**East African Scholars Journal of Agriculture and Life Sciences**
*Abbreviated Key Title: East African Scholars J Agri Life Sci*
ISSN 2617-4472 (Print) | ISSN 2617-7277 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-5 | Issue-2 | Feb-2022 | DOI:10.36349/easjals.2022.v05i02.003

**Original Research Article**

# Efficacy of Chilli Pepper *Capsicum frutescens* (L.) for the Control and Management of Cowpea Weevil *Callosobruchus maculatus* (F.) Infesting Cowpea *Vigna unguiculata* (L.) Walp in Storage Environment

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**Article History**
**Received:** 13.01.2022
**Accepted:** 17.02.2022
**Published:** 26.02.2022

**Journal homepage:**
http://www.easpublisher.com

**Quick Response Code**

**Abstract:** Chilli pepper, *Capsicum frutescens* (L.) (whole and powder) was evaluated for their insecticidal activities against the bruchid, *Callosobruchus maculatus* to prevent loss of cowpea in storage. There were eight treatments (1.0g, 2.0g and 3.0g of chilli pepper powder, 1.0g, 2.0g and 3.0g of whole fruit of chilli pepper, actellic dust 2% and no protectant control) in five replications laid-out in complete randomized design. 200g of cowpea seeds were admixed with each of the treatments for their efficacy against oviposition, damage and weight loss to Callosobruchus maculatus. Percentage germination and proximate composition were also tested after storing seeds for periods ranging between 38 days and 4 months. Results revealed that chilli pepper powder and whole fruits at all levels reduced to its barest minimum the number of eggs laid or hatched by *Callosobruchus maculatus* preventing adult emergence and survival at 38 days after infestation, weight loss after 4 months and increased percentage germination as compared to control (60.0±0.0 and 40.0±0.0). Chilli pepper had significant influence on proximate composition as treated cowpea retained their nutrient after four months of storage. 3.0g chilli pepper powder was observed to be very effective than other treatments and control.

**Keywords:** Chilli pepper, cowpea, *Callosobruchus maculatus*, storage environment.



## INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is an indigenous African annual herbaceous grain legume from the genus *Vigna* (Singh *et al.*, 1997). It plays a vital nutritional role globally as a major source of dietary protein, carbohydrate and vitamins particularly in tropical and subtropical regions where availability and consumption of animal protein is low (Ofuya, 1986).

*Callosobruchus maculatus* F. (*Coleoptera: Bruchidae*) is a major cosmopolitan polyphagous post-harvest insect pest of cowpea throughout the tropics where it causes severe quantitative and qualitative losses manifested in direct weight loss, reduction in quality and aesthetic value as well as germinability (Ofuya and Bamigbola, 1991) resulting in substantial loss of revenue. Infact, infestation can affect 100% of the stored cowpea and 60% grain loss within a few months (Kang *et al.*, 2013). Apart from detrimental economic impact, these losses pose a major threat to food security (Ekeh *et al.*, 2013).

Infestation of cowpea by this insect starts on the field when the pods are mature at which time the pest lays their eggs on them. The larvae burrow their way into the seed, feeding on the endosperm. The weevil develops into a sexually mature adult within the seeds (Wilson, 1998; Asawalam and Nwoko, 2021). An individual bruchid can lay 20 – 40 eggs and in optional conditions each egg can develop into productively active adult in 3 weeks (Mashela, 2012; Asawalam and Nwoko, 2021).

However, the use of inorganic insecticides is the most popular method heavily relied upon for controlling this insect pest and other related pests of stored products including organochlorines and organophosphates, but their use is eliciting much concern due to their undesirable impact on the environment and humans such as soil and water pollution, mammalian toxicity and pest resurgence. Consequently, research in the use of natural pesticide for crop protection and storage has recently increased because they are economically and environmentally safe, less hazardous to humans and often less toxic to

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beneficial organisms (Sharah and Ali, 2008; Asawalam and Nwoko, 2021). Botanicals of different kinds have been suggested as promising alternatives to synthetic insecticides due to ease of accessibility and their medicinal values (Akinkurole, Adedire and Odeyemi, 2006; Oni and Ogungbite, 2015). In many areas of Tropical Africa, locally available materials are widely used to protect stored produce against damage by insect pests (Stoll, 2000). The potentials of which have been reported by many workers (Ofuya, 2001; Yusuf and Ahmed, 2005) and therefore being suggested as alternative to synthetic insecticides (Zibaee, 2011).

Echezona (2006) noted that, the efficacy of chilli pepper (*Capsicum frutescens* L.) in the control of *Callosobruchus maculatus (*F.) seems to be conflicting. While Ajayi *et al.,* (1987) states that grind chilli pepper at 10g/kg cowpea afforded no significant effect on *Callosobruchus maculatus,* Ivibrajo and Agbaje (1986) and Ofuya (1986) corroborated that, it caused moderate adult mortality and therefore afforded some degree of protection against post-harvest losses caused by this pest. Notwithstanding, many of subsistence farmers still treat their stored cowpea seeds with various cultivars of pepper successfully (Echezona, 2006). In this work, efficacy of chilli pepper (*Capsicum frutescens* L.) against cowpea bruchid (*Callosobruchus maculatus* F.) were evaluated under laboratory condition.

## MATERIALS AND METHODS

Experimental site: The Laboratory experiment was conducted at crop production laboratory of Yaba College of Technology, Odoragushin, Epe Campus (Longitude 3˚58˚56˚E and 6˚38˚36˚N). It lies on km 16, along Epe, Ijebu-ode road, Epe, Lagos.

Collection of cowpea, chilli pepper, actellic dust and *C. maculatus*: The cowpea (Ife Brown Variety), chilli pepper seeds and actellic dust (2%) were purchased from Lagos State Input Supply Company (LAISCO), Epe depot. The chilli pepper seeds were air-dried for two weeks until they are crisp dry. The grinded fruits were made to pass through a 0.2 mm sieve and kept in an air tight container. A laboratory culture of *C. maculatus* were derived from a colony originating from infested cowpea seeds collected from open market at Epe. They were kept in a kliner jar for use of the experiment. When oviposition has been noticed after one week, the parent stock of *C. maculatus* were removed by seiving the grain with a 2.00mm sieve. The grain with the oviposited ova were left under laboratory condition (30±5$^0$C and 50±5% relative humidity) until the emergence of F1 progeny that was used for the experiment (Ekeh e*t al.,* 2013).Experimental protocol: The treatments (1.0g of Capsicum powder, 2.0g of Capsicum powder, 3.0g of Capsicum powder, 1.0g whole fruit of Capsicum, 2.0g whole fruit of Capsicum, 3.0g whole fruit of Capsicum, Actellic dust and control) were applied in 5 replications based on the followings:

Efficacy of low and high rate of *Capsicum frutescens* powder and whole fruit on oviposition of *C. maculatus*: This was done following method described by Echezona (2006) with modifications. Each of the dried pepper samples (fruits and powder) and Actellic dust was weighed out at three rates of 1.0, 2.0 and 3.0g corresponding to 10%, 25% and 35% added to 200g of the wholesome cowpea seeds in a 200ml plastic container. Perforated muslin cloth was used to cover each container to ensure adequate ventilation. The muslin bag was held in place with two tight rubber bands. The seeds and test materials were shaken thoroughly in the container until the materials were evenly distributed among the seeds. The contents of the plastic containers was allowed to settle down for two hours before the introduction of the freshly emerged adults of *C. maculatus* (3 males and 3 females), into each vial for oviposition and arranged in completely randomized design (CRD) on a laboratory bench. The check (control) comprised the container with no protectant (i.e. with neither pepper fruit nor powder nor actellic dust). The total number of eggs lay after 21 days and the numbers of adult bruchids that emerged and survived in each container were recorded 38 days after infestation.

Weight loss and damage done to the seeds by the bruchid: After 4 months of storage, the cowpea seeds were weighed again. The difference between the weight before the commencement of the experiment and at the end of the experiment constitute loss in weight due to the insect pest activity. Damage done to the storage seeds was measured as the number of seeds perforated among the 200g of seeds sampled in each plastic container at the end of the experiment.

Effect of *Capsicum frutescens* on cowpea seeds germination: Seeds from the different treatments were subjected to germination test to determine the viability of the treated and untreated seeds. After 4 months of storage, 20 seeds were randomly selected from each of the whole fruit and powdered chilli pepper and placed on 8 rolls of paper towels for germination and re-wetted with distilled water in an amount equal to 2.5 tonnes the volume in weight of the paper used in the test, whilst the control was set up. The percentage of the seeds that germinated were noted after 5-8 days. All germinating experiment were conducted in temperature ranging from 20˚C-30˚C.

Effect of *Capsicum frutescens on C. maculatus* infestation of cowpea: No-choice and free-choice was used to determine oviposition and inhibition effect of *C. frutescens* powder and whole fruit on adult emergence of *C. maculatus* following methods described by Ofuya *et. al*. (1992). For no-choice test used to determine the ovicidal activity of the *C. frutescens*, seeds of cowpea were exposed to adult bruchids for egg laying in several petri-dishes (9.0 diameter). Group of seeds bearing 50 freshly emerge larvae were placed in separate petri-dishes and treated with the treatments (powdered chilli pepper, whole fruit of chilli pepper and Actellic dusts) in 5 replications. A control was also set up in which the seeds were not treated. The number of adult weevils that emerged from these seeds after 2 weeks were counted and recorded. To determine oviposition deterrence of *C. frutescens* on the other hand, 20 seeds of cowpea were treated with the 2 treatments (chilli pepper powder and whole fruit) separately in different petri-dishes in 5 replications with newly emerged copulating weevils introduced unto them. A replicated control using cowpea seeds in different petri-dishes which are not treated was set-up. The number of eggs laid on the seeds in different petri-dishes was counted 2 weeks after infestation.

On-choice test, 20 cowpea seeds were treated with the two treatments (chilli pepper powder and whole fruit) and their cotyledons marked with green marker to differentiate it from 20 untreated ones respectively. A newly emerged copulating pair of *C. maculatus* was introduced into the petri-dishes. Egg laid was counted 2 weeks after treatment.

Proximate composition of treated and untreated cowpea seeds: Proximate analysis of the cowpea seeds used for the study before and after insect infestation was done according to methods described by Association of Analytical Chemist (AOAC) (2002) to determine the percentage nutrient (moisture, ash, fat, crude fibre, protein and carbohydrate) and benefit or losses due to *C. maculatus* infestation. Here, infested cowpea seeds were cleaned and sieved to remove *C. maculatus* and its body parts. Later, 10g of each infested but cleaned cowpea seeds drawn in triplicate were used for their proximate compositions (Ekeh *et. al*. 2013).

Data analysis: Egg counts and damage percentages were subjected where necessary to appropriate transformation procedures before analysis of variance was carried-out on them. Significant means were separated using Duncan multiple Range Test (DMRT) at 5% probability level.

## RESULTS

Phytochemical constituents of chilli pepper: The phytochemical studies of chilli pepper extract used as bio-pesticide in this experiment is presented in Table 1. It revealed that flavonoids (210.05%) and resins (187.61%) were significantly higher in concentration. The steroids (43.27%) and tannin (31.02%) were moderately present while glycosides (0.43%), saponin (0.41%), reducing sugar (1.78%) and terpenoides were present in lesser amounts. However, alkaloids and acidic compounds were absent in the sample.

**Table-1: Phytochemical constituents of chilli pepper**

| PARAMETERS | Qualitative Indication | Quantitative Indication (%) |
|---|---|---|
| Tannin | ++ | 31.02 |
| Glycosides | + | 0.43 |
| Terpenoides | + | 5.67 |
| Flavonoids | +++ | 210.05 |
| Alkaloids | - | Not detected |
| Saponin | + | 0.41 |
| Reducing sugar | + | 1.78 |
| Acidic compounds | - | Not detected |
| Resins | +++ | 187.61 |
| Steroids | ++ | 43.27 |

(+++) = present in large quantity, (++) = present in moderate quantity, (+) = present in small quantity, (-) = not present

Toxicity of Capsicum powder, whole fruit and Actellic dust on the Oviposition and adult emergence survival rate of *C. maculatus* on cowpea seeds: Shown in Table 2 is the toxicity of capsicum powder, whole fruit and actellic dust on the oviposition and adult emergence survival rate of *C. maculatus* on cowpea seeds. There was significant variation ($p < 0.05$) in the values recorded for the mean number of eggs laid/hatched at 21 days after infestation with control having the highest value (75.5±8.3) while the lowest was recorded in actellic dust (00.0±00.0). The same scenario was observed in the number of adult emergence and Percentage adult survival at 38 days after infestation as control recorded the greatest damage (60.0 + 00.0 and 40.0 + 00.0). Thus, all the treatments (protectants) significantly reduced number of egg laid/hatched (oviposition) by the insects while they completely halt adult emergence and survival of *C. maculatus.* Here, seeds treated with actellic dust (2%) had the least number of eggs, adult emergence and percentage adult survival. Thus *C. maculatus* are really controlled by the application of synthetic insecticides.

**Table-2: Toxicity of Capsicum powder, whole fruit and Actellic dust on the Oviposition and adult emergence survival rate of *C. maculatus* on cowpea seeds**

| Rates of capsicum powder whole fruit (treatment) | Mean number of eggs laid/hatched (+SE) at 21days after infestation | Mean number of adult emergence (+SE) at 38days | Percentage adult survival (+SE) at 38days after infestation |
|---|---|---|---|
| 1.0g (20%) of Capsicum powder (T1) | 55.3 + 8.3$^{c}$ | 00.0 + 00.0$^{a}$ | 00.0 + 00.0$^{a}$ |
| 2.0g (35%) of Capsicum powder (T2) | 55.7 + 8.3$^{c}$ | 00.0 + 00.0$^{a}$ | 00.0 + 00.0$^{a}$ |
| 3.0g (45%) of Capsicum powder (T3) | 50.2 + 8.3$^{c}$ | 00.0 + 00.0$^{a}$ | 00.0 + 00.0$^{a}$ |
| 1.0g whole fruit of Capsicum (T4) | 70.1 + 8.3$^{a}$ | 00.0 + 00.0$^{a}$ | 00.0 + 00.0$^{a}$ |
| 2.0g whole fruit of Capsicum (T5) | 66.1 +8.3$^{ab}$ | 00.0 + 00.0$^{a}$ | 00.0 + 00.0$^{a}$ |
| 3.0g whole fruit of Capsicum (T6) | 64.2 + 8.3$^{b}$ | 00.0 + 00.0$^{a}$ | 00.0 + 00.0$^{a}$ |
| Actellic dust (T7) (2%) | 00.0 + 00.0$^{d}$ | 00.0 + 00.0$^{a}$ | 00.0 + 00.0$^{a}$ |
| Control (untreated cowpea seed) | 75.5 +8.3$^{a}$ | 60.0 + 00.0$^{b}$ | 40.0 + 00.0$^{b}$ |

Mean with the same letter are not significantly different according to DMRT Arcsine transformed

Seed weight loss and damage due to *C. maculatus* when exposed to 200g dry cowpea: Table 3 shows the seed weight loss and damage due to *C. maculatus* when exposed to 200g dry cowpea seeds. There was no significant variation in the values recorded for the initial seed weight (at commencement of experiment) as all treatment had constant weight. However, there was significantly higher values recorded for cowpea seed weight (g) after 4 months of storage with marginal reduction in actellic dust (200±1.8) than those recorded in control (untreated cowpea seeds) (181.5±1.8). Damage done to cowpea seeds in terms of number of existing holes/perforation after 4 months of storage (g) showed significantly higher percentage damage in control (596.0±63.9) than in other treatments with the lowest value observed in actellic dust (00.0±63.9). The Capsicum powder and whole fruit at all levels showed significant reductions as a result of limited contact of the bruchid with the trested seeds. This is in consonance with the work of Asawalam and Anaeto (2014).

Here, damaged seeds are riddled with adult emergence holes and defaced with egg covers which leads to reduced weight and poor quality product. Thus, Capsicum powder and whole fruit tended to confer protection on cowpea better than when cowpea was not treated (181.5±1.8) as the treatments faired best (significantly low) in terms of weight loss in seeds.

**Table-3: Seed weight loss and damage due to *C. maculatus* when exposed to 200g dry cowpea**

| Treatment | Initial seed weight (at the commencement of the experiment (g) | Cowpea seed weight after 4months of storage(g) (+SE) | Damage done to cowpea seeds in terms of number of existing holes/perforations after 4months of storage (g) (+SE). |
|---|---|---|---|
| 1.0g of Capsicum powder (T1) | 200$^{a}$ | 192.0 + 1.8$^{cd}$ | 378.8 + 63.9$^{e}$ |
| 2.0g of Capsicum powder (T2) | 200$^{a}$ | 193.5 + 1.8$^{bc}$ | 317.8 + 63.9$^{f}$ |
| 3.0g of Capsicum powder (T3) | 200$^{a}$ | 193.9 + 1.8$^{b}$ | 320.6 + 63.9$^{f}$ |
| 1.0g whole fruit of Capsicum (T4) | 200$^{a}$ | 193.8 + 1.8$^{b}$ | 481.6 + 63.9$^{c}$ |
| 2.0g whole fruit of Capsicum (T5) | 200$^{a}$ | 193.2 + 1.8$^{bc}$ | 494.0 + 63.9$^{b}$ |
| 3.0g whole fruit of Capsicum (T6) | 200$^{a}$ | 190.9 + 1.8$^{d}$ | 461.0 + 63.9$^{d}$ |
| Actellic dust (T7) | 200$^{a}$ | 200.0 + 1.8$^{a}$ | 00.0 + 63.9$^{g}$ |
| Control (untreated cowpea seed) (T8) | 200$^{a}$ | 181.5 + 1.8$^{e}$ | 596.0 + 63.9$^{a}$ |

*Mean with the same letter are not significantly different according to DMRT*

Percentage of cowpea seeds treated with different doses of powder and whole fruit of *Capsicum frutescens* after 4 months of storage for their germination percentage: There was significant difference among the treatments at various rates of application. Chilli pepper powder and whole fruits at all levels as well as actellic dust provided better protection and ensured higher germination percentage than the control (which had severely damaged seeds). Viability of cowpea seeds after 4 months with these treatments (chilli pepper powder and whole fruit as well as actellic dust) ranged from 80% (actellic dust) to 50% (1.0g whole fruit of Capsicum). The control was highly damaged by *C.maculatus* as it had zero percent. (Table 4). Thus, beetle damage caused significant reduction in seed viability.

**Table-4: Percentage of cowpea seeds treated with different doses of powder and whole fruit of *Capsicum frutescens* after 4months of storage for their germination percentage.**

| Treatment | Germination (%) (+SE) |
|---|---|
| 1.0g of Capsicum powder (T1) | 55 + 8.4$^{d}$ |
| 2.0g of Capsicum powder (T2) | 64 + 8.4$^{c}$ |
| 3.0g of Capsicum powder (T3) | 70 + 8.4$^{b}$ |
| 1.0g whole fruit of Capsicum (T4) | 50 + 8.4$^{c}$ |
| 2.0g whole fruit of Capsicum (T5) | 53 + 8.4$^{ed}$ |
| 3.0g whole fruit of Capsicum (T6) | 55 + 8.4$^{d}$ |
| Actellic dust (0.1g)(T7) | 80 + 8.4a |
| Control (untreated cowpea seed) (T8) | 0.00 + 0.0$^{f}$ |

*Mean with the same letter are not significantly different according to DMRT*

Oviposition by *C. maculatus* and adult emergence (bearing fresh eggs) treated with different doses of *Capsicum frutescens* powder and whole fruits: Shown in table 5 is the result of oviposition by *C. maculatus* and adult emergence (bearing fresh eggs) treated with different doses of *Capsicum frutescens* powder and whole fruits. The treatments/protectants therefore significantly reduced oviposition and adult emergence relative to control, probably through their toxicity on the potential egg laying adults. The control had significantly higher number of eggs laid on seeds (20.4±5.6) under no choice condition and mean adult beetles emerging from the seeds (2.3±0.14) when compared to those treated with *Capsicum* powder (1.8±0.14) and whole fruits (1.0±0.14).

**Table-5: Oviposition by *C. maculatus* and adult emergence (bearing fresh eggs) treated with different doses of *Capsicum frutescens* powder and whole fruits.**

| Treatment | Mean number of eggs (+SE) laid on seeds under no-choice condition | Mean number of adult beetles (+SE) emerging from seeds |
|---|---|---|
| Capsicum whole fruit (T1) | 10.2 + 5.6$^{b}$ | 1.0 + 0.14$^{b}$ |
| Capsicum powder (T2) | 3.1 + 5.6$^{c}$ | 1.8 + 0.14$^{c}$ |
| Control (T3) | 20.4 + 5.6$^{a}$ | 2.3 + 0.14$^{a}$ |

*Mean with the same letter are not significantly different according to DMRT Arcsine transformed*

Proximate composition of cowpea seeds before and after *C. maculatus* infestation: Table 6a shows the result of the proximate composition of cowpea seeds before weevil infestation. It indicated that the seeds make a complete meal containing concentrations of moisture (8.30%), protein (20.51%), carbohydrates (56.24%), ash (5.13%), fat (2.33%) and dietary fibre (7.49%). Similar results was reported by Ahmed (2009) confirming that cowpea contain ash (4.4-3.7%), fat (1.1-3.0%), dietary fibre (5-6%), protein (20-23%) and carbohydrate (60-66%). The variation in the nutritive value may be attributed to the variety of cowpea used and threshing efficiency. However, the high nutritional composition of cowpea may have endeared it to have a prominent place in the native agriculture of tropical and sub-tropical regions of the world in terms of food security (as protein supplement in the daily diets of rural and urban masses) and fodder for ruminant animals.

**Table-6a: Proximate composition of cowpea seeds before infestation**

| Nutrient (+SE) | Proximate composition of cowpea seeds before infestation (+SE) |
|---|---|
| Moisture | 8.30 |
| Ash | 5.13 |
| Fat | 2.33 |
| Crude fibre | 7.49 |
| Protein | 20.51 |
| Carbohydrate | 56.24 |

**Table-6b: Proximate composition of cowpea seeds after infestation (+SE)**

| Treatment | Moisture (%) | Ash (%) | Fat (%) | Crude fibre (%) | Protein (%) | CHO (%) |
|---|---|---|---|---|---|---|
| Cowpea treated with 1g of Capsicum powder ($T_1$) | 6.51±0.02$^{e}$ | 4.11±0$^{b}$ | 1.72±0.10$^{bc}$ | 6.01±0.12$^{d}$ | 16.01±0.03$^{c}$ | 54.39±0.10$^{f}$ |
| Cowpea treated with 2g of Capsicum powder ($T_2$) | 6.91±0.08$^{c}$ | 4.12±0.02$^{b}$ | 1.81±0.01$^{b}$ | 6.31±0.03$^{c}$ | 17.90±0.02$^{abc}$ | 55.51±0.02$^{b}$ |
| Cowpea treated with 3g of | 7.32±0.05$^{b}$ | 4.13±0.02$^{b}$ | 2.00±0.02$^{a}$ | 7.01±0.01$^{b}$ | 18.90±0.01$^{ab}$ | 53.66±0.10$^{g}$ |

| Treatment | Moisture (%) | Ash (%) | Fat (%) | Crude fibre (%) | Protein (%) | CHO (%) |
|---|---|---|---|---|---|---|
| Capsicum powder ($T_3$) | | | | | | |
| Cowpea treated with 1g of whole fruit of Capsicum ($T_4$) | 6.31±0.02$^g$ | 3.63±0.01$^e$ | 1.45±0.01$^d$ | 5.01±0.01$^f$ | 17.50±0.04$^{abc}$ | 56.49±0.04$^a$ |
| Cowpea treated with 2g of whole fruit of Capsicum ($T_5$) | 6.41±0.04$^f$ | 3.88±0$^d$ | 1.52±0.01$^d$ | 5.31±0$^e$ | 16.91±0.02$^{bc}$ | 54.49±0.14$^e$ |
| Cowpea treated with 3g of whole fruit of Capsicum ($T_6$) | 6.64±0.10$^d$ | 3.98±0$^c$ | 1.69±0.02$^c$ | 5.42±0.02$^e$ | 18.09±0.04$^{abc}$ | 55.22±0.02$^c$ |
| Dust (0.1g) ($T_7$) | 8.29±0.02$^a$ | 5.09±0.03$^a$ | 2.10±0.05$^a$ | 7.40±0$^a$ | 20.02±0.01$^a$ | 55.07±0.04$^d$ |

*Mean with the same letter are not significantly different according to DMRT*

Table 6b shows the proximate composition of cowpea seeds after weevil infestation. There was no significant variation in the ash, fat, crude fibre, crude protein and carbohydrate content. When compared with values obtained before weevil infestation (Table 5a), the treatments have higher rates resulting in decrease in nutritive contents of the stored cowpea seeds. This shows that untreated/unprotected cowpea seeds frequently suffer devastation and damage from attack of *C. maculatus* after infestation by feeding inside seeds which rendered them unfit for food and seed in a few months. (Fayape and Ofuya, 1999), emergent holes and loss of weight (Ofuya and Bamigbola, 1991).

# DISCUSSION

This study demonstrates that capsicum powder and whole fruit significantly reduced the level of *Callosobruchus maculatus* (F.) damage compared to control. Although, they manifested a much lower level of efficacy than the synthetic insecticide (actellic dust 2%) in reducing *C. maculatus* damage to cowpea in storage. Egg laying, subsequent adult emergence by beetles were significantly reduced, so also adult mortality with degree of variations. The highest mean number of eggs laid (75.5 ± 8.39) and total number of adult emergence at the control (60.0 ± 0.001) significantly reduced when compared with the values obtained when chilli pepper whole fruits and powder were applied. However, products from *Capsicum frutescens* have known medicinal and pharmaceutical significance and have been analyzed to contain phytochemicals including (tannins, flavonoids, resins, steroids) which may presumably have elicited the insecticidal action.

The efficacy of the treatment in succession was actellic dust – capsicum powder – capsicum whole fruit. The viability of the treatment illustrated the magnitude of insect multiplication and damage which can occur in untreated cowpea seeds. The present study also showed that the effectiveness of the capsicum powder and fruits in reduction of adult emergence, percentage cowpea weight loss and holes and adult mortality after 4 months of storage was dose dependent as it could be observed in 3g of capsicum powder for weight loss and 2g of capsicum powder for damage done on seeds in terms of number of existing holes. This is in consonance with the findings of Javid and Mpotokwane (1997) who reported that the powders of *Capsicum frutescens*, *Capsicum annum* and *Capsicum chinenses* effectively reduced oviposition of *C. maculatus*. Similar reports by Rajapakse (1990) recorded high adult mortality of *C. maculatus* and *Sitophilus oryzae* with the leaves of *Piper nigrum* while Abdullah and Muhammad (2004) revealed that powder of *Piper guineese* had pronounced effect on fecundity of *C. maculatus* when compared to treatment with actellic dust.

The effectiveness of capsicum powder and whole fruit in suppressing adult emergence by causing adult mortality probably suggests its high contact toxicity to the weevils. This confirms the assertion of Ogunwolu and Odunlami (1996) and Yusuf and Galadima (2009) that, the properties required in any chemical for controlling biting, chewing or boring insects include toxicity to adults, reduction of oviposition, ovicidal activity and toxicity to immature stages. This is also corroborated by Ofuya (1986) which submitted that, inhibition of oviposition and reduction in adult emergence are two common mechanisms which have been observed as basis for low damage by *C. maculatus* to seeds protected by many other plant materials. Similar result was reported on repellency and oviposition deterrence by some powdered chilli pepper fruits against the brunchid by Lale (1994).

The actellic dust was superior to capsicum powder and whole fruits. Therefore, the performance of actellic dust (2%) in this experiment confirms the assertion of Singh (1987) who reported that, synthetic insecticides are relied upon mostly for prevention or reduction of storage beetles. Similar to this were the findings of Yusuf and Galadima (2009). It is known that actellic dust 2% has both contact and fumigant action (Hill, 1983) and so the slight advantage it had over the capsicum powder and whole fruit in suppressing *C. maculatus* population and damage may be due to its vapour action (Yusuf and Galadima 2009). Also, the powders of certain edible spices: *Capsicum spp.*, *Piper guineense* Schum and Thorn and *Dennetia tripetala* Baler, etc. have been shown to possess appreciable vapour pressures (pungency) so that toxic fumigant effects against stored grain insects is achieved especially in hermetic storage facilities (Lale, 1993; 1994; 1995; Dawodu and Ofuya, 2000). The pungency in pepper fruit is caused by Capsaicin and its level in pepper varies among different spice pepper cultivars (Rhim and Espigs, 1991; Echezoma, 2006). Thus, Echezoma (2006) observed that, the relative pungency of the different pepper cultivars could therefore explain the inconsistent results obtained in the control of *C. maculatus* using chilli pepper by earlier workers. While Ajayi *et al.*, (1987) did not observe any protectant effect of chilli pepper on *C. maculatus*, Ofuya (1986) demonstrated that it afforded some degree of protection against the pest. Like *capsicum frutescens* fatty acids, phenolic, alkaloids and terpenes especially monoterpenes are often found to be bioactive constituents of plant products (Lale, 1995).

The lowest germination percentage was recorded in control (0%) while the highest was observed in actellic dust (80%), 55 – 70% in capsicum powder and 50 – 55% in capsicum whole fruit. This indicates that lack of proper protection in stored produce could result in severely perforated grains not fit for human consumption but also of very poor viability. The result is in line with the findings of Kang *et al.*, (2013) who reported that after 3 to 6 months of storage, cowpea seeds treated with powdered pepper had the highest germination percentage while the untreated cowpea had the lowest germination percentage. Similar reports by Ivibrajo and Agbaje (1986) indicated that, surface treatment of cowpea with *Piper guineense* and *Capsicum spp.* did not affect the germinative potential of the seeds compared with the control. Yusuf and Galadima (2009) also reported similar findings on the use of neem (*Azadirachta indica*) seed powder, mahogamy (*Khaya senegalensis*) bark powder and actellic dust (2%) on maize grains against *Sitophilus zeamais* (Mots) as well as Rahman and Tahkder (2006) which showed that plant materials (ginger and turmeric rhizomes, karate, red pepper and pepper fruits) tested against *C. maculatus* did not show any visible adverse effect on emergence capacity of the cowpea seeds.

Moreover, it could be observed in the proximate analysis after 4 months that capsicum powder and whole fruits as well as actellic dust retained moisture and other nutritive values. This might be attributed to the fact that, the materials could have acted as film over cowpea seeds, thereby protecting the seeds from evapotranspiration as well as from devastating effects of *C. maculatus*.

## CONCLUSION AND RECOMMENDATIONS

Cowpea (*V. unguiculata* L.) Walp is a major source of dietary protein in tropical and sub-tropical regions of the world. The growth of agricultural based economies of the world depends on the sustained supply of quality seeds.

The *C. maculatus* is the major storage pest of cowpea (*V. unguiculata* L.) in the tropics. Damaged seeds are riddled with adult exit holes and perforations and may be turned to an unslightly powdery mass in severe infection and therefore unfit for human consumption. The result of this study shows that capsicum powder were almost as effective as actellic dust and therefore,it is a potential in protecting cowpea against *C. maculatus* and could serve as a better alternative to synthetic insecticide. It could also save cost as compared to actellic dust which is expensive and may not be accessible to small holder farmers at critical periods like other insecticides which are most often imported. The treatments thus significantly achieved high mortality of adult *C. maculatus* and reduced weight loss due to its ability to inhibit oviposition by *C. maculatus*.

Since capsicum powder and fruits are edible, it gives advantage over actellic dust which is non-edible. The availability, biodegradability, low cost rate and relatively non-harzardous makes it good option as potential bio-pesticide in upgrading traditional crop protection practices in Nigeria and the world as a whole as against mammalian toxicity and environmental pollutions associated with the continuous use and abuse of synthetic insecticides for storing grains meant for consumption.

This study ranks actellic dust superior as a synthetic insecticide and also ranks 3g of capsicum powder superior used as it has shown to have reduced adverse effect of *C. maculatus* on cowpea seed and also did not affect germination percentage of cowpea seeds. Thus, an appreciable level of protection in stored cowpea against damage by *C. maculatus* could be achieved using Capsicum powder and whole fruit under a good and well-coordinated system of store management. In Nigeria, grounded chilli pepper is readily available in the local markets all year round for farmer's use to protect their crops from insect pests of cowpea particularly in storage environment.

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**Cite This Article:** Rosulu HO, Oni MO, Ofuya TI, Adebayo RA (2022). Efficacy of Chilli Pepper *Capsicum frutescens* (L.) for the Control and Management of Cowpea Weevil *Callosobruchus maculatus* (F.) Infesting Cowpea *Vigna unguiculata* (L.) Walp in Storage Environment. *East African Scholars J Agri Life Sci, 5*(2), 44-52.