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INTERACTION OF NUTRIENT COMPOSITION, TEMPERATURE AND MOISTURE CONTENT OF BEAN SEEDS TO BRUCHID INFESTATION

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ABSTRACT

Baseline information for determining the role of nutrient composition, temperature and moisture content on the biological activities of bean weevils in storage was determined. The study was conducted using different temperature sources of black or white muslin clothing two moisture levels of 12±1% and 15±1% and a solarization periods of 48 hours, 72 hours and 96 hours. Disinfested cowpea seeds were infested with 4 pairs of pristine adult *C. maculatus* in each treatment combination and allowed to mate and oviposit. *C. maculatus* had no egg laid 24 hours, at 48 hours significantly high eggs were laid on cowpea seeds covered with white muslin cloths and exposed to 48 hours solarization. Percentage mortality on cowpea seeds covered with black and white muslin cloths and exposed to different hours of solarization showed that 100% mortality in cowpea seeds covered with black muslin cloth and exposed to 72 and 92 hours solarization. There was significant decrease in egg mortality in the control experiment. Solarization and use of black muslin cloth polypropylene sheet may serve as grain protectant when utilized effectively in suppressing bionomics of *C. maculatus* on cowpea seeds during storage.

Keywords: Solarization, Moisture content, Nutrient composition, Bionomics, *Callosobruchus maculatus*, Temperature

INTRODUCTION

One popular legume for human consumption is the common bean (*Phaseolus vulgaris L.: Fabaceae*). It is one of the most extensively consumed grains in the sub-Saharan Africa and it is endowed with significant social, economic, and nutritional significance (Souza *et al*. 2010, Oliveira *et al*. 2013; Lopes *et al*., 2018a, b). The bean weevils *Callosobruchus maculatus* (F.) and *Zabrotes subfasciatus* (Boheman) (Coleoptera: Chrysomelidae) are the major pests affecting the common bean storage, particularly their larvae which causes damage by penetrating and feeding on the cotyledons of the stored Cowpea (Melo *et al*. 2015; Tigist *et al*. 2018).

Stored grains control of insect pests is principally executed by using synthetic insecticides, including phosphine (PH3), pyrethroids, and organophosphorus compounds (Agrafioti *et al*. 2019; Gourgouta *et al*. 2019). Continued and indiscriminate use of pesticides is of worldwide concern as it poses risks to human health as well as the environment, thereby necessitating the need for the implementation of new pest management strategies/options for stored products (Gonçalves *et al*. 2015). The study was aimed at generating baseline information for determining the role of nutrient composition, temperature and moisture content on the biological activities of bean weevils in storage.

MATERIALS AND METHODS

Study Area:

The research was carried out in the Laboratory of Crop and Soil Science Department, Faculty of Agriculture, Rivers State, Nigeria; situated between latitude $4^{0}53^{1}43^{11}$N and longitude $6^{0}54^{1}$ 00^{11}E.

Experimental material & insect culture and rearing

Cowpea seeds (Banjar kilikili variety) was purchased from Southern Plateau, Jos and transferred into a double-layered polythene bag and the opening was held with a tight rubber band and kept at -4 ^{O}C for five days in order to kill any pest present. After 5 days of cold treatment, the seeds were placed and spread on polythene sheet on a laboratory bench and covered with screen gauze held in place at the edges with heavy stones, so that the seeds can equilibrate to atmospheric conditions for three days. Thereafter, the cowpea seeds were packed into disinfested Kilner jars and kept on the laboratory bench until ready for use (Akuba *et al*., 2023).

Cowpea seeds infested with *C. maculatus* were obtained from infested cowpea seeds at Mile 3 market, Port Harcourt, Rivers State. The insects were allowed to multiply in the laboratory and in order to raise teneral adults for the experiment. Cowpea seeds thermally disinfested by keeping them in a freezer at -4°C for five days to kill any insect pest and later acclimatized for 48 hours. Adult insects were sieved from the initial culture and introduced to the disinfected cowpea seeds in order to raise a sub culture of F1 weevils of known age. The insets were allowed to lay eggs for 72 hours and later sieved and allowed the eggs to stay for 35 days in order to obtain pristine adult insects of uniform age.

Experimental design

The study was conducted using different temperature sources of black or white muslin clothing two moisture levels of 12±1% and 15±1% determined using air oven dry method and solarization periods of 48 hours, 72 hours and 96 hours was adopted. The experiment was carried out in a 3x2x4 factorial experiment in CRD and each treatment combination was replicated three times.

Proximate analysis of Cowpea seeds

Cowpea seeds (Banjar kilikili) were taken to Plant Anatomy and Physiology Research Laboratory at University of Port Harcourt for Proximate Analysis of the following parameters: carbohydrates, protein, lipids/crude fats, ash, moisture and crude fibre contents after the procedure by the Association of Official and Analytical Chemicals (AOAC) 2005.

Proximate Analysis

Carbohydrate: Carbohydrate was determined in the Laboratory using Cleg Anthrone method. Absorbance of the standard glucose was read and the value of carbohydrate as glucose was calculated using the formula below.

$$\%CHO \text{ as glucose} = \frac{25 \text{ x absorbance of sample}}{\text{absorbance of standard glucose x 1}}$$

Crude Protein: Crude protein was determined using Kjeldahl method.

$$\% \text{ organic Nitrogen} = \frac{\text{titer value x 1.4 x 100 x 100}}{100 \text{ x } 20 \text{ x } 0.1}$$

Ash: Ash was determined using Furnace method. 1gram of the dried sample was weighed into porcelain crucible which was previously preheated and weighed. The crucible was inserted into a muffle furnace and regulated to a temperature of 630°C for three hours and allowed to cool to room temperature and reweighed.

$$\% \text{ Ash} = \frac{\text{weight of crucible+Ash sample}-\text{weight of crucible}}{\text{weight of sample}} \text{ x} \frac{100}{1}$$

Crude fats: Crude fats was determined using Soxhlet extraction method.

$$\% \text{ Lipid} = \frac{\text{weight of flask and extract}-\text{weight of empty flask}}{\text{weight of sample extracted}} \frac{100}{1}$$

Moisture: Moisture was determined using air oven dry method. 1 gram of the sample was weighed into a clean dried porcelain evaporating dish and placed in oven to maintain a temperature of 105°C for six hours. The evaporating dish was cooled in desiccators to room temperature then it was reweighed and recorded.

$$\% \text{ moisture} = \frac{\text{weight of fresh sample}-\text{weight of dried sample}}{\text{weight of sample used}} \text{ x} \frac{100}{1}$$

Crude Fibre: crude fibre was determine using (Gooch crucible).

$$\% \text{ Crude fibre} = \frac{w2-w3}{w1} \text{ x } 100$$

Moisture content experiment

Twenty grams of cowpea seeds were weighed into four plastic containers and two moisture content levels of 12±1 % and 15±1 of cowpea seeds using the formulae below were adopted for the experiment.

Weight of sample, Wet weight (WW), Dry weight of sample (DW)

Weight moisture content= WW-DW

$$\% \text{ moisture content} = \frac{DW}{DW} \; x \; 100\%$$

New moisture required = %MC

$$\% \text{ MC} = \frac{WW2-DW2}{DW} \; x \; 100$$

$WW_2 - DW_2 = DW_{2\,(g)}$

Solarization experiment

Twenty grams of cowpea seeds were also weighed into different plastic containers, and subjected to 48hr, 72hr and 96hr solar radiation using black muslin cloth, white muslin cloth and Punch holes and a control of (0)h was included.

Infestation of cowpea seeds with the cowpea seed beetles for experimental study

Disinfested cowpea seeds were infested with 4 pairs of pristine adult *C. maculatus*, and covered with either black or white muslin cloth and a control where only holes were punched on the containers. The insects were allowed to mate and oviposit for a period of seven days on the cowpea seeds. Data on the number of dead and living insects and number of eggs laid on the cowpea seeds were counted and recorded daily for a period of 7 days.

Solar radiation technique and exposure

Exposure of infested seeds to solar heat energy was conducted following the procedure described by Mekasha *et al.* (2006) with some modifications. Different plastic containers were used for infested seeds carrying cowpea bruchid eggs. The plastic containers bearing the infested cowpea seeds were exposed to solar heat treatment for 48, 72, and 96 hours. A control (0) h exposure was included and kept in the laboratory without exposure to solar radiation.

The exposure period was carried out from sunrise to sunset for each day and the treatment was removed and kept in the laboratory throughout the night and brought out the next day for the solarization treatment to continue until the individual exposure period (hours) were met (Mekasha *et al.*, 2006; Akuba *et al*., 2023). The number of adults dead and alive as well as egg laid were recorded on each treatment.

Cowpea seeds weight loss

Weight of the cowpea seeds were taken in batches at the beginning and at termination of the experiment using an electronic sensitive Metler balance (IndiaMART). The difference in the weight was recorded and % weight loss of each of the forms was calculated by taking the difference between the initial weight and final weight. The result was express in percentage

$$(\%) \text{ Weight loss} = \frac{C-T}{C}$$

C= Initial weight(g) T= finial weight (g)

Data Collection and analyses

Data was collected for the following:

Egg laid by *C. maculatus* on cowpea seeds in a period of seven days, mortality rate on each treatment combination was taken daily for a period of seven days and insects' emergence at 35 days and weight loss due to weevil infestation suffered by cowpea seeds were taken. Analysis of variance was run in factorial combinations in CRD using R software (v. 4.1 and significant means were separated using New Duncan Multiple Range Test at $P<0.05$ significance level

RESULTS AND DISCUSSION

Proximate composition of cowpea seed (Banjar Kilikili variety)

Result from the study shows that Banjar kilikili variety contains 53.0% carbohydrate,16.94% protein, 3.74% ash, 2.20% lipid, 10.41%moisture, and 13.71% fibre as shown in Table 1 below

Table 1: Proximate composition of cowpea seed (Banjar Kilikili variety)

Parameters	Percentage (%)
Carbohydrate	53.00
Protein	16.94
Ash	3.74
Lipid	2.20
Moisture	10.41
Fibre	13.71

Effect of temperature and moisture content on *C. maculatus* oviposition on cowpea

Callosobruchus maculatus shows no eggs were laid by the adult on the cowpea variety after 24 hours, at 48 hours significantly higher number of eggs were observed on cowpea seeds covered with black net and white muslin cloths and expose to 48 hours solarization, this was followed by cowpea seeds whose moisture content was raised and left in the laboratory. From the same table the result shows that higher number of eggs were laid on cowpea seeds covered with black muslin clothes and kept at normal moisture content across the 7 days while fewer eggs were laid on cowpea seeds which moisture content were raised and exposed to solarization for 72 and 92 hours (Table 2)

Table 2: Effect of temperature and moisture content on *C. maculatus* oviposition on cowpea seed covered with white and black muslin clothe and exposed to 48, 72 and 96 hours solarization

Exposure	12±1% Moisture content			15±1% Moisture content		
	Muslin clothe colour			Muslin clothe colour		
	Black	White	Net	Black	White	Net
Day 1						
0hr	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
48hrs	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
72hrs	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
96hrs	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Day 2						
0hr	0.33±0.33	0.33±0.33	0.67±0.33	0.67±0.33	0.33±0.33	0.33±0.33
48hrs	0.00±0.00	0.67±0.33	0.33±0.33	0.33±0.33	0.00±0.00	0.00±0.00
72hrs	0.33±0.33	0.33±0.33	0.33±0.33	0.00±0.00	0.00±0.00	0.00±0.00
96hrs	0.33±0.33	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Day 3						
0hr	1.33±0.33	0.33±0.33	1.33±0.67	0.67±0.33	0.67±0.67	0.33±0.33
48hrs	0.33±0.33	0.67±0.33	0.33±0.33	0.33±0.33	0.00±0.00	0.00±0.00
72hrs	0.67±0.67	0.33±0.33	0.33±0.33	0.33±0.33	0.00±0.00	0.00±0.00
96hrs	0.33±0.33	0.00±0.00	0.00±0.00	0.33±0.33	0.00±0.00	0.33±0.33
Day 4						
0hr	2.33±0.33	1.00±0.58	1.33±0.67	1.33±0.67	1.00±0.58	0.67±0.67
48hrs	0.67±0.33	0.67±0.33	0.67±0.33	0.67±0.33	0.00±0.00	0.00±0.00
72hrs	1.00±0.00	0.67±0.33	0.33±0.33	0.33±0.33	0.00±0.00	0.00±0.00
96hrs	1.00±0.00	0.00±0.00	0.67±0.33	0.33±0.33	0.00±0.00	0.33±0.33
Day 5						
0hr	4.33±0.33	2.33±0.33	2.67±0.33	2.67±0.88	2.00±0.58	1.33±0.88
48hrs	1.00±0.57	1.67±.33	0.33±0.33	1.33±0.33	0.33±0.33	0.33±0.33
72hrs	1.67±0.33	0.67±0.33	0.33±0.33	0.67±0.67	0.33±0.33	0.33±0.33
96hrs	2.00±0.00	0.33±0.33	1.33±0.67	1.33±0.33	0.00±0.00	1.00±0.58
Day 6						
0hr	6.67±0.67	3.00±.58	4.00±1.15	4.00±0.58	3.00±0.58	1.67±0.67
48hrs	2.00±0.58	1.67±0.33	1.00±0.58	1.67±0.33	1.00±0.00	0.67±0.33
72hrs	2.33±6.67	1.00±0.58	1.00±0.58	1.00±0.58	1.00±0.58	0.67±0.33
96hrs	2.00±.00	1.00±0.58	2.00±0.58	2.00±0.58	0.33±0.33	2.00±0.58
Day 7						
0hr	8.33±0.88	4.33±0.67	4.67±0.88	5.00±0.58	3.33±0.33	2.33±0.88
48hrs	3.00±0.58	2.33±0.67	1.33±0.33	2.67±0.33	1.33±0.33	2.00±0.58
72hrs	2.67±0.88	1.67±0.67	1.67±.67	1.33±0.33	2.33±0.33	1.33±0.33
96hrs	2.33±0.33	1.33±0.88	2.33±0.88	2.67±0.67	1.33±0.33	2.67±0.33

Effect of temperature and moisture content on percent mortality of *C. maculatus*

Effect of temperature and moisture content on *C. maculatus* percentage mortality on cowpea seeds covered with black and white muslin cloths and exposed to different hours of solarization showed that 100% mortality was recorded on cowpea seeds covered with black, white muslin cloth and net which were exposed to 48, 72 and 92 hours solarization. From the same table least percentage mortality was recorded on cowpea seeds covered with black, white muslin cloth and net that were left in the laboratory (Table 3)

Table 3: Effect of temperature and moisture content on percent mortality of *C. maculatus* on-cowpea seed covered with black and white cloth and exposed to 48, 72 and 96 hours solarization

Exposure	12±1% Moisture content			15±1% Moisture content		
	Muslin clothe colour			Muslin clothe colour		
	Black	White	Net	Black	White	Net
Day 1						
0hr	0.00±0.00^{g}	0.00±0.00^{g}	0.00±0.00^{g}	0.00±0.00^{g}	0.00±0.00^{g}	0.00±0.00^{g}
48hrs	0.00±0.00^{g}	4.17±4.17^{g}	16.67±8.33^{ef}	0.00±0.00^{g}	20.83±11.02^{def}	29.17±4.17^{bcde}
72hrs	3.75±0.00^{g}	10.83±7.08^{fg}	29.17±4.17^{bcde}	29.23±4.23^{bcde}	29.17±.17^{bcde}	45.83±4.17^{a}
96hrs	25.00±0.00^{cde}	33.00±4.00^{bcd}	37.00±0.00^{abc}	41.67±25.00^{ab}	25.00±0.00^{cde}	37.50±0.00^{abc}
Day 2						
0hr	0.00±0.00	0.00±0.00	0.00±0.00	00.00±0.00	0.00±0.00	0.00±0.00
48hrs	0.00±0.00	4.17±4.17	16.67±8.33	8.33±8.33	25.00±12.50	25.00±12.50
72hrs	25.00±0.00	25.00±0.00	25.00±0.00	33.33±8.33	41.67±4.17	45.83±4.17
96hrs	25.00±0.00	29.17±4.17	25.00±0.00	37.50±0.00	41.67±8.33	50.00±0.00
Day 3						
0hr	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
48hrs	8.33±8.33	45.83±4.17	50.00±0.00	45.83±4.17	58.50±8.50	75.00±12.50
72hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
96hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
Day 4						
0hr	0.00±0.00	0.00±0.00	0.00±0.00	8.33±8.33	0.00±0.00	0.00±0.00
48hrs	100.00±0.00	100.00±0.00	100.00±0.00	83.33±4.17	83.33±4.17	83.50±4.00
72hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
96hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
Day 5						
0hr	0.00±0.00	0.00±0.00	0.00±0.00	16.67±8.33	8.33±8.33	8.33±8.33
48hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
72hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
96hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
Day 6						
0hr	0.00±0.00	8.33±4.17	0.00±0.00	16.67±8.33	8.33±8.33	8.33±8.33
48hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
72hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
96hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
Day 7						
0hr	8.33±4.17	4.17±4.17	8.33±4.17	20.23±10.58	16.67±8.33	24.67±12.33
48hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
72hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
96hrs	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00

Effect of temperature and moisture content on *C. maculatus* adult emergence

Table 4 shows the effect of moisture content and solarization on the *C. maculatus* adult emergence on cowpea covered with different muslin cloth colours and exposed to different hours of solarization. The results reveal significantly higher number of adult *C. maculatus* emergence from cowpea placed in the laboratory, and generally cowpea not exposed to solarization has higher adult emergence. Similar trends were observed over the five days.

Table 4: Effect of temperature and moisture content on *C. maculatus* adult emergence of cowpea seed covered with black and white cloth and exposed to 48,72, and 96 hours solarization

Exposure	12±1% Moisture content			15±1% Moisture content		
	Muslin cloth colour			Muslin cloth colour		
	Black	White	Net	Black	White	Net
Day 1						
0hr	4.67±0.33	4.67±0.33	4.67±0.33	4.33±0.67	4.67±0.33	3.00±0.58
48hrs	4.33±0.33	3.67±0.33	3.33±0.33	4.00±0.00	3.33±0.33	3.67±0.33
72hrs	3.33±0.33	3.00±0.00	3.00±0.58	2.33±0.33	2.33±0.33	1.67±0.33
96hrs	2.33±0.33	2.33±0.33	2.33±0.33	1.33±0.33	1.33±0.33	1.33±0.33

Day 2						
0hr	4.33±0.33	4.67±0.33	4.67±0.33	4.00±0.58	4.67±0.33	3.00±0.58
48hrs	4.00±0.58	3.67±.33	3.00±0.58	3.67±0.33	3.00±0.00	3.00±0.58
72hrs	2.00±0.00	2.33±0.33	2.00±0.00	2.33±0.33	2.00±0.58	1.00±0.00
96hrs	1.67±0.33	1.67±0.33	1.67±0.33	0.67±0.33	1.00±0.00	1.00±0.00
Day 3						
0hr	4.00±0.58	3.67±0.33	3.33±1.20	3.33±0.33	3.33±0.67	2.67±.67
48hrs	3.67±0.67	3.67±0.33	2.00±0.00	2.67±0.33	2.00±0.58	2.33±0.33
72hrs	1.67±0.33	1.67±0.33	1.67±0.33	1.33±0.33	2.00±0.58	1.00±0.00
96hrs	1.33±0.33	1.33±0.33	1.67±0.33	0.67±0.33	1.00±0.00	1.00±0.00
Day 4						
0hr	2.67±0.88	3.00±0.58	3.67±0.33	3.00±0.00	3.33±0.67	2.67±0.67
48hrs	1.67±0.33	2.00±0.58	1.33±0.33	2.00±0.58	2.00±0.58	2.33±0.33
72hrs	1.33±0.33	1.67±0.33	0.33±0.33	1.00±0.00	1.33±0.67	1.00±0.00
96hrs	0.33±0.33	1.33±0.33	0.67±0.33	0.67±0.33	0.67±0.33	1.00±0.00
Day 5						
0hr	2.00±0.58	2.67±0.33	3.00±0.58	3.00±0.00	3.00±0.58	2.33±0.33
48hrs	1.00±0.00	0.67±0.33	0.67±0.33	2.33±0.33	2.00±0.58	2.00±0.00
72hrs	1.00±0.00	0.00±0.00	0.00±0.00	1.00±0.00	1.33±0.67	1.00±0.00
96hrs	0.33±0.33	0.33±0.33	0.33±0.33	0.33±0.33	0.00±0.00	0.33±0.33

Effect of temperature and moisture content on *C. maculatus* and percentage weight loss of cowpea seed

Weight loss in cowpea seeds due to *C. maculatus* infestation were higher in cowpea seeds covered with net exposed to 72 hours solarization though not significantly different from cowpea seeds covered with black muslin clothes kept in the laboratory. From Table 5 least Percentage weight loss was recorded on cowpea seeds covered with black clothes and left in the laboratory.

Table 5: Effect of temperature and moisture content on *C. maculatus* on percentage weight loss of cowpea seed covered with black and white cloth and exposed to 48, 72, and 96 hours solarization

Exposure	12±1% Moisture content			15±1% Moisture content		
	Muslin cloth colour			Muslin cloth clolour		
	Black	White	Net	Black	White	Net
0hr	6.13±1.29	7.20±1.36	7.23±2.48	4.63±0.12	7.40±1.35	7.00±1.25
48hrs	16.87±3.62	12.27±3.84	11.87±5.65	6.93±1.10	5.97±1.22	5.67±1.32
72hrs	7.70±0.60	5.57±0.77	9.43±1.60	10.50±3.80	11.97±1.76	17.20±1.25
96hrs	10.33±4.03	11.70±3.40	7.40±2.65	12.93±0.93	8.50±0.15	7.57±1.23

Discussion

The values for crude protein recorded from the study were similar to the range of 15.62 and 17.91 % reported by Alayande *et al.* (2012) but not in agreement with the report of Otitoju *et al.,* (2015) whose values ranged between 21.02 and 26.90 %. This suggests that the cowpea variety had same crude protein as earlier reported and therefore could be good source of plant protein which is used as the main source of protein especially among low-income earners where animal protein is an unaffordable luxury (Santos and Boiteux, 2013) therefore protecting it against insect infestation in store is eminent. The value for crude fat was higher than that of Olopade *et al.* (2017) who reported a value of 1.86%, while Otitoju *et al.* (2015) in their report recorded values ranging from 2.96 to 3.25 %. All these value show that cowpea cannot be considered as an oil seed. Seeds are considered as oil seeds when their oil yield is greater than 17% (Adaramola *et al*., 2016), thus Banjar kilikili cowpea variety is not an oil seed. The crude fibre recorded in the current study also agrees with that of (Alayande *et al*., 2012 and Otitoju *et al*., 2015).

There was a decrease in eggs laid by female *C. maculatus exposed* to solarization for 24 and 48 hours and increase in eggs laid for day 7 in cowpea seed left in the laboratory covered with black muslin cloth. The significant decrease in egg laid by the bruchid among the control group was consistent with the findings of Lale and Ajayi (2001) and Lale and Vidal (2003) who studied the effect of solarization on egg mortality and progeny emergence of *C. maculatus* and showed that; solar heat treatment of cowpea seeds can adequately control infestation by cowpea seed bruchids. It has been shown that exposing infested cowpea grains to a temperature of 57^0C for 1hr in an oven kills all the immature stages (eggs, larvae and pupae) of *C. maculatus* within the seeds – this temperature per exposure time was thus reported as the thermal death point of *C. maculatus* (Murdock and Shade,1991). After 96 hours of exposure to solar radiation there was an increase in mortality of cowpea bruchid on cowpea seeds covered with black and white muslin cloths. The death of this insect could be due the inability of *C. maculatus* to tolerate high temperature (Akuba et al., 2023) generated by the black cloth which is known to be heat absorber as earlier reported by Beakett *et al,* (2007) that elevating temperature can cause rapid mortality of stored product.

The significantly lower adult emergence recorded in the current study is indicative of the suppressive effects of the heat treatments on immature stages of cowpea weevils, as earlier reported by Peter and Sule, (2019) that cowpea bruchids infesting cowpea seeds exposed to solar radiation in polypropylene sheets had lesser progeny development similar

assertion was reported by Murdock and Shade, (1991) that high levels of control achieved as a result of the solar heat treatments indicates that this technique has the potential of curbing pest outbreak in the store (Maina and Lale, 2004).
The significant weight loss recorded in cowpea seeds exposed to heat for up to 96 hours agrees with earlier reported by Peter and Sule, (2019) that led to more percentage weight loss in similar experiment.
Solarization therefore may serve as grain protectant when utilized effectively (Ragaa *et al*. (2017). Since it can be used in place of chemical where sun drying provided adequate protection of cowpea seeds against infestation by *C. maculatus* by increasing the exposition time to sun light the number of bruchid adults decreases drastically (Alice *et al*., (2013)

CONCLUSION

This study highlights the potential of solarization to effectively suppress the bionomics of *C. maculatus* on cowpea seeds during storage. The findings suggest that with the use of black muslin cloth polypropylene sheet, the thermal death point of *C. maculatus* in the study area could be pegged to 72hrs and 96hrs exposure of infested cowpea seeds as 100% mortality was achieved.

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