaru *et al.*, 2014). Okra has an ability to lower total cholesterol levels, improve digestive health, improve cardiovascular health, aid the immune system, lower blood pressure and protect heart health. As a vision Booster, okra contains a very high content of vitamin 'A', as well as antioxidants components like beta carotenes, xauthein and lutein. Antioxidants are powerful compounds that destroy or neutralize free radicals, which are the dangerous byproducts of cellular metabolism (Kumar *et al.*, 2013). Free radicals are responsible for the degradation of

the cells in the body including those responsible for vision. With high levels of okra in your diet, you will have more protection for your sight, including muscular degeneration and cataracts (Kumar *et al.*, 2010; Kumar *et al.*, 2013).

2.22 Medicinal uses okra

Okra has the following medical properties: antispasmodic; demulcent; diaphoretic; diuretic; emollient; stimulant; vulnerary. The roots are very rich in mucilage, having a strongly demulcent action (Kumar *et al.,* 2010). This mucilage can be used as a plasma replacement. An infusion of the roots is used in the treatment of syphilis. The juice of the roots is used externally in Nepal to treat cuts, wounds and boils. The leaves furnish an emollient poultice. A decoction of the immature capsules is demulcent, diuretic and emollient. It is used in the treatment of catarrhal infections, dysuria and gonorrhoea. The seeds are antispasmodic, cordial and stimulant. An infusion of the roasted seeds has sudorific properties (Kumar *et al.*, 2013). Purgative properties okra possesses are beneficial for bowel purification. Due to okra fiber content, sufficient water levels in faces are ensured. Consequently, no discomfort and constipation bothers the patient (Farinde *et al.*, 2007). Wheat bran, applied for this purpose, can impose certain irritation on the bowels, while okra makes it smooth and all- convenient and safe for the user. Mucilage provides soft effect on the bowels. Stimulating bile movement, okra washes excess cholesterol and harmful substances from the body, this benefits the organism in general, as the toxins and bad cholesterol can induce various health conditions(Mamkagh, 2016). Okra poses no threat to the organism, causes no addiction; it is completely safe and Reliable. Moreover, it contains a bunch of useful nutrients and is cheaper than chemical alternatives. Okra contains fibre is a valuable nutrient for intestine microorganisms, this ensures proper intestine functionality(Noorlaila *et al*., 2015). Okra ensures recovery from psychological and mental conditions, like, depression and general weakness. Okra is an effective

remedy for ulcers and joint healthiness. It is used counteract the acids, due to its alkaline origin. It also guards the mucous membranes of the digestive system, by covering them with additional layer. Okra is additionally applied for pulmonary inflammations, bowel irritations, and sore throat. According to Indian researches, okra is a complex replacement for human blood plasma. In order to keep the valuable substances safe, it's necessary to cook okra as shortly as possible, processing it either with steam, or on low heat (Kumar *et al.*, 2010; Attigah *et al.*, 2013).

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Survey on Okra utilization

At least 200 questionnaires were administered in each major producing areas/regions including Northern, Upper East, Eastern, Central/Western, Brong Ahafo, Ashanti, Volta and Greater Accra. In all a total 1560 questionnaires were administered randomly to both male and females including mostly farmers and marketers. The study was conducted between June and November 2016. Translations were made in the native language where respondents could not speak English. The questionnaire used is as shown in Appendix 1.

3.2 Extraction and Determination of Okra Pectin Yield

Okra (Balabi genotype) was cultivated in Akrofu, Volta Region from August 2016 to November 2016 and all agricultural practices including thinning, weed control and watering were carried out under controlled environmental conditions. The okra pods were harvested at different ages (5-19 days) after flowering. The okra pods were cut and the seeds removed. The separated okra pods were dried, milled to powder and then stored in zip-lock bags in a freezer until ready for extraction. Okra pectin was isolated using extraction method at pH 6.0 according to previous extraction protocol (Alba *et al.,* 2015).

The dried okra powder (20g) was defatted with petroleum ether (1g:10 ml) by placing the okraether mixture on a rotar shaker (120 rpm, 25^{o}C) for 4 h. The defatted okra powder was subjected to aqueous extraction with 0.1M phosphate buffer (1g powder: 30ml buffer solution), pH 6 at 80 ^{o}C for 1 h. After extraction, the soluble polymer was separated from the insoluble residue by centrifugation (3000 rpm for 10 min at 25 ^{o}C). The solubilized pectin in the supernatant was

concentrated by evaporation at 80 ºC and then precipitated with 96 % (v/v) aqueous ethanol at 40 ºC for 1h (1:2). Extraction with aqueous alcohol is to remove proteins and some polar compounds. Pectin substances were precipitated with the ethanol. The extraction with ethanol was followed with washing using isopropanol and then oven dried.

The pectin yield will be calculated based on the amount of dry powder sample used for the extraction process and the amount of dried pectin after extraction (Archana *et al*., 2013; Samavati, 2013). The percentage yield (w/w) was calculated on dry weight basis using the following equation:

$$\text{Pectin extraction yield } (\%) = \frac{weight\ of\ dried\ pectin\ extract}{weight\ of\ dried\ okra\ powder} \times 100 \qquad (1)$$

3.3 Protein content analysis

Protein content of the okra extract was analysed by means of the Lowry method. The protein content of the samples was calculated using standard calibration curve, which was generated with Bovine Serum Albumin (BSA) (200 -3200 µg ml^{-1}). The blank (0 µg ml^{-1}) consists of distilled water and dye reagent. The dried okra pectin extract (1 mg) was weighed and dissolved in 1 ml of distilled water. The mixture was warmed at 40 ºC until pectins dissolved. The samples (100 µl), each standard and blank (100 µl) were pipetted into separate clean test tubes. Lowry reagent (100 µl) was added to each tube, vortexed and incubated for 10 min at room temperature. Folin-Ciocalteau phenol reagent (50 µl) was then added and resulting solution was vortexed and incubated at room temperature for 30 min Absorbance readings were then taken at 650 nm using a spectrophotometer.

3.4 Total Carbohydrate content analysis

Total carbohydrate was determined by using the phenol-sulphuric acid method. A 10 mg of the dried pectin extract was weighed and dissolved in 100 ml of distilled water. The mixture was warmed with stiring at 40 ^{o}C until complete solubilisation and 2 ml of the solubilized pectin solution was pipetted into separate clean test tubes. 6 ml of concentrated sulphuric acid was added to each tube followed by 1.2 ml of 5 % Phenol was subsequently added and the resulting solution was vortexed and incubated for 5 min at 90 ^{o}C in a static water bath. The solution was then allowed to cool to room temperature and absorbance readings were then taken at 490 nm using a UV-VI spectrophotometer. The total carbohydrate content was calculated using a standard calibration curve generated with galactose (0-40 µg ml^{-1}). The blank (0 µg ml^{-1}) consists of distilled water, concentrated sulphuric acid and 5 % phenol.

3.5 Statistical analysis

The data obtained were analyzed using IBM SPSS Statistics 20 (IBM Corp., 2011). Analysis of variance (ANOVA) was performed at 5% level of significance to test for differences among variables.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1 Okra Survey Findings

Table 2 presents the demographics of 1560 respondents in the okra survey conducted.

Table 2: Demographics of respondents and their knowledge of Okra

Parameter	Frequency (%)
Gender	
Male	38.9
Female	61.1

Age group	
Below 20	11.6
21-30	36.4
31-40	28.5
41-50	15.2
Above 50	8.3
Occupation	
Farmers	10
Sellers	25.3
Others	64.7
Education	
Basic School	23.7
Secondary	36.9
Tertiary	22.7
Non-formal	16.7
Ethnic Group	
Akan	22.5
Fante, Wasa, Nzema	14.5
Ewe	21.9
Northern (Gurisi, Dagbani, Frafra)	28.0
Ga-Adangbe	13.1
Know Okra	
Yes	96.9
No	3.1
Know Varieties of Okra	
Yes	47.6
No	52.4

Okra popular known as okro in Ghana is locally known as nkruma (Akan), fetri (Ewe), pora (Kasem), momi (Krobo), manna (Dagbani), ma'na (nankam) and many more. A wide variety of okra exist in Ghana. However, there are no common names for the various okra varieties. Across the ethnic groups, it was found that okra is classified based on color (where varieties such as light green, dark green, dark and red exist), surface nature of pod (smooth-skin varieties and rough skin varieties), length (short and long varieties), season of growth (dry season and wet season varieties).

Out of the 1560 respondents, majority were females representing 61.1%. About 36.4 % of the respondents were aged between 21 – 30 years representing the majority. Vegetable farmers and sellers contributed to 10 % and 25.3 % of the total respondents. The results also indicate 36.9 % of the respondents had secondary education whilst respondents with non-formal education contributed 16.7 %. The northern ethnic groups contributed the largest percentage of 28.0 % whilst Ga-Adangbe ethnic groups contributed to 13.1 %. Although 96.9 % of the respondents knew okra, only 47.6 % had some knowledge of the various okra varieties. The varietal differences among the okra stemmed from differences in color, length, season of growth and surface characteristics of the fruit. Based on these characteristics, green (pale or dark), white, long, short, smooth skinned, rough skinned, rainy season and dry season okra varieties were reported across the various ethnic groups. The red variety (Porisongo) was reported among the Kasenas and Nankanas in the Upper East Region.

The preference for a particular variety of okra was based on its sliminess thus its ability to increase thickness of soup and stew. Some respondents preferred the short dark green varieties due to its high ability to increase the thickness of soups and stews. Whilst others preferred the long and white varieties which do not yield highly viscous soups and stews.

It was revealed that 9.2 % of the respondents do not eat okra with reasons such as okra causes (or aggravates) piles, impotency, nausea leading to vomiting after consumption. Others stated their dislike for okra due to its slimy nature in foods. Meanwhile some respondents suggested the consumption of dried okra for minimal health risks.

Despite the various buttressed dislikes for okra, most respondents were found to consume okra basically in the form of soup and stew. Majority of the respondents had no special reasons for

eating okra. It was however generally revealed that the consumption of okra in Ghana was based on its availability, suitability with certain foods, being a cultural food and medicinal/clinical benefits.

It was found that all the parts of okra plant are useful in various applications (food and medicine) especially in Northern Ghana. However, the fruit pod (both dry and fresh) was found to be widely used. The fresh okra stem was reported to be applied in pito clarification, the treatment of boils and sores as well as used for firewood. The leaves as well as the young flowers were found to be used in soups among the frafras, kasenas and nankanas in Upper East Region. The roots were also found to be applied in the treatment of cold and cough in children probably due to the presence of antibacterial phytochemicals.

Besides the treatment of boils, sores, cough and cold as mentioned above, the okra plants was found to be employed in child birth and in the treatment of shingles, chicken pox, diarrhea, fractures and dislocation. For the treatment of diarrhea, the fresh pod is usually sliced, boiled with salt pitre (‘kanwa’) and consumed.

In addition to the food and medicinal uses of okra, it was also found that the fresh stem was widely utilized in pito production for clarification purposes. The dried stems were also reported to be used as firewood for cooking especially in the rural areas of Upper Eastern Ghana.

It was revealed that 95.9 % of the respondents had little (or no) knowledge on the existence of products developed from the okra fruit. However, suggestions from the respondents included the development of canned okra, okra-based soap and medicinal products for treating chicken pox, shingles, diabetes and heart diseases.

About 65 % respondents stated that okra fruit is available throughout the year but abundant between June to September depending on the rains start in the year. About 64.8 %, 30.7 % and 7.6 % of respondents were found to preserve okra using drying, freezing and other methods respectively. Other methods such as blanching/parboiling before freezing (or refrigeration), submerging in water (at room temperature) and covering with a moist cloth or jute bag were found to be used in the preservation of the okra fruit.

Table 3: Eating frequency of okra among respondents per week

Description	**Frequency (%)**
Do not eat Okra	7.9
Once	24.3
Twice	29.1
Thrice	17.6
Four times	10.4
Five times	3.7
Six times	1.9
Everyday	5.2

Table 3 indicates majority of the respondents which represented 29.1 % eat okra at least twice in a week. About 24.3 % also eat okra at least once in a week whilst 5.2 % consumed okra every day. However, it was revealed that the eating frequency were influenced by ready increased availability and cheaper cost of okra when in season. Bulk cooking was also reported to be a factor in the eating frequency of okra among respondents.

The results indicate that 94.7%, 22.1% and 9.6% of the respondents use okra as food, medicine and other applications, respectively (**Figure 2**).

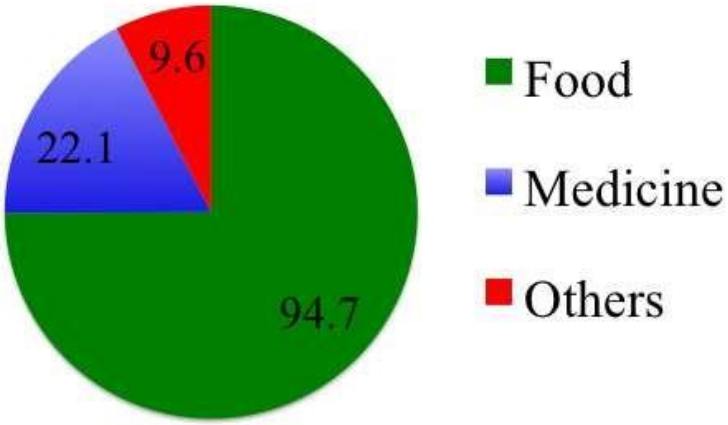

Figure 2: Uses of okra among respondents (%)

Okra is widely used as food in form of soup (73.1%) and stew (68.7%) consumed popularly with with banku (81.3%) and TZ (38.8%) (**Figure 3**; **Figure 4**).

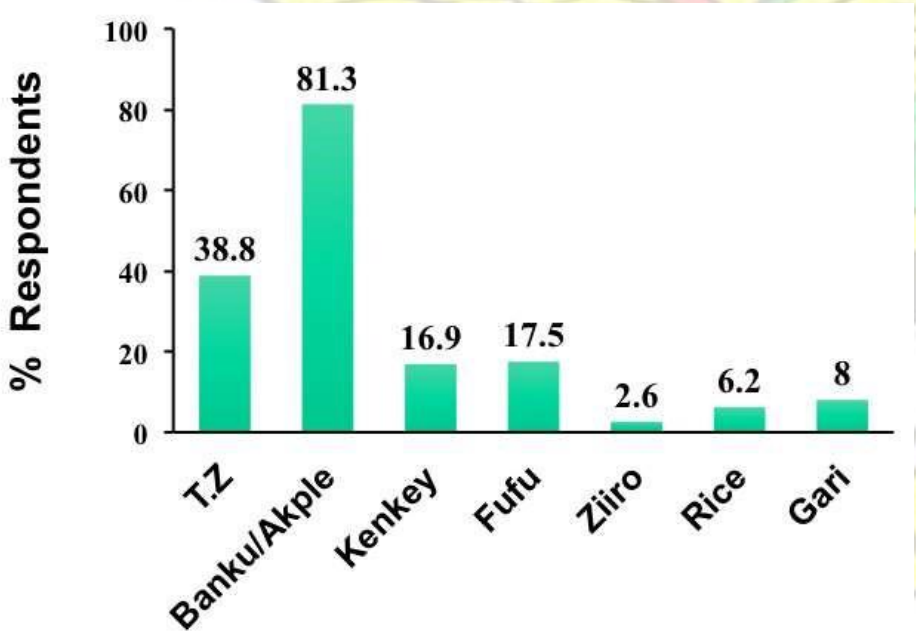

Figure 3: Foods consumed with okra among correspondents

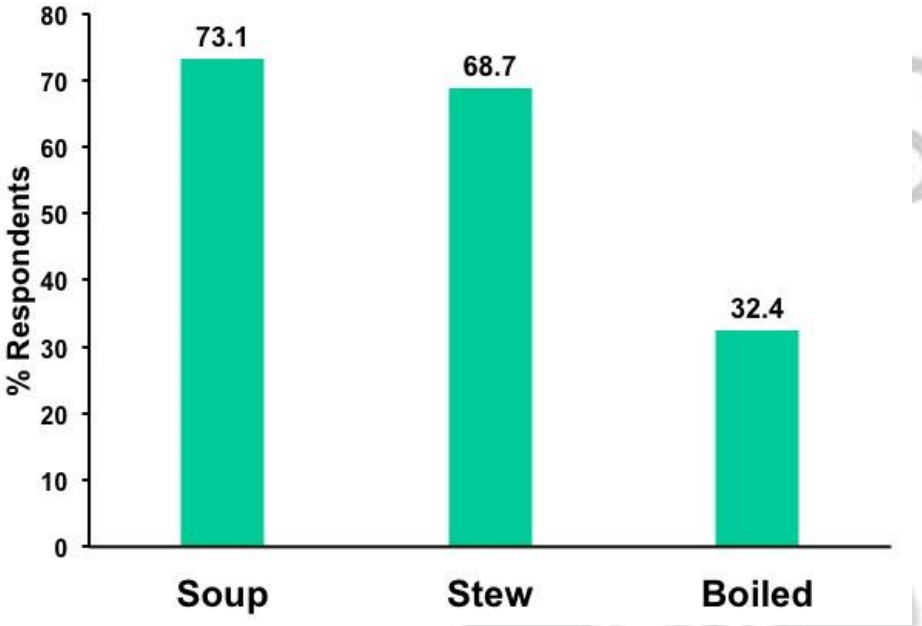

Figure 4: Forms of okra consumption

Table 4: The application of okra in the treatment of diseases

Disease	Frequency (%)
Diarrhoea	2.5
Boils, sores, wounds and inflammation	7.2
Dislocation and fractures	1.6
Ananse	4.7
Child birth	0.3
Others	7.1
None	76.5

Missing values = 0.4 %

About 22.1 % of the respondents revealed that okra is applied in the traditional medicine in treatment of at least diarrhea, boils, inflammation, dislocation, shingles, difficulty in child delivery and others including chicken pox, cold and diabetes (**Figure 2**). About 7.2 % respondents revealed the use of okra parts (leaves, roots, young flowers) in the treatment of boils, sores, wounds and inflammation (Table 4).

It was revealed that salt pitre and cola nuts were other materials used with okra in its medicinal applications. Crushed okra fruit pod or leaves were reported to be used in combination with crushed cola nuts in the treatment of shingles. In the treatment of diarrhea, respondents reported that fresh okra fruits were either sliced, chopped or crushed, boiled with salt pitre and consumed alone. It was also reported that okra soup or stew was consumed among individuals with low appetite for food.

As shown in **Table 5**, 65.2 % of the respondents reported that okra is always available and that 90.6 %, 21.6 % and 1.5 % of the respondents use okra fruit pods leaves and flowers respectively. The availability of the okra was reported to be influenced rainfall pattern. Okra was found to be generally used for food (94.7 %) and medicine (22.1 %). However, 9.6 % of the total respondents stated other uses involving the stem which included pito clarification and firewood in the rural areas. Okra fruits were found to be the most used (89.9 %) parts of the okra plant in food. The young leaves as well as moderately matured leaves were reported to be used in soups for consuming *Tuo Zaafi* and banku.

Table 5: Availability, personal use and utilization of okra among respondents

Description	**Frequency (%)**
Always Available	
Yes	65.2
No	34.8
Personal Use	
Leave	21.6
Fruits	90.6
Flowers	1.5
Knowledge of Any Okra Product	
Yes	4.1
No	95.9
General Uses of Okra	
Food	94.7

Fruit for food	89.9
Leave for food	34.0
Others (flowers) for food	1.5
Medicine	22.1
Fruit for medicine	11.5
Leave for medicine	8.1
Stem for medicine	12.8
Others for medicine	4.0
Others (pito clarification, firewood)	9.6
Fruit for others	0.8
Stem for others	10.8

Table 6: The frequency of the various forms of consumption among the ethnic groups

Ethnic Group	Total(n)	Soup		Stew		Boiled	
		Count	Percent	Count	Percent	Count	Percent
Akan	349	239	68.48	273	78.22	102	29.23
Fante, Wasa, Nzema	223	107	47.98	133	59.64	56	25.11
Ewe	341	218	63.93	151	44.28	25	7.33
Northern (Gurisi, Frafra, Dagbani)	435	381	87.59	344	79.08	285	65.52
Ga-Adangbe	204	136	66.67	114	55.88	11	5.39

Table 6 indicates 87.59 %, 79.08 % and 65 % of northerners consume okra in the form of soup, stew or boiled respectively. The Akans (78.22 %) consumed okra mostly in the form of stew.

The leaves, fruits and young flowers were reported to be utilized in soups and stews.

Table 7: The relationship between the ethnic group and various applications of okra

Ethnic Group	Total(n)	Medicine		Food		Others	
		Count	Percent	Count	Percent	Count	Percent
Akan	349	95	27.22	339	97.13	7	2.00
Fante,Wassa, Nzema	223	22	9.87	206	92.38	4	1.79
Ewe	341	30	8.80	313	91.79	4	1.17
Northern (Gurisi, Frafra, Dagbani)	435	183	42.07	433	99.54	125	28.74
Ga-Adanbge	204	15	7.35	180	88.24	8	3.92

From **Table 7**, okra is highly used (42.07 %) for medicinal purposes among the Northern ethnic groups (Gurisi, Frafra, Dagbani) although some respondents reported okra to be responsible for piles and impotency. About 28.74 % of the northern ethnic groups reported other uses of okra including, pito clarification and firewood in rural areas.

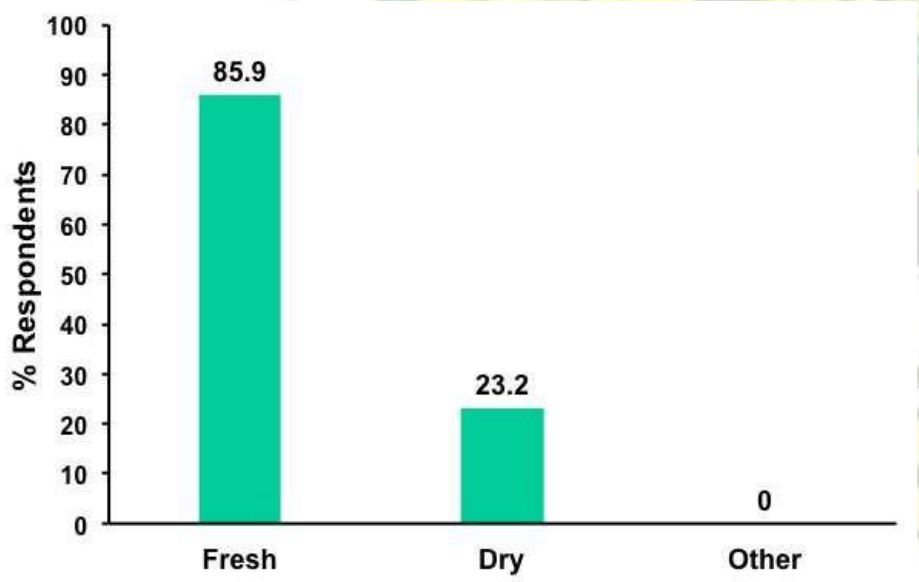

Figure 5: Forms of okra used in Food

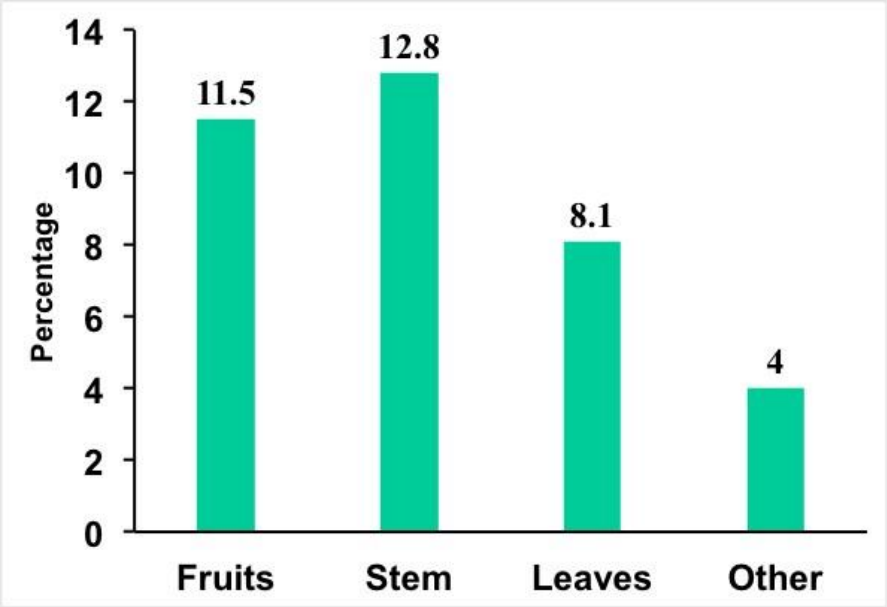

Figure 6: Utilization of Various Okra Parts in traditional medicine

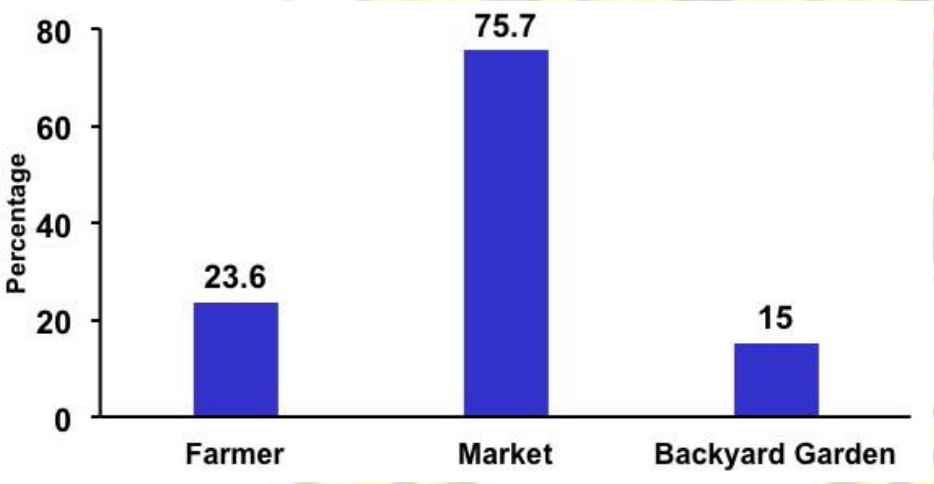

Figure 7: Sources of okra for correspondents

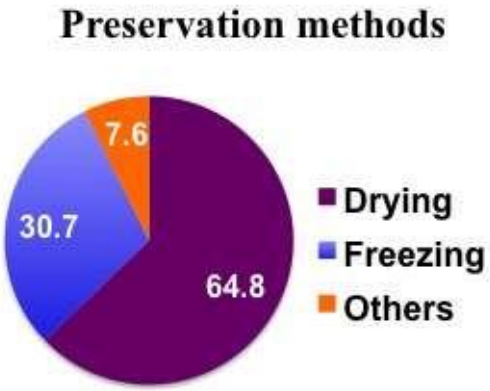

Figure 8: Availability and preservation of okra among the respondents

About 64.8 %, 30.7 % and 7.6 % of the respondents reported okra to be preserved by drying, freezing and other methods respectively (Figure 8). Freezing was reported to be used mainly for maintaining freshness though some consumers reported freezing had a negative impact on the taste and colour of okra. The results are indicative of limited form of processing and preservation for okra which is mostly available in the raining season implying the need to explore other means such as canning to ensure its availability and adequacy throughout the year.

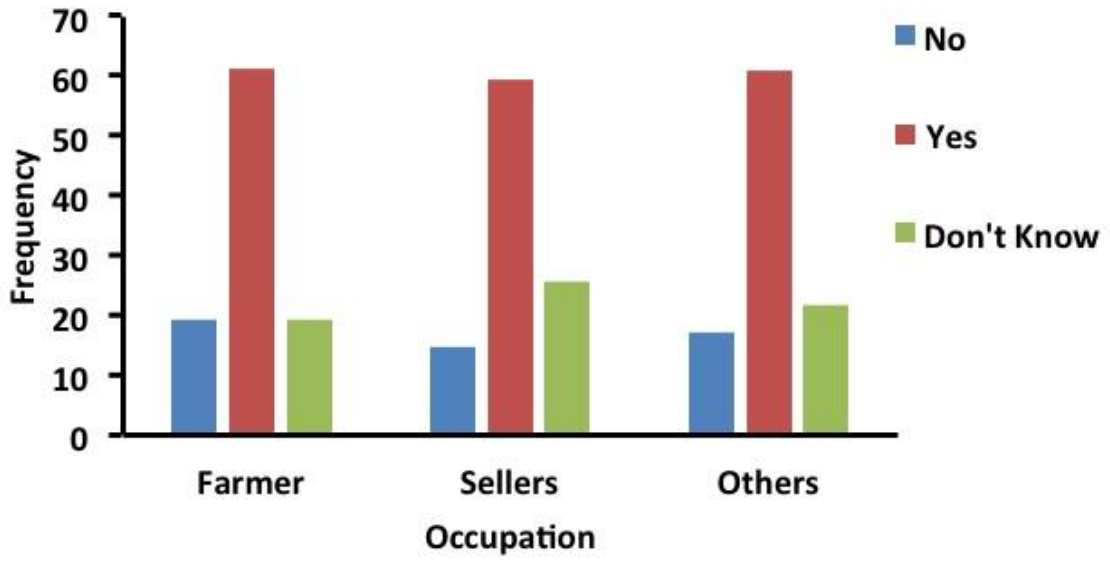

Figure 9: The relationship occupation and interest in new okra products

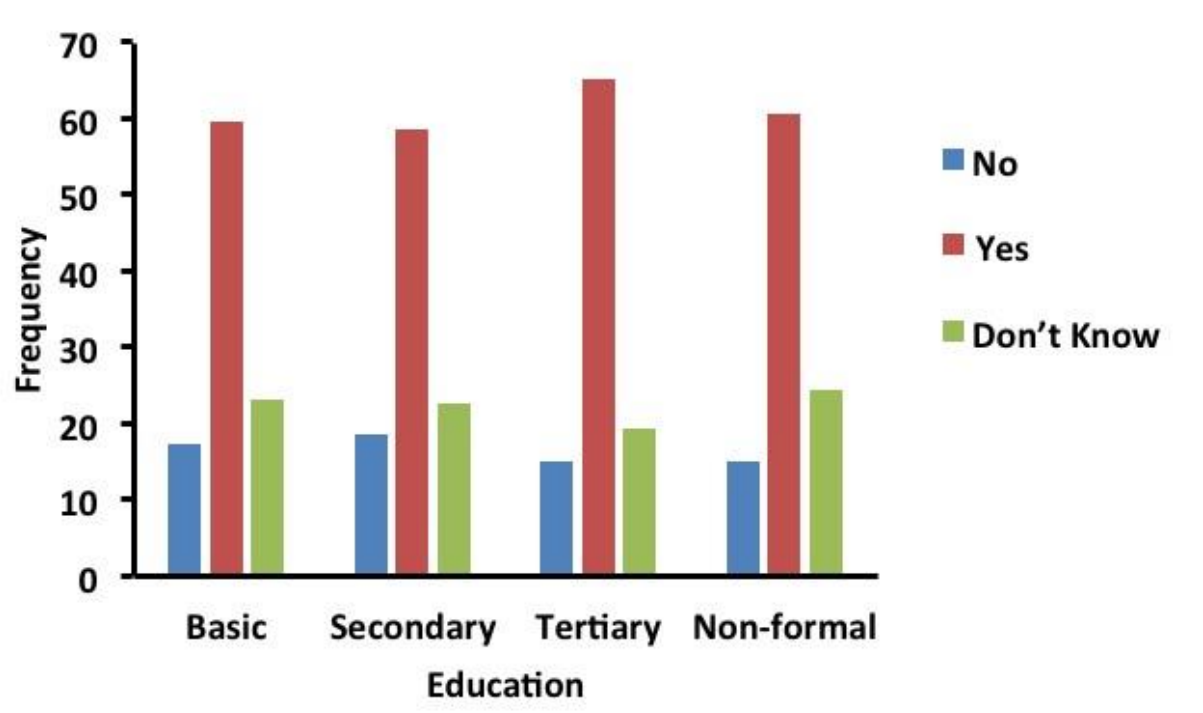

Figure 10: The relationship education and interest in new okra products

Farmers contributed the majority (61.29 %) of respondents interested in new okra products (**Figure 9**). However, individuals who were not interested in new okra products were of the view that, the products may be slimy in nature, which might make them undesirable.

The majority (65.22 %) of respondents with tertiary education (in the education category) were interested in new products being developed from okra (Figure 10). It was suggested that okra should used in soap production and canned okra products

4.2 Okra pectin at different maturity of the fruits

The okra pectin was extracted from Balabi genotype and the yield obtained as well as the purity (protein and carbohydrate contents) of the samples at different maturity of the okra fruits are presented in Table 7. The maturity used here refers to the days of harvesting after flowering.

Table 8: Okra pectin yield at different maturity and purity of extract.

Sample/Maturity (Days*)	Pectin Yield (%)	Total carbohydrate (%)	Protein (%)
5	12.5 ±1.0[a]	60.3 ±0.1[a]	11.6 ±0.2[a]
10-11	11.0 ±1.0[a]	60.1 ±0.2[a]	11.7 ±0.1[a]
14-15	20.7 ±1.1[b]	58.5+0.3[a]	11.9 ±0.1[a]
18-19	8.7 ±1.0[c]	59.7 ±0.2[a]	11.8 ±0.1[a]

*Days after flowering. Values ad Mean ±SD.

[a-c]Mean values in the same column followed by different superscript letters are significantly different ($p < 0.05$)

The results indicate that okra at 14-15 days after flowering produced the highest pectin yield (20.7%) (Table 7). However, samples harvested after 18-19 days of maturity had the least pectin yield. Thus pectin yield increased from the early maturity, peaked at 14-15 days and then decreased. Similar results have been reported previously where okra mucilage content increased from index 1 (light green coloured with soft texture) to index 2 (light green coloured but its texture

is hard) and then gradually decreased from the fruit tissues at maturity index 3 (green whitish or green yellowish with hard texture and tip not easily broken) (Sreeshma and Nair, 2013; Noorlaila *et al*. 2015). The increasing in pectin content from okra from the early maturity to the midlle age could be attributed to growth and development of the okra itself. The mucilage in okra contributes to moisture balance of the fruit and prevent it from drying out (Sreeshma and Nair, 2013). However, the declining in mucilage content as okra matures is possibly due to degradation process and lignification of the cell walls. It could also be due to drying out as the fruit matures. Thus the muscilage or pectinous matrix of cell layers undergoes degradation process as it enters senescence period (Western *et al., 2*000; Sreeshma and Nair 2013; Noorlaila *et al*. 2015). There were no significant differences ($p > 0.05$) in the protein (11.6-11.9%) and total carbohydrate contents of the crude extracts purity of the extracts obtained (58-60%) (Table 8) among the various samples. This is simply because the crude extracts were not further purified by dialysis. The results obtained, however, are similar to previous findings for both yield and purity of okra pectin extracts (Agbenorhevi *et al.* 2015; Alba *et al.* 2015).

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Okra is a widely known red or green vegetable across the country among the various ethnic groups. There are varietal differences among okra in Ghana. However, these are varieties are not scientifically classified leading to different names for the various varieties across the different ethnic groups. The fruit is available all year round but abundant in the rainy season between July to September.

Okra is widely used for food in Ghana in the form of soup and stew with banku. Okra also had other applications in traditional medicine, pito clarification and firewood. However, a greater number of the respondents showed interest in new products being developed from okra.

Differences in educational level, occupation and ethnic group had a significant influence on the utilization of okra in Ghana. In the medicinal utilization of okra, it greatly used especially in the rural areas of northern Ghana for the treatment of diarrhea, boils, sores, shingles, fractures and dislocations.

Results indicated that pectin yield was significantly influenced by the maturity of the fruit/pod. For Balabi genotype used, okra pods harvested 14-15 days after flowering produced the highest pectin yield implying the suitable maturity for harvesting the fruits if high pectin content/yield is desired.

5.2 Recommendations

The following are recommended for further studies to complement the present findings for to advance knowledge and increase the economic value of okra:

- Further studies to determine the stage of maturity and also method of cultivation for optimum pectin yield for the various okra genotypes
- Explore the utilization of okra pectin in foods and medicinal products

- Education of stakeholders (including farmers and marketers on the potential of okra in various applications and thus help improve or diversify its uses.

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APPENDICES

Appendix 1: Okra Survey Questionnaire

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI
DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

Topic: A Survey on Okra(Okro) utilization in Ghana

The purpose of this survey/questionnaire is to collect information on the uses of Okra. We would be very appreciative if you could please kindly take a few minutes of your time to fill this questionnaire for us. Thank you.

Please tick [✓] and/ or complete the blank space provided with your response as appropriate.

Background Data

1. Sex: Male [ ] Female [ ]
2. Age group: Below 20 [ ] 21-30 [ ] 31-40 [ ] 41-50 [ ] Above 50 [ ]
3. Your level of education? Basic level [ ] Secondary [ ] Tertiary [ ] Non-formal [ ]

   Other (specify)…….
4. Region/Town…….
5. Ethnic group……..
6. Occupation

……

Okra

7. (a) Do you know okra fruit? Yes [ ] No [ ]

(b) Do you know of the various varieties/types? Yes [ ] No [ ]

(c) If yes, which varieties do you know? Which do you prefer? Why do you prefer this variety?

.....

8. What is the local name for Okra? .....
9. Do you eat Okra? Yes [ ]/ No [ ]

   Why?.....
10. Which part of the okra do you use? Leaves[ ] Fruits/Pod[ ] Seed[ ] Other[ ]
11. Methods of preparation for consumption. In what form is Okra consumed?

    Soup[ ], Stew[ ], Boiled [ ] Fried [ ] Other (specify…….
12. What do you usually eat it with? .....
13. How many times do you consume it in a week? 1….. 2….. 3…. 4…. 5….. 6….. 7…..
14. In which state do you use the okra? Fresh [ ], Dry [ ], other ……
15. Where do you obtain your okra from? Farmer [ ], Market [ ] Backyard garden [ ]
16. Is it always available? Yes [ ] No [ ]
17. Which time of the year is it in abundance? ……

18. Methods of preservation? Drying [ ], Freezing [ ], Other (specify)……
19. (a) Do you know of any other uses of Okra fruit? Yes [ ] No [ ] (b) If Yes, please mention.....
    .....
    .
20. (a) Do you know of any product made with Okra? Yes [ ] No [ ]
    (b) If Yes, mention some?.....
    .....
21. (a) What are the uses of the Okra that you know ? Food/Eaten [ ] Tea [ ] Medicine [ ] Other (s) (specify) ……

    (b) Part(s) used for various applications

Okra uses	Part used

	Fruit/Pod	Leaves	Stem	Other (specify)
Eaten/Food				
Medicine				
Others……..				

22. Which disease do you use it to treat or prevent?
    .....

23. (a) Will you be interested in a new products developed from Okra?
    Yes [ ] No [ ] Don't know [ ]

    (b) If Yes, any

    suggestion?……

Thank you for completing this questionnaire.
Thank you for your cooperation in completing this survey.
Please provide your Name and Contact if you would like to know the outcome of this survey

……

Appendix 2: Some Statistical Outputs

Frequencies

Statistics

		Sex	Age Group	Level Education	Location/Region	Ethnic Groups	Occupation
N	Valid	1557	1549	1522	1560	1554	1549
	Missing	3	11	38	0	6	11

Statistics

		Knowledge of Okra	Knowledge of Types	Eat Okra?	Eating Frequency	Diseases Treated or Prevented with Okra
N	Valid	1558	1558	1560	1552	1553
	Missing	2	2	0	8	7

Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	605	38.8	38.9	38.9
	Female	952	61.0	61.1	100.0
	Total	1557	99.8	100.0	
Missing	System	3	.2		
Total		1560	100.0		

Age Group

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below 20	179	11.5	11.6	11.6
	21-30	564	36.2	36.4	48.0
	31-40	442	28.3	28.5	76.5
	41-50	236	15.1	15.2	91.7

	Above 50	128	8.2	8.3	100.0
	Total	1549	99.3	100.0	
Missing	System	11	.7		
Total		1560	100.0		

Level Education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Basic	360	23.1	23.7	23.7
	Secondary	562	36.0	36.9	60.6
	Teretiary	346	22.2	22.7	83.3
	Non-formal	254	16.3	16.7	100.0
	Total	1522	97.6	100.0	
Missing	System	38	2.4		
Total		1560	100.0		

Location/Region

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Upper East	201	12.9	12.9	12.9
	Northern	204	13.1	13.1	26.0
	Western	248	15.9	15.9	41.9

	Eastern	78	5.0	5.0	46.9
	Ashanti	259	16.6	16.6	63.5
	Greater Accra	195	12.5	12.5	76.0
	Volta	300	19.2	19.2	95.2
	Cape Coast	75	4.8	4.8	100.0
	Total	1560	100.0	100.0	

Ethnic Groups

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Akan	349	22.4	22.5	22.5
	Fante,Wasa,Nzema	225	14.4	14.5	36.9
	Ewe	341	21.9	21.9	58.9
	Northern(Gurisi,Frafra, Dagbani)	435	27.9	28.0	86.9
	Ga-Adangbe	204	13.1	13.1	100.0
	Total	1554	99.6	100.0	
Missing	System	6	.4		
Total		1560	100.0		

Occupation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Farmer	155	9.9	10.0	

	Vegetable/Food Seller	392	25.1	25.3	10.0
	Others	1002	64.2	64.7	35.3
	Total	1549	99.3	100.0	100.0
Missing	System	11	.7		
Total		1560	100.0		

Knowledge of Okra

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	49	3.1	3.1	3.1
	Yes	1509	96.7	96.9	100.0
	Total	1558	99.9	100.0	
Missing	System	2	.1		
Total		1560	100.0		

Knowledge of Types

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	816	52.3	52.4	52.4
	Yes	742	47.6	47.6	100.0
	Total	1558	99.9	100.0	
Missing	System	2	.1		
Total		1560	100.0		

Eat Okra?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	143	9.2	9.2	9.2
	Yes	1417	90.8	90.8	100.0
	Total	1560	100.0	100.0	

Eating Frequency

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	dont eat okra	122	7.8	7.9	7.9
	Once	377	24.2	24.3	32.2
	Twice	452	29.0	29.1	61.3
	Thrice	273	17.5	17.6	78.9
	Four	161	10.3	10.4	89.2
	Five times	57	3.7	3.7	92.9
	Six times	30	1.9	1.9	94.8
	Everyday	80	5.1	5.2	100.0
	Total	1552	99.5	100.0	
Missing	System	8	.5		
Total		1560	100.0		

Diseases Treated or Prevented with Okra

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	None	1188	76.2	76.5	76.5
	Diarrhoea	39	2.5	2.5	79.0
	Boils, Sores, wounds and inflammation	113	7.2	7.3	86.3
	Dislocation and Fractures	25	1.6	1.6	87.9
	Others (Diabetes, Heart diseases, Cold, Cough, Constipation etc)	110	7.1	7.1	95.0
	Ananse	73	4.7	4.7	99.7
	Easy Childbirth	5	.3	.3	100.0
	Total	1553	99.6	100.0	
Missing	System	7	.4		
Total		1560	100.0		

Interested in Ne Okra

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	264	16.9	17.0	17.0

	Yes	945	60.6	60.7	77.6
	Don't Know	348	22.3	22.4	100.0
	Total	1557	99.8	100.0	
Missing	System	3	.2		
Total		1560	100.0		

Statistics

		Soup	Stew	Boiled
N	Valid	1557	15582	1558
	Missing	3		2

Soup

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	417	26.7	26.8	26.8
	Yes	1140	73.1	73.2	100.0
	Total	1557	99.8	100.0	
Missing	System	3	.2		
Total		1560	100.0		

Stew

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	487	31.2	31.3	31.3
	Yes	1071	68.7	68.7	100.0
	Total	1558	99.9	100.0	

Missing	System	2	.1		
Total		1560	100.0		

Boiled

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	1053	67.5	67.6	67.6
	Yes	505	32.4	32.4	100.0
	Total	1558	99.9	100.0	
Missing	System	2	.1		
Total		1560	100.0		

Eat Okra?

Case Processing Summary

Eat Okra?		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Ethnic Groups	No	143	100.0%	0	0.0%	143	100.0%
	Yes	1411	99.6%	6	0.4%	1417	100.0%

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Ethnic Groups * Eat Okra?	1554	99.6%	6	0.4%	1560	100.0%

Ethnic Groups * Eat Okra? Crosstabulation

Count

		Eat Okra?		Total
		No	Yes	
Ethnic Groups	Akan	15	334	349
	Fante,Wasa,Nzema	41	184	225
	Ewe	30	311	341
	Northern(Gurisi,Frafra, Dagbani)	45	390	435
	Ga-Adangbe	12	192	204
Total		143	1411	1554

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Ethnic Groups * Eat Okra? * Soup	1551	99.4%	9	0.6%	1560	100.0%
Ethnic Groups * Eat Okra? * Stew	1552	99.5%	8	0.5%	1560	100.0%
Ethnic Groups * Eat Okra? * Boiled	1552	99.5%	8	0.5%	1560	100.0%

Count

Ethnic Groups * Eat Okra? * Soup Crosstabulation

Soup			Eat Okra?		Total
			No	Yes	
No	Ethnic Groups	Akan	8	95	103
		Fante,Wasa,Nzema	36	75	111
		Ewe	16	93	109
		Northern(Gurisi,Frafra, Dagbani)	17	9	26
		Ga-Adangbe	10	55	65
	Total		87	327	414
Yes	Ethnic Groups	Akan	7	239	246
		Fante,Wasa,Nzema	5	107	112
		Ewe	14	218	232
		Northern(Gurisi,Frafra, Dagbani)	28	381	409
		Ga-Adangbe	2	136	138
	Total		56	1081	1137
Total		Akan	15	334	349

Count					
	Ethnic Groups	Fante,Wasa,Nzema	41	182	223
		Ewe	30	311	341
	Total	Northern(Gurisi,Frafra, Dagbani)	45	390	435
		Ga-Adangbe	12	191	203
			143	1408	1551

Ethnic Groups * Eat Okra? * Stew Crosstabulation

Stew			Eat Okra?		Total
			No	Yes	
No	Ethnic Groups	Akan	6	61	67
		Fante,Wasa,Nzema	37	49	86
		Ewe	24	160	184
	Total	Northern(Gurisi,Frafra, Dagbani)	19	46	65
		Ga-Adangbe	6	78	84
	Ethnic Groups		92	394	486

Count

Yes		Akan	9	273	282
		Fante,Wasa,Nzema	4	133	137
		Ewe	6	151	157
		Northern(Gurisi,Frafra, Dagbani)	26	344	370
		Ga-Adangbe	6	114	120
	Total		51	1015	1066
Total		Akan	15	334	349
		Fante,Wasa,Nzema	41	182	223
		Ewe	30	311	341
	Ethnic Groups	Northern(Gurisi,Frafra, Dagbani)	45	390	435
		Ga-Adangbe	12	192	204
	Total		143	1409	1552

Ethnic Groups * Eat Okra? * Boiled Crosstabulation

Boiled		Eat Okra?		Total
		No	Yes	
No	Akan	12	232	244

Count					
	Ethnic Groups	Fante,Wasa,Nzema	40	126	166
		Ewe	30	286	316
	Total	Northern(Gurisi,Frafra, Dagbani)	24	105	129
		Ga-Adangbe	12	181	193
			118	930	1048
Yes	Ethnic Groups	Akan	3	102	105
		Fante,Wasa,Nzema	1	56	57
		Ewe	0	25	25
		Northern(Gurisi,Frafra, Dagbani)	21	285	306
		Ga-Adangbe	0	11	11
	Total		25	479	504
Total		Akan	15	334	349
	Ethnic Groups	Fante,Wasa,Nzema	41	182	223
		Ewe	30	311	341
		Northern(Gurisi,Frafra, Dagbani)	45	390	435
		Ga-Adangbe	12	192	204
	Total				

Count

	143	1409	1552

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Knowledge of Okra * Occupation	1547	99.2%	13	0.8%	1560	100.0%
Knowledge of Types * Occupation	1547	99.2%	13	0.8%	1560	100.0%

Knowledge of Okra * Occupation

Crosstab

Count

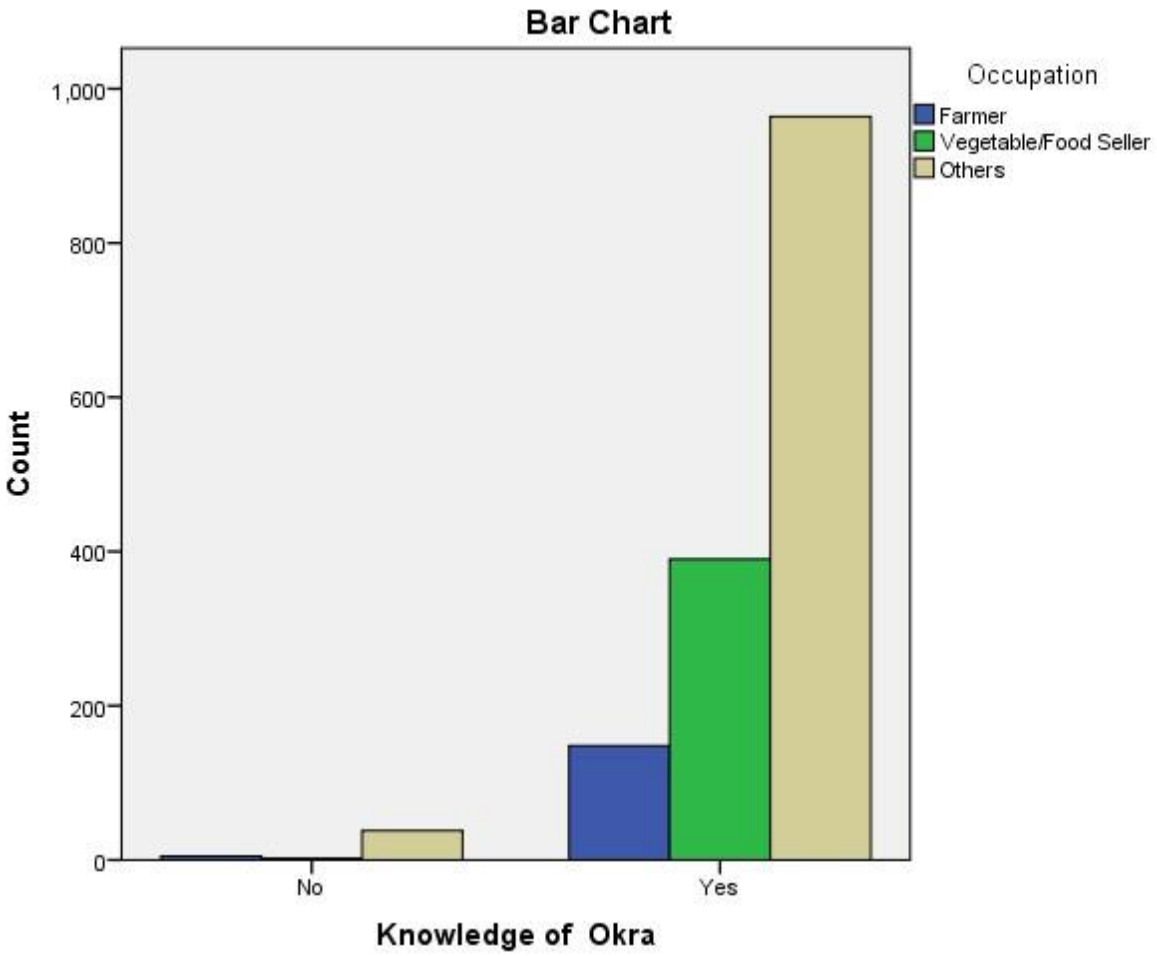
		Occupation			Total
		Farmer	Vegetable/Food Seller	Others	
Knowledge of Okra	No	5	2	38	45
	Yes	148	390	964	1502
Total		153	392	1002	1547

Chi-Square Tests

	Value	df	Asymp. Sig. (2sided)
Pearson Chi-Square	10.825[a]	2	.004
Likelihood Ratio	14.673	2	.001
Linear-by-Linear Association	3.541	1	.060

N of Valid Cases	1547		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 4.45.



Knowledge of Types * Occupation

Crosstab

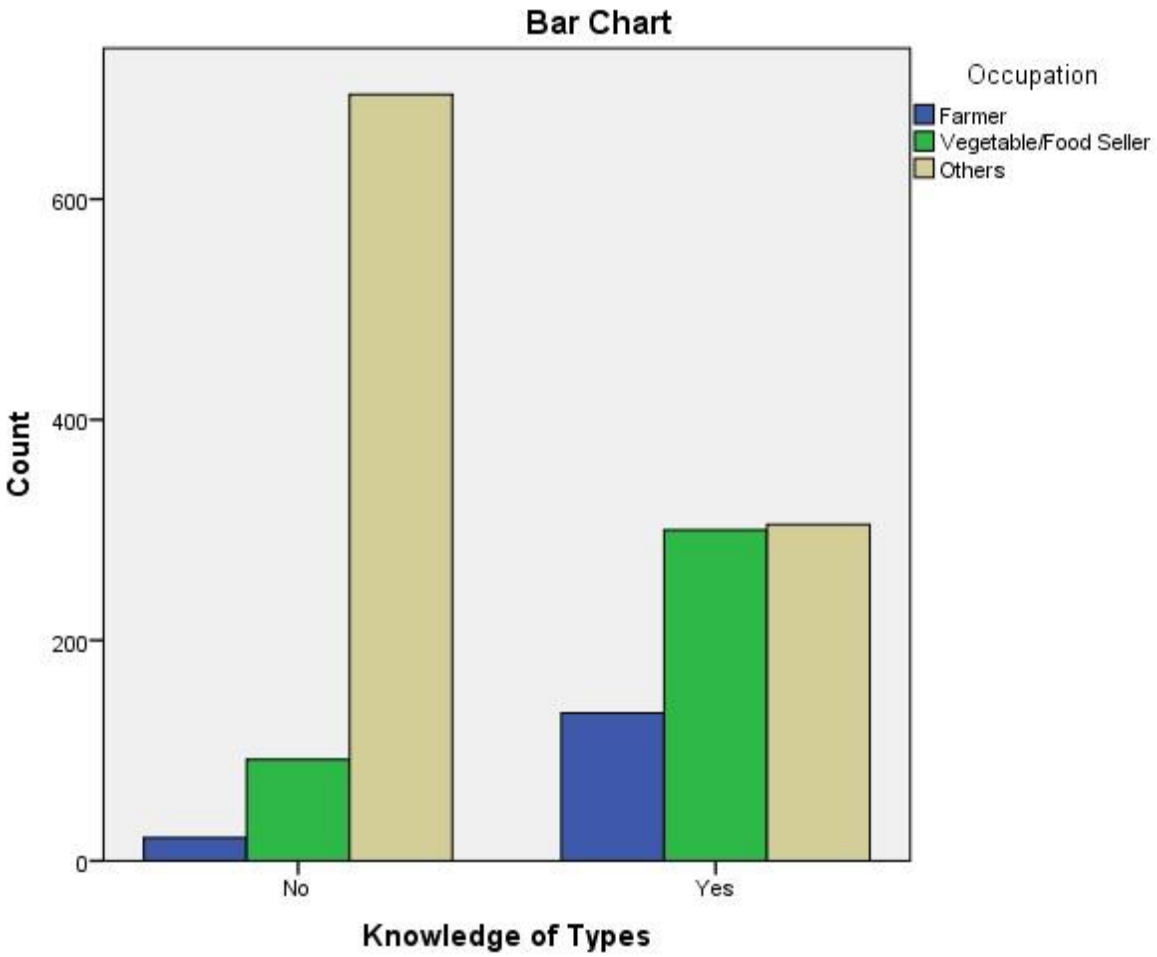
Count

		Occupation			Total
		Farmer	Vegetable/Food Seller	Others	
Knowledge of Types	No	21	92	695	808
	Yes	134	300	305	739
Total		155	392	1000	1547

Chi-Square Tests

	Value	df	Asymp. Sig. (2sided)
Pearson Chi-Square	342.452[a]	2	.000
Likelihood Ratio	361.274	2	.000
Linear-by-Linear Association	312.650	1	.000
N of Valid Cases	1547		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 74.04.



Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent

Level Education * Interested in New okra Products	1519	97.4%	41	2.6%	1560	100.0%
Occupation * Interested in New okra Products	1546	99.1%	14	0.9%	1560	100.0%

Level Education * Interested in New okra Products

Crosstab

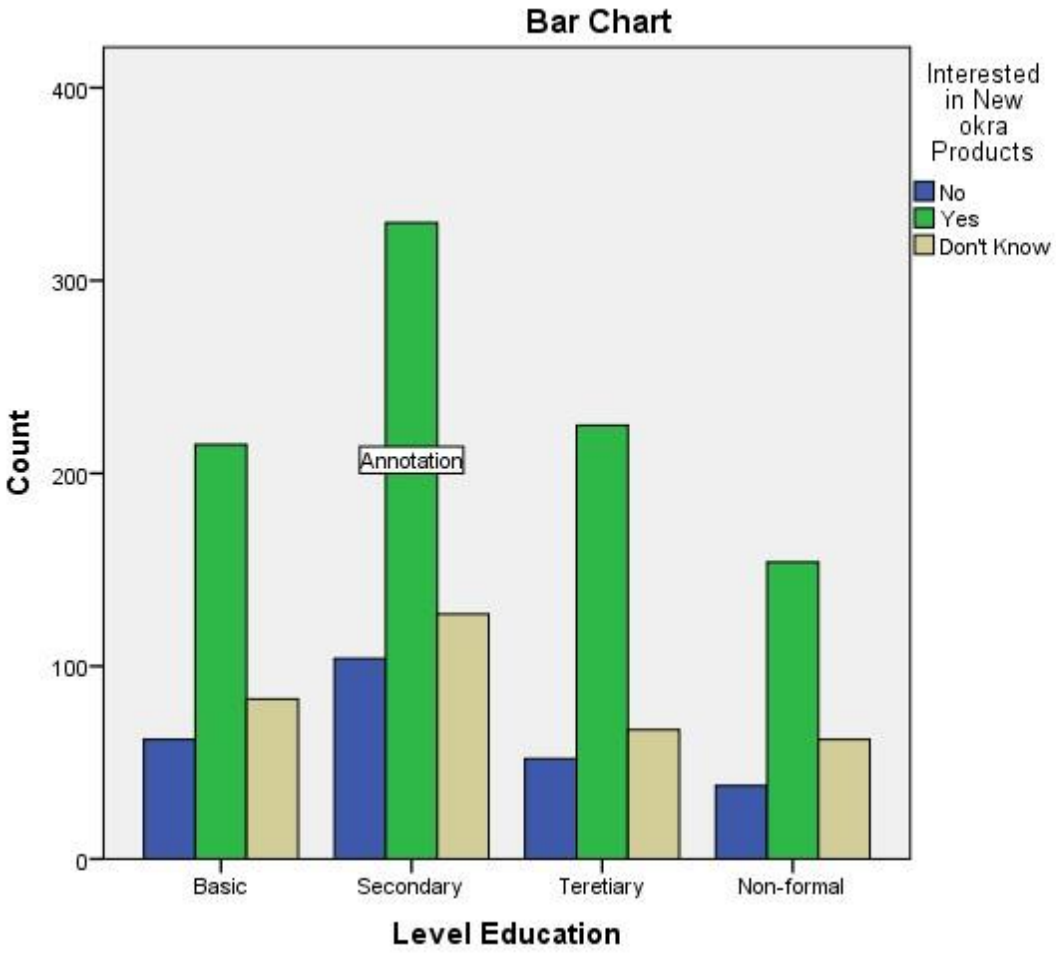
Count

		Interested in New okra Products			Total
		No	Yes	Don't Know	
Level Education	Basic	62	215	83	360
	Secondary	104	330	127	561
	Teretiary	52	225	67	344
	Non-formal	38	154	62	254
Total		256	924	339	1519

Chi-Square Tests

	Value	df	Asymp. Sig. (2sided)
Pearson Chi-Square	5.616[a]	6	.468
Likelihood Ratio	5.646	6	.464
Linear-by-Linear Association	.376	1	.540
N of Valid Cases	1519		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 42.81.



Occupation * Interested in New okra Products

Crosstab

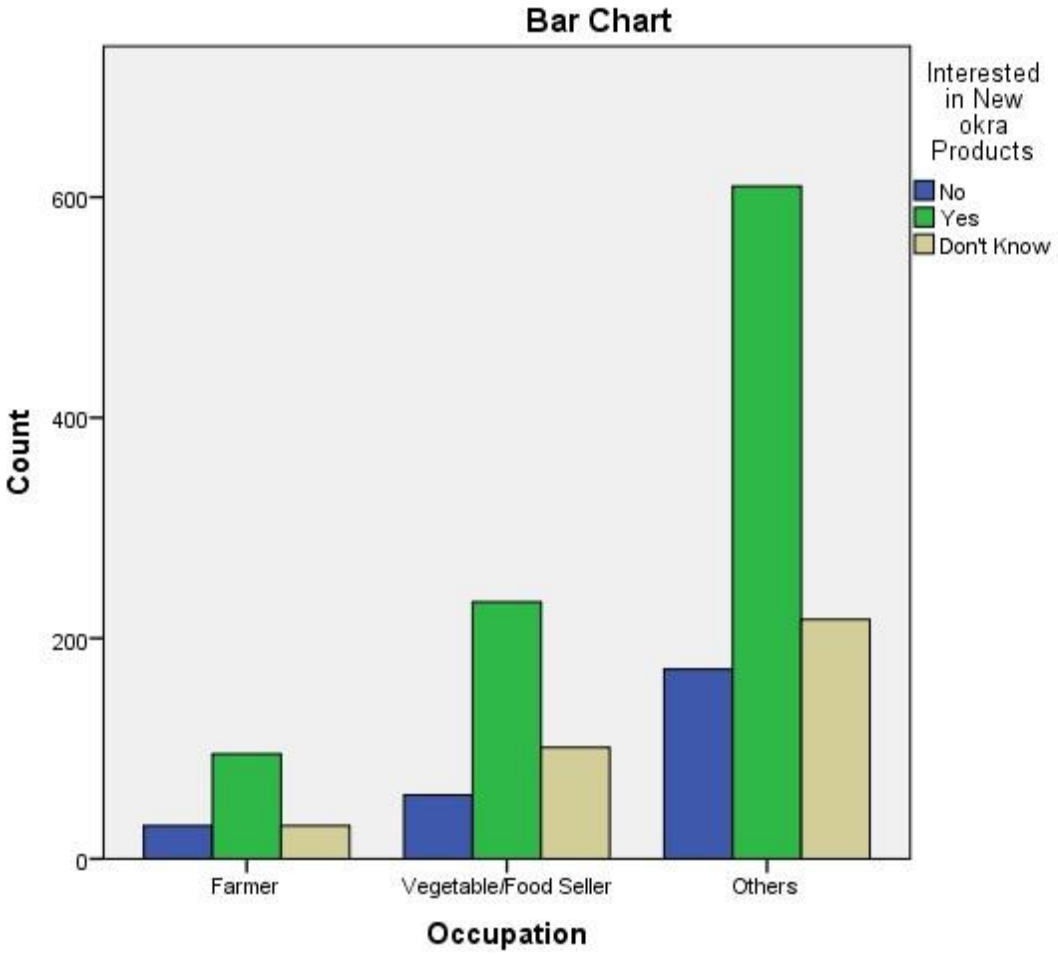
Count

		Interested in New okra Products			Total
		No	Yes	Don't Know	
Occupation	Farmer	30	95	30	155
	Vegetable/Food Seller	58	233	101	392
	Others	172	610	217	999
Total		260	938	348	1546

Chi-Square Tests

	Value	df	Asymp. Sig. (2sided)
Pearson Chi-Square	4.581[a]	4	.333
Likelihood Ratio	4.548	4	.337
Linear-by-Linear Association	.034	1	.853
N of Valid Cases	1546		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 26.07.


Bar Chart
Interested in New okra Products
No
Yes
Don't Know
Count
600
400
200
0
Farmer
Vegetable/Food Seller
Others
Occupation