QUALITY ATTRIBUTES OF WEEVILS *(Callosobruchus Maculatus)* INFESTED COWPEA (*Vigna unguiculata*) PRODUCTS

Oyeyinka[1], S. A., Oyeyinka[2], A. T., Karim[1], O. R., Kayode[1], R. M. O., Balogun[1], M. A. and Balogun[1], O. A

ABSTRACT

[1]Department of Home Economics and Food Science, University of Ilorin, Ilorin, Nigeria
[2]Department of Food, Agric. and Biological Engineering, Kwara State University, Nigeria
Corresponding author: oyeyinka.sa@unilorin.edu.ng / sartf2001@yahoo.com +2347066395421

Cowpea is an important food legumes widely consumed in almost every part of the world including Nigeria. The cowpea seeds are often rendered worthless by the cowpea weevils (Callosobruchus Maculatus).This infestation usually originate in the field and continue progressively in stored seeds. This study therefore evaluated the growth rate of weevils, weight loss of the stored cowpea seeds, and the effect of weevils on the proximate, functional and sensory properties of cowpea products (cowpea flour and akara). Akara is a deep-fat fried ball prepared from whipped cowpea paste, flavoured with pepper, onion and salt. Twenty five (25) matured weevils were inoculated into 6.4kg of fresh uninfested cowpea seeds and stored at room temperature (25 ± 5°C) for 4 weeks duration of the study. The number of live weevils was counted and the weight of cowpea seeds was measured weekly and Samples were taken weekly from the stored weevil infested cowpea seeds, milled into flour and evaluated for proximate composition and functional properties. The flours were subsequently used in the production of akara and subjected to sensory evaluation. Data obtained were subjected to analysis of variance test and means separated at 5% probability level. Proximate composition of the flours varied significantly with moisture (10.51-11.51%), ash (3.01-3.20%), protein (16.46-19.61%) and fat contents (1.12-1.40%) decreasing with increase in the duration of storage period while carbohydrate (63.24-67.86%) and crude fibre (0.91-1.01%) increased. All the functional properties including loose bulk density (0.56-0.66g mL^{-1}), packed bulk density (0.75-0.86g mL^{-1}), water absorption capacity (1.00-1.25 g water g^{-1} flour) and oil absorption capacity (0.8-1.10 g water g^{-1} flour) decreased significantly as duration of storage increased. A similar trend observed for the flours was obtained for the proximate composition of the akara samples with moisture (10.52-11.63%), ash (3.59-3.82%), protein (16.60-19.97%) and fat contents (2.06-2.30%) decreasing with increase in duration of storage, while carbohydrate (61.41-66.21%) and crude firbre (0.88-0.97%) increased. Sensory attributes of akara produced from uninfested cowpea flour was the most acceptable, flour from one week infested cowpea was comparable with the uninfested cowpea flour in aroma, taste, texture and acceptability. Generally, panelist described the texture of akara made from these flours as dry with a tough outer surface and a beany flavor.

***Keywords**: Quality attributes, Cowpea storage, Weevil infesation, Akara production, cowpea Flour*

INTRODUCTION

Cowpea is an important food legume and an essential component of cropping systems in the drier regions of the tropics (Singh *et al*., 1998). Being a fast growing crop, cowpea curbs erosion by covering the ground, fixes atmospheric nitrogen, and its decaying residues contribute to soil fertility (Adu-Dapaah *et al*., 1999). In West and Central Africa, cowpea is of major importance to the livelihoods of millions of people providing nourishment and an opportunity to generate income (Latunde-Dada *et al.*, 1999). The bulk of the diet of rural and urban poor Africa consists of starchy food made from cassava, yam, plantain and banana, millet, sorghum, and maize. The addition of even a small amount of cowpea ensures the nutritional balance of the diet and enhances the protein quality by the synergistic effect of high protein and lysine from cowpea and high methionine and energy from the cereals (Saber and Hussein., 1998). This nutritious and balanced food ensures good health and enables the body to resist infectious diseases and slow down their development.

The nutritional composition of cowpea is similar to that of most edible legumes. It contains about 24% protein, 62% soluble carbohydrates, and small amounts of other nutrients (Boulter *et al.* 1975). Thus, most of its nutritional value is provided by proteins and carbohydrates. The high protein content represents a major advantage in the use of cowpea in nutritional products, for infant and children's food, and to compensate for the large proportion of carbohydrates often ingested in African diets. Cowpea is especially rich in lysine, but it is deficient in sulfurous amino acids. Compared to other legumes, methionine and tryptophan levels are high. Cooked ground cowpea products make nutrition innovation a reality. Cowpea powders, in particular, are cost-effective and versatile and can be used in nearly any application such as in snack foods, cereals, dips and even cookies. Bean powders offer the same nutritional benefits as whole, prepared beans (Mitchell, 2009).

However, a sizeable amount of stored grain is often lost by pest infestation. Bean weevil is a pest of stored beans and peas belonging to the beetle family *Bruchidae* (commonly known as the seed weevils because the larvae develop inside the seeds of various plants). Occasionally one may take a package of dried beans or peas out of the closet only to find it infested with the bean weevil, or, weevils may be noticed when they try to escape through the window. Dead weevils may accumulate on the sills.

Callosobruchus maculatus lay eggs on legume host pods as they approach maturity in the field but emergence usually occurs after harvest (Brooker 1967). *Callosobruchus maculatus* lay eggs on the surface of seeds and larval emergence holes in seeds are symptomatic of infestations in storage. Infestation may occur in the field and during storage while the larvae feed inside the beans (Schmale, 2006); Wacker, 2006). This reduces the food value of the beans as well as reducing the germination potential of the bean seed. Literature abounds on the effect of insecticides control of bean weevil on beans (Rendon, 2011). However, little or no information exist on the effect of weevil growth on quality attributes of weevil infested beans based products. The aim of this study is to determine the effect of weevil on quality attributes of products from infected cowpea products (i.e. flour and *akara*).

MATERIALS AND METHODS

Sample preparation

A cultivar of fresh uninfected cowpea seeds (6.4kg) was used for this study (brown-coloured testa) was obtained from a market in Ilorin. The seeds were cleaned, packaged in plastic container and stored in room condition (27ºC). Experimental insects were bred from a sample obtained from infested stored grain supplied by a local producer. Twenty-five weevils were transferred into the plastic container containing 6.4 kg of cowpea grain. The plastic container was covered with its lid and kept in a room at 25 ± 5°C and allowed to stand for 4 weeks. Samples were taken weekly and milled to obtain cowpea flour.

Proximate composition of infested cowpea flour

Proximate analyses for moisture, protein (N x 6.25), fat, ash, and crude fibre of samples were determined according to AOAC (1990) procedures. Carbohydrate content was calculated by difference.

Water absorption capacity of infested cowpea flour

Water absorption capacity (WAC) of flour was determined following methods of Sosulski *et al*., (1976). One gram of flour sample was mixed with 10ml of distilled water. The mixture was allowed to stand at room temperature for 30 minutes and then centrifuged (Philips Drucker, Oregon, USA) at 2000g for 30mins. Water absorption capacity was expressed as gram of water bound per gram of flour.

Oil absorption capacity of infested cowpea flour

Oil absorption capacity (OAC) of flour was determined following methods of Sosulki *et al*., (1976). One gram of flour sample was mixed with 10ml of refined soybean oil (sp.gravity 0.9092). The mixture was allowed to stand at room temperature for 30 minutes and then centrifuged (Philips Drucker, Oregon, and USA) at 2000g for 30 minutes; oil absorption capacity was expressed as gram of oil bound per gram of flour.

Bulk densities

The method of Mpotokwane *et al*., (2008) was adopted for the determination of loose bulk density with slight modification. A measuring cylinder (100mL) was filled with flour to mark (100mL), and the content weighed. The packed bulk density was also obtained by following the same procedure but tapping for 50 times prior to weighing. Bulk density was calculated as the ratio of the bulk weight and the volume of the container (g mL^{-1}) (Asoegwu *et al*., 2006).

Sensory evaluation

The method described by Akingbala *et al.,* (1981) was used in the preparation of *akara*. The prepared *akara* were served to students in the Department of Home Economics and Food Science, University of Ilorin, Nigeria. The panelists were made to assess the *akara* for aroma, taste, color, texture and overall acceptability based on a 9-point Hedonic scale (9=like very much, 1=dislike extremely).

Weight loss of infested cowpea seeds

The weight loss of the infested cowpea seeds was determined by weighing the sample before and after infestation and calculating the difference.

Weight before infestation – weight after infestation

Statistical analysis

Experiments were carried out in triplicates and data were subjected to analysis of variance. Mean scores of some of the results and their standard deviations were reported. Duncan's multiple range test was used to separate the significantly different means at 5% probability level.

RESULTS AND DISCUSSION

Proximate composition of infested cowpea flour

The proximate composition of the cowpea flours showed that the moisture content ranged between 10.51 and 11.61% for infested cowpea flour at week 3 and week 1 respectively (Table 1). The moisture content of the flour showed a significant (p≤0.05) increase at week 1 and thereafter decreased. The initial sharp increase may be due to the respiratory activity of fewer weevils which could lead to the production of moisture and carbon dioxide. However, the resulting decrease could be attributed to the increase in population of the weevils as evident in Figure 1. It is expected that the competition among the weevils will increase and their requirement for moisture may also increase.

The ash content of the flours is not significantly different (p≤0.05) form each other. The ash content of the flours ranged from 3.01 to 3.20% (Table 1). Infested cowpea flour at week 1 and the uninfected cowpea flour had similar values. Similarly, infested cowpea flour at week 2, week 3 and week 4 had same values for the ash content. The values obtained in this study are similar to the reports of McWatters, (1983) for production of akara from cowpea paste and Nigerian cowpea flour. Findings from this study showed that the presence of weevils in cowpea during storage may not significantly affect the ash content of the flours.The fibre content of the flours varied from 0.91 to 1.01% for the infested cowpea flour at week 1 and infested cowpea flour at week 3 respectively. The fibre content, although was observed to increase from week 1 to week 4 of storage, the increase was not significant (p≤0.05) and should not affect the quality of the flours. Olapade *et al.,* (2004*)* reported higher fibre values (1.88) for cowpea flour (Table 1). The difference may be due to cultivar of cowpea used for the study. Weevil growth did not significantly affect the fibre content of the flours.

There were significant differences in the protein content of the flours ranging from 16.46 to 19.66% for the infested cowpea flour at week 4 and infested cowpea flour at week 1 respectively. The protein content of the uninfected flour was higher than the value (19.3%) reported by McWatters (1983) but lower than the value (24.39%) reported by Olapade *et al*., (2004). The variation may be attributed to difference in cultivar used and possibly the processing methods. The protein content of the flours decreased significantly (p≤0.05) from 19.61% to 16.46%. This decrease suggests that the weevils consumes the protein content for growth and thus may account for the low values recorded as the period of storage increased (Table 1)

The fat content ranged from 1.12 to 1.40% for the infested cowpea flour at week 4 and uninfested cowpea flour respectively. The fat content obtained in this study were lower than values reported by Mcwatters (1983) but comparable with values of fat reported by Olapade *et al*., (2004). There was significant difference in the carbohydrate content of the flours with values ranging from 63.21 to 67.84% for the infested cowpea flour at week 1 to infested cowpea flour at week 4. Olapade *et al*., (2004) reported similar values (61.29%) for cowpea flour, while Mcwatters (1983) reported lower values (54.7%).

Functional properties of infested cowpea flour

Water absorption capacity (WAC) of the flours varied with storage period. There was a significant difference (p≤0.05) in the WAC of the flours with values ranging from 1.00 g mL^{-1} to 1.25 g mL^{-1} for infested cowpea flour at week 4 and uninfested cowpea flour respectively. Falade and Kolawole (2011) and Enwere and Ngoddy (1986) reported higher values of 1.64 g mL^{-1} and 4.78 g mL^{-1} respectively for cowpea flours. The difference in the WAC of the flours may be attributed to the cultivar used. WAC decreased significantly (p≤0.05) with increase in storage period till the 3rd week after which the value was constant. Since proteins are the major constituents of flours responsible for the bulk of water uptake (Afoakwa 1996), the decrease in the WAC could be attributed to the low protein content of the flours as storage period increased. Sefa-Dedeh and Stanley (1979) investigated the relationship of microstructure of cowpeas to water absorption and dehulling properties and demonstrated that intact seeds, although non-homogenous in nature, had a highly organized cellular structure. Although starch, pectic substance and other macromolecules contribute to water absorption, the chief water-imbibing component of seeds is protein (Mayer and Plojakoff-Mayber 1975). This observation suggests that the economic value of akara produced from cowpea infested cowpea will be low and hence, there is the need to prevent infestation at all cost.

The oil absorption capacity (OAC) of the flours decreased significantly (p≤0.05) with increasing storage period with values ranging from 0.8 g mL^{-1} to 1.10 g mL^{-1} for infested cowpea flour at week 4 and uninfested cowpea flour respectively (Table 2). The value obtained from this study for uninfested cowpea flour is higher than the value (0.75 g mL^{-1}) and similar to those reported by Falade and Kolawole (2011). This observation suggests that the native proteins in the cowpea flours have not been altered and hence had lower OAC. Henshaw and Lawal, (1993) reported that heat denaturation of cowpea protein has been associated with high oil absorption capacity of cowpea. The mechanism of oil absorption involves the physical entrapment of oil by food components and the affinity of nonpolar protein side chains for lipids (Kinsella 1982; Sathe *et al*., 1982). The OAC of flours is important for the development of new food products as well as their storage stability, particularly for flavour binding and in the development of oxidative rancidity.

The loose bulk density (LBD) of the flours decreased significantly (p≤0.05) with values ranging from 0.56 g mL^{-1} to 0.66 g mL^{-1} for infested cowpea flour at week 4 and uninfected cowpea flour respectively. The results are similar to values reported by Henshaw and Sobowale, (1996); Olapade *et al.*, (2003) and Falade and Kolawole, (2011) for different cultivars of cowpea flours but higher than values (0.49 g mL^{-1}) reported by Olapade *et al.,(* 2004) for physico-chemical properties of premixes for preparation of Akara. The LBD was observed to increase slightly before decreasing to a value of 0.56 g mL^{-1} at week 4.

The packed bulk density (PBD) decreased significantly (p≤0.05) from 0.85g/mL to 0.75 g mL^{-1} for uninfected cowpea flour and infested cowpea flour at week 4 respectively (Table 2). Lower PBD (0.63 g mL^{-1}; 0.713 g mL^{-1}) were reported by Falade and Kolawole (2011) and Olapade *et al.* (2004) respectively. The difference in the bulk densities could be attributed to the difference in the particle size (Perez, 1997).

Proximate composition of *akara*

The proximate compositions of the *akara* produced from cowpea flour as presented in Table 3 varied significantly (p≤.05) among the samples. The range of values for the proximate composition were moisture content (10.52-11.63%), ash (3.59-3.82%), crude fibre (0.88-0.97%), protein (16.60-19.97%), fat (2.06-2.30%) and carbohydrate (61.41-66.21%). Generally, the moisture, ash, protein and fat contents of the *akara* decreased significantly (p≤0.05), while carbohydrate and crude fibre content increased as storage period increased. The decrease in the protein content of the samples could be attributed to the effect of the weevils on the cowpea flours as shown in Table 1. The protein content of the flours decreased with an increase in the storage period and increase in the number of weevils (Figure 1). This observation corroborates the previous observation that the major nutrient of the cowpea being consumed by the weevils is the protein fraction. Similar protein value was reported by Mcwatters, (1982).

The ash content (3.82%) of the akara prepared from uninfected cowpea flour was relatively higher than the ash content (3.20%) of the flour (Table 1). similar values were reported by Olapade *et al*., (2004). According to Tundall 1983; Ihekoronye and Ngoddy, 1985; Bamgbose *et al.*, 1991, the addition of pepper to cowpea flour contributes significantly to the ash content of the flour since pepper is essentially a good source of minerals, therefore the increase in ash content of the uninfested cowpea flour akara may be attributed to the added pepper. The moisture content values were lower than the value (40.8%) reported by Mcwatters, (1982) and higher than the value (7.42%) recorded by (Olapade *et al*., 2004) in their study on the physico-chemical properties of premixes for preparation of Akara. The decrease in fat content of the akara was not unexpected because the OAC of the flours also decreased with increase in storage period and increase in the number of weevils. This observation agrees with the report of Ravi and Sushelamma, (2005) where they attributed the oil retaining-properties of food materials to the nature and protein content.

Mean Sensory Scores of *akara*

The sensory scores of the akara prepared from the infested and uninfected cowpea flours as shown in Table 4 showed a significant difference among the samples. *Akara* made from uninfested cowpea flour was highly acceptable in all the sensory attributes. *Akara* made from infested cowpea flour at week 1 was comparable with the uninfested cowpea flour in aroma, taste, texture and acceptability. Ratings for samples prepared from infested cowpea flour stored up till week 2, week 3 and week 4 showed a decreasing trend. The low rating for texture of the cowpea flour could be attributed to its poor water absorption capacity and foaming capacity. Dovlo *et al.*, (1976) attributed poor acceptance of akara prepared from cowpea flour to poor re-hydration problem. Formation of stable foam is essential in akara preparation (Ngoddy *et al.*, 1986) since it contributes to the desirable spongy texture of the final product (Hung and Mc Watter, 1990). Generally, panelist described the texture of akara made from these flours as dry with a tough outer surface and a beany flavor. The dry texture may be attributed to the crust formation that occurred at the surface of these preventing the transfer of a sufficient amount of heat to completely cook the interior (Mcwatters, (1982). *Akara* made from the uninfested cowpea flour was much more accepted by the panelist and this is demonstrated in the overall acceptability of the sample.

Weevil growth curve

The population of the weevils increased from 25 to 165 excluding the dead weevils as the storage week of cowpea increased. The increase in their growth rate as evident in the number of weevil was significantly high at the 3^{rd} week of storage (Figure 1). A corresponding decrease in the weight of the cowpea was observed as the week of storage increased. The weight of the cowpea used for this study before inoculation was 6.4 kg with a progressive reduction to 5.8 kg, 4.2 kg, 3.8 kg and 2.1 kg for week 1, 2, 3 and 4 respectively (Figure 2). The drastic weight reduction may be attributed to the increase in the respiration of the weevils and a corresponding increase in the demand for food leading to damage of the cowpea and resulting weight loss.

CONCLUSION

This study has revealed that cowpea weevil (*Callosobruchus Maculatus)* attacks majorly the protein content of cowpea during storage which in turn significantly affected some other nutritional and functional properties of the flours. Although, the use of cowpea flour simplified preparation of paste for akara production by eliminating soaking, dehulling and grinding operations, the consumption of such product may not be sufficient to supply the necessary nutrient needed for growth and healthy living, particularly when infested cowpea flours are employed. Weevil growth increased with the storage period and a resultant decrease in the cowpea weight. In general, proper storage of cowpea is necessary in order to maintain its quality attributes as well as its quantity, while weevil infested cowpea could be sterilized using non thermal processing methods such as irradiation coupled with subsequent storage in air tight containers to prevent recontamination.

Table 1: Proximate composition of cowpea flour

Sample	Moisture content (%)	Ash (%)	Fibre (%)	Protein (%)	Fat (%)	Carbohydrate (%)
UCFW0	$11.55^{b}\pm3.20$	$3.20^{a}\pm0.50$	$0.92^{b}\pm0.00$	$19.61^{a}\pm4.10$	$1.40^{a}\pm0.50$	$63.24^{d}\pm4.00$
ICFW1	$11.61^{a}\pm0.50$	$3.20^{a}\pm0.50$	$0.91^{c}\pm0.50$	$19.66^{ab}\pm7.20$	$1.39^{ab}\pm0.50$	$63.21^{d}\pm8.90$
ICFW2	$11.60^{a}\pm1.10$	$3.01^{b}\pm1.00$	$0.91^{bc}\pm1.00$	$19.59^{b}\pm1.00$	$1.37^{b}\pm1.50$	$63.51^{c}\pm3.00$
ICFW3	$10.51^{d}\pm1.00$	$3.01^{b}\pm1.00$	$1.01^{a}\pm0.50$	$16.61^{c}\pm1.10$	$1.12^{c}\pm1.10$	$67.74^{b}\pm2.50$
ICFW4	$10.54^{c}\pm0.50$	$3.01^{b}\pm1.00$	$1.00^{a}\pm0.50$	$16.46^{d}\pm1.70$	$1.12^{c}\pm1.70$	$67.86^{a}\pm1.00$

Mean with the same superscripts in a column are not significantly different from each other p($\leq$0.05)
UCFW0: Uninfested cowpea flour at week 0; ICFW1: Infested cowpea flour at week 1; ICFW2: Infested cowpea flour at week 2
ICFW3: Infested cowpea flour at week 3; ICFW4: Infested cowpea flour at week 4

Table 2: Functional properties of cowpea flour

Sample	LBD (g/mL)	PBD (g/mL)	WAC (g/mL)	OAC (g/mL)
UCFW0	$0.66^{a} \pm 0.00$	$0.86^{a} \pm 0.00$	$1.25^{a} \pm 0.00$	$1.10^{a}\pm 0.00$
ICFW1	$0.63^{c} \pm 0.00$	$0.83^{b} \pm 0.00$	$1.15^{b} \pm 0.00$	$1.04^{b}\pm 0.00$
ICFW2	$0.65^{b} \pm 0.00$	$0.82^{c} \pm 0.00$	$1.02^{c} \pm 0.00$	$1.02^{c}\pm 0.00$
ICFW3	$0.58^{d} \pm 0.00$	$0.77^{d} \pm 0.00$	$1.00^{d} \pm 0.00$	$0.9^{d}\pm 0.00$
ICFW4	$0.56^{e} \pm 0.00$	$0.75^{e} \pm 0.00$	$1.00^{d}\pm0.00$	$0.8^{e}\pm 0.00$

Mean with the same superscripts in a column are not significantly different from each other p ($\leq$0.05)
UCFW0: Uninfested cowpea flour at week 0; ICFW1: Infested cowpea flour at week 1; ICFW2: Infested cowpea flour at week 2
ICFW3: Infested cowpea flour at week 3; ICFW4: Infested cowpea flour at week 4

Table 3: Proximate composition of *akara*

Sample	M.C. (%)	Ash (%)	Crude Fibre (%)	Protein (%)	Fat (%)	Carbohydrate (%)
AUCW0	$11.58^{b}\pm0.50$	$3.82^{a}\pm0.50$	$0.90^{b}\pm0.50$	$19.97^{a}\pm0.00$	$2.30^{a}\pm0.00$	$61.41^{d}\pm0.00$
AICW1	$11.63^{a}\pm2.00$	$3.82^{a}\pm0.50$	$0.88^{c}\pm0.50$	$19.95^{a}\pm5.20$	$2.28^{a}\pm0.50$	$61.41^{d}\pm4.30$
AICW2	$11.61^{a}\pm1.10$	$3.60^{b}\pm0.50$	$0.89^{c}\pm1.00$	$19.32^{b}\pm1.00$	$2.27^{a}\pm1.00$	$61.80^{c}\pm1.50$
AICW3	$10.52^{d}\pm0.50$	$3.59^{c}\pm1.00$	$0.97^{a}\pm0.50$	$16.80^{c}\pm0.50$	$2.20^{b}\pm0.00$	$65.90^{b}\pm0.50$
AICW4	$10.56^{c}\pm0.00$	$3.59^{bc}\pm0.50$	$0.97^{a}\pm0.50$	$16.60^{d}\pm1.10$	$2.06^{c}\pm1.10$	$66.21^{a}\pm5.10$

Mean with the same superscripts in a column are not significantly different from each other p ($\leq$0.05)
UCFW0: Uninfested cowpea flour at week 0; ICFW1: Infested cowpea flour at week 1; ICFW2: Infested cowpea flour at week 2
ICFW3: Infested cowpea flour at week 3; ICFW4: Infested cowpea flour at week 4

Table 4: Mean sensory scores of *akara*

Sample	Aroma	Taste	Colour	Texture	Acceptability
AUCW0	$7.40^{a}\pm2.10$	$7.40^{a}\pm1.40$	$8.20^{a}\pm0.80$	$7.00^{a}\pm1.1o$	$7.00^{a}\pm1.6$
AICW1	$6.10^{ab}\pm1.90$	$6.70^{a}\pm1.60$	$6.20^{b}\pm1.80$	$5.90^{ab}\pm1.50$	$6.10^{ab}\pm1.6$
AICW2	$6.10^{ab}\pm1.40$	$6.10^{ab}\pm0.90$	$5.40^{cb}\pm1.30$	$4.70^{bc}\pm1.10$	$5.60^{ab}\pm1.6$
AICW3	$4.40^{b}\pm1.80$	$4.80^{bc}\pm1.60$	$6.40^{b}\pm1.50$	$4.90^{bc}\pm1.40$	$4.50^{bc}\pm2.0$
AICW4	$4.40^{b}\pm1.80$	$4.30^{c}\pm1.90$	$4.60^{c}\pm1.70$	$4.10^{c}\pm1.90$	$3.70^{c}\pm2.1$

Mean with the same superscripts in a column are not significantly different from each other p ($\leq$0.05)
UCFW0: Uninfested cowpea flour at week 0; ICFW1: Infested cowpea flour at week 1; ICFW2: Infested cowpea flour at week 2
ICFW3: Infested cowpea flour at week 3; ICFW4: Infested cowpea flour at week 4

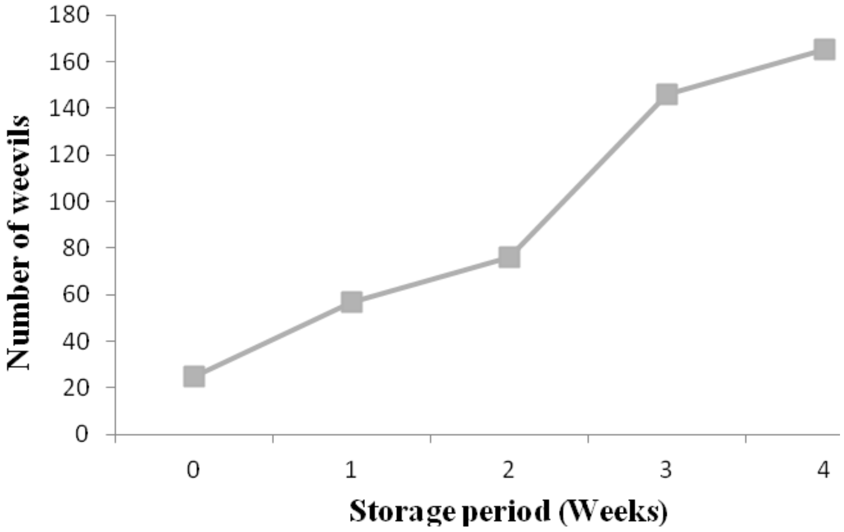

Figure 1: Weevil Growth Rate

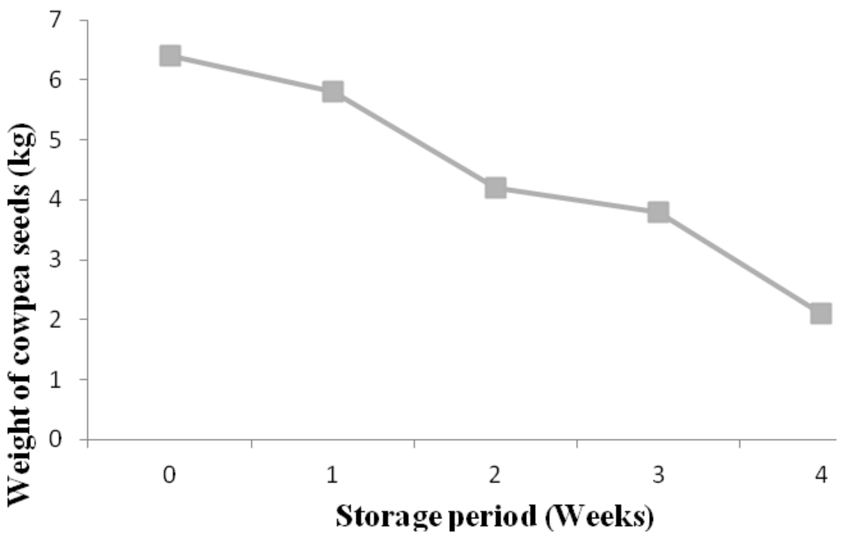

Figure 2: Weight Loss of Cowpea Seeds

REFERENCES

Adu-Dapaah, H. K., Singh, B. B. and Fatokun, C. 1999. A fascinated mutant in cowpea (*Vigna unguiculata* [L.] Walp.). Acta Agronomica Hungarica 47: 371

Afoakwa, E. O. 1996. Storage characteristics and quality evaluation of cowpea-fortified traditional foods. B.Sc. dissertation. Department of Nutrition and Food Science, University of Ghana, Legon-Accra, Ghana.

Akingbala J. O., Rooney, L. W, Faubian, J. M. 1981. A laboratory procedure for the preparation of ogi a Nigerian fermented food. *J. Food Sci*., 46, 1523-1536

AOAC 1990. Official Methods of Analysis. Association of Official Analytical Chemists, Washington, DC

Bamigbose, O., Ogundipe, J. T. and Akinpelu, A. T. 1991. Effect of processing on the level of iron in some common pepper. *Nigerian Food Journal*. 9:154-158

Boulter, D., Evans, I. M. 1975. S-Methyl-l-cysteine content of various legume meals, *Plant Foods Hm. Nutr.* 24, 257-261

Brooker, R. H. 1967. Observations on three bruchids associated with cowpea in northern Nigeria. *Journal of Stored Products Research*, 3: 1-15.

Cardona C. 2007. Common Beans: Latin America. In: Hodges R, Farrel R, Durables G (eds) Crop Post-Harvest. Science and Technology. Blackwell Science, Oxford, UK, pp. 145-150.

Dovlo, F. E, Williams, C. E. and Zoaka, L. 1976. Cowpea: Home preparation and use in West Africa International Development Research.

Falade, K.O and Kolawole, T. A. 2011. Effect of irradiation dose on physical, functional and pasting properties of cowpea *Journal of food process Engineering*, A Wily periodicals inc. pp(6): ISSN 1745-4530

Henshaw F.O, and Lawal S.A. 1993. Effect of processing methods on the functional properties of cowpea flour. *Journal of. Tropical science*. 33:377-385

Henshaw, F.O, and Sobowale , M. K. 1996.Cowpea flour produced from different bean varieties; functional properties, composition and acceptability of products. *Nigerian Food Journal*, 14:62-70

Ihekoronye, I. A. and Ngoddy, P. O. 1985. Intergrated food science and technology for the tropics. Macmillian publisher,London.improvement of food legumes by breeding, 3 – 5 July, 1972, NY, United Nations Protein

Kinsella, J. E. 1982. Relationship between structural and functional properties of food protein. In *Food Proteins* (P.F. Fox and J.J. Condon, eds.) pp. 51–60, Applied Science Publishers, London.

Latunde-Dada, A.O., R.J. O'Connell, P. Bowyer, and J.A. Lucas. 1999. Cultivar resistance to anthracnose disease of cowpea caused by *Colletotrichum destructivum* O'Gara. European *Journal of Plant Pathology* 105: 445–450.

Mayer, A. M., and Poljakoff-Mayber, A. 1975. The Germination of Seeds, 2nd ed. Page 27. Pergamon Press: Elmsford, NY.

McWatters, K. H. 1983. Compositional, physical, and sensory characteristics of akara processed from cowpea paste and Nigerian cowpea flour. Cereal Chemistry. 60:333-336

McWatters, K. H., and Brantley, B. B. 1982. Characteristics of akara prepared from cowpea paste and meal. *Food Technol*. 36:66-68.

Mitchell, 2009. Consumption of dry beans, peas, and lentils could improve diet quality in the US population. *J Am Diet Assoc*, 2009. 109(5): p. 909-13.

Mpotokwane, S. M., Gaditlhatlhelwe, E., Sebaka, A. and Jideani,V. A. 2008. Physical properties of bambara groundnuts from Botswana. *Journal of Food Eng*. *89*, 93–98.

Ngoddy, P. O., Enwere, N. J., and Onuorah, V. I. 1986. Cowpea flour performance in *akara* and *moin-moin* preparations. *Tropical. Science*.26:101-119.

Olapade, A. A., Akingbala, J. O., Oguntunde, A. O., and Falade, K. O. 2003. Effect of processing method on the quality of cowpea (*Vigna unguiculata*) flour for akara preparation. *Plants Foods for Human Nutrition*, 58:1-10.

Olapade, A. A., Ugokwe, P. U., Ozumba, A. U., Solomon, H. M., Olatunji, O. and Adelaja, S. O. 2004. *Nigerian Food Journal* Vol. 22:54-59.

Perez, E. 1997. Characterization of starch insolate from plantain (Musa paradisiacal normalis). Starch ⁄ Starke, 49, 45–49.

Ravi, R. and Sushelamma, N. S. 2005. Simultaneous optimization of a multiresponse system bydesirability function analysis of boondi making: a case study. *Journal of Food Science*, 70, S539–S547.

Rendon, H. 2011.Insecticides effect of wild plant powders on bean weevil. *African journal of Agricultural research*, pp. 971-977. ISSN 1991-637X

Saber, M. M. and Hussein, M. H. 1998. Induced mutations for resistance to rust disease in cowpea (*Vigna sinensis*). Bulletin of Faculty of Agriculture, University of Cairo 49(1): 47–48.

Sathe, S.K., Deshpande, S.S. and Salunkdh,D.K. 1982. Functional properties of winged bean proteins. *Journal of Food Science*. *47*, 503–507.

Schmale, I., Wackers, F. L., Cardona, C., and Dorn, S. 2006. Biological control of the bean weevil, *Acanthoscelides obtectus* (Say) (Col. *Bruchidae*), by the native parasitoid *Dinarmus basalis* (Rondani) (Hym: Pteromalidae) on small-scale farms in Colombia. *Journal of Stored Products*. Res. 42:31-41.

Sefa-Dedeh, S. and Stanley, D. 1979 Microstructure of cowpea variety, Adua ayera. *Cereal Chemistry*, *56:* 367.

Singh B. B., Singh, S. R., Adjadi, O. 1985. Bruchid resistance in cowpea. *Crop* Science. 25:736-739.

Singh, B. B. 1998. Sources of resistance to septoria, scab, bacterial blight and *Cercospora* leaf shot. IITA Annual Report 1998. Project 11. Pages 24

Singh, B. B. and Adu-Dapaah, H. K.1998. A partial male sterile mutant in cowpea. *African Crop Science Journal* 6: 97 101

Singh, M. and Krikorian, H. D. 1982. The inhibition of trypsin activity in vitro by phytate. *Journal of Agricultural*, *Food Chemistry*, 32: 799.

Sosulski, F. W. 1976.The method for determining absorptivity in hard redspring wheat. Cereal Chemistry. 39;344.

Tundall, H. D.1983. Vegetables in the Tropics. Macmillian publisher limited London pp.347-378.

Wackers F. L., Schmale I, Cardona C, and Dorn S. 2006. Biological control of the bean weevil, *Acanthoscelides obtectus* (Say) (Col.: Bruchidae), by the native parasitoid *Dinarmus basalis* (Rondani) (Hym: Pteromalidae) on small-scale farms in Colombia. *Journal of Stored Product Research* 42:31-41.