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Comparative effect of Sweet Orange (*Citrus sinensis*) peel, Bitter Leaf (*Vernonia amygdalina*), Figwort (*Scrophularia californica*), Pawpaw Leaf (*Carica papaya*) powder and synthetic insecticide on the control of dried plantain chip pest *Tribolium castaneum* (Red flour beetle)

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Summary: This research work was conducted to determine the comparative effect of Sweet Orange (*Citrus sinensis*) peel, Bitter Leaf (*Vernonia amygdalina*), Figwort (*Scrophularia californica*), Pawpaw Leaf (*Carica papaya*) powder and synthetic insecticide on the control of dried plantain chip (*Tribolium castaneum*). Leaves of *V. amygdalina, S. californica, C. papaya* and *C. sinensis* were used. Each of the four plant powders at two different concentrations (5g and 10g) were used to compare with the effectiveness of synthetic and those without treatment (control) for the period of 28th days in a completely randomized design (CRD). The result revealed that increase in live insect was evident in zero treatment followed by those dried chip treated with *C. papaya* at 5% conc. whereas least value was recorded for those chip applied with synthetic and *S. californica* slightly follows. However, the value obtained for dead insect was highest in those chips with synthetic in which *S. californica* follows whereas least value was recorded for zero treatment and *C. papaya* at 10% conc. The value recorded for damaged done by *T. castaneum* on the chip was highest at *C. sinesis* at 10g application. The lowest value was recorded for control and synthetic while plant extract *S. californica* follows. However, the weight of chip left was highest in botanical applied with *S. californica* when compared with other botanical and the synthetic. It is therefore recommended that the botanical Figwort (*S. californica*) with either 5 or 10% concentration used in this study can serves as a good substitute to the synthetic insecticide for chips storage since its fumigant activities can penetrate the crevices made by the pests on chips to affect the hiding stages.

Key words: *Tribolium castaneum*, plantain chip pest, Figwort, synthetic insecticide.

Introduction

Plantains (*Musa* sp.) are plants producing fruits that remain starchy at maturity (Marriot and Lancaster 1983, Robinson 1996) and need processing before consumption. It is an important crop that contributes to food security and poverty alleviation in Africa countries. It is estimated that about 70 million people in West and Central Africa derive more than 25% of their carbohydrates from plantains, making them one of the most important sources of food energy throughout the African lowland humid forest zone (Swennen 1990, Isah *et al.* 2009). However, its production represents 82% of the world production (FAO 2016). Plantains are good sources of carbohydrates, dietary fibers, proteins, vitamin C, and minerals (Tortoe *et al.* 2012) and are eaten on diverse forms: boiled, steamed, baked, pounded, roasted, or sliced and fried/ dried into chips. Overripe plantains are processed into beer or spiced with chili pepper, fried with palm oil and served as snacks ('dodo-ikire'). Industrially, plantain fruits serve as composite in the making of baby food ('Babena' and 'Soyamusa'), bread, biscuit and others (Ogazi 1996, Akyeampong 1999).

Despite its economic, food and socio-cultural functions, plantain production remains hampered by numerous biotic (pests and diseases) and abiotic (poor soils, climate change etc.) factors. Also, the difficulty of fresh fruits conservation causes important post-harvest losses (65-85% of the weight of fruits) and an irregularity of its availability throughout the year (Babajide *et al.* 2008). To overcome the highly perishable nature of fruits, plantain are transformed into chips which are traditionally dried under the sun (Hounhouigan *et al.* 2003), thus enhancing food security (Babajide *et al*. 2008). The production process consists of peeling, blanching and drying the fruits then crushing and milling them (Akingbala *et al.* 1995, Akissoe *et al.* 2001). The resulting flour, with a median particle size of 70-75µm (Okaka and Anajekwu 1990, Akissoe *et al.* 2001), is mixed with boiling water in ratio 1:4 to produce a coloured gel-like paste called 'amala'. Though 'amala' is largely eaten by Yoruba tribe of south-western Nigerian while other part regards it as 'plantain fufu'.

Moreover, the processing crops to chips helps to increase their shelf life, reduce transport cost by reducing bulkiness, improve handling quality, remove non-edible and unmarketable parts and make producers earn higher income by helping them keep their produce till the season of scarcity (Eze *et al.* 2006). Plantain chips are usually spread to dry on the ground rock surfaces, road sides and spacious roofs. The drying plantain chips are exposed to insects and fungal attack that could be inadvertently carried to storage (Chijindu and Boateng 2008, Isah *et al.* 2009). Post-harvest losses constitute major problems limiting their availability in most producing regions of Sub-Sahara Africa (Sugri and Johnson 2009). Although recent researches have evolved methods of storing fresh produce, they are still under trial and have kept these produce for a few days (Akanonwur and Sodie 2005). *Musa* sp. can only be stored for relatively long period of time in the form of dried chips or fried (Fayemi 1999). The dry stored products are attacked by many pests that cause serious damages to the products. It is necessary therefore to such pests, since cares and expenditures for pest control in field crops would be of no use if the products will be attacked and damaged when stored.

Research have identified some of the insect pest involved in causing severely attacked on stored produce such as Red flour beetle, *Tribolium castaneum* is one of the primary pests infesting dry stored produce worldwide (Garcìa *et al.* 2005). Vernier *et al.* (2005) reported that dried yam chips in traditional storage systems are severely attacked by *Dinoderus porcellus* Lesne (Coleoptera: Bostrichidae), which easily destroys stocks in few days. These pests, also found in dried cassava chips (Schäfer *et al.* 2000) causes visual damage by penetrating the chips thus depreciating their market value and negatively influence the quality of reconstituted plantain paste (Babarinde *et al.* 2013). However, several kinds of preventive and curative control measures are being tried. Among these, chemical pesticides have been used for a long time with some measure of success but with serious setbacks (Gupta *et al.* 2001). These setbacks include; danger of pesticide misuse, pest resistance, killing of non-target species, the destruction of the balance of the ecosystem (Garcìa *et al.* 2005) and resurgence, residue in food and feed etc. (Iloba and Ekrakene 2006). Therefore, there is an urgent need to develop an alternative control method that preserves human health and the environment.

Alternatives to these synthetic chemicals are extracts or powders from of some aromatic plants (Onu *et al.* 2015). In fact, plants contain bioactive metabolites, which act as antifeedants, repellents, and toxicants against a wide range of insects that attack stored products (Rajendran and Sriranjini 2008). In addition, these indigenous plants, which are used as crude materials to control insect pest infestations, are harvested locally, cheap, and require only limited processing (Grzywacz *et al.* 2014). Similarly, plant extract have proved to control enormous storage insect pest populations, and it is an environment-friendly management option (Keneni *et al.* 2011). Therefore, the use of botanicals and insect-resistant dry plantain chips to control insect pest appear as a promising alternative. This necessitated the search for alternative sources for containment of storage insect pest of plantain chips. Hence, in the present investigation, four plant powders were tried as bio pesticide for the control *T. castaneum* on plantain chips Ayetoro, Ogun State, Nigeria. The general objective is to compare the effect of Sweet Orange peel (*Citrus sinesis*), Bitter Leaf (*Vernonia amygdalina*), Pawpaw Leaf (*Carica papaya*) and California figwort (*Scrophularia californica*) powders with synthetic insecticide on the control of *T. castaneum* on plantain chips.

Materials and methods

Experimental location

The experiment was conducted at the Crop production laboratory, College of Agricultural Sciences, Olabisi Onabanjo University, Ayetoro, Ogun State, Nigeria. Climate is sub-humid tropical with an annual rainfall of 1,909.3mm. Rainy season is between early April and late October. Maximum temperature varies between 29°C during the peak of the wet season and 34°C at the onset of the dry season and mean annual relative humidity is 81%. Most soil in the area is sandy-loam in nature. Agriculture is one of the main occupation of the people of Ayetoro (Onakomaiya *et al*. 1992).

Procurement of Plantain and chips preparation

Bunches of matured but unripe plantain fruits were obtained from Ayetoro Market, Ogun State, Nigeria. The plantain were peeled and sliced into chips of about 4 mm thickness. It was later sun dried for some weeks till a moisture content of 8.5% was reached. Determination of moisture content was done according to AOAC (1990) method.

Collection and preparation of plant leaves into powders

The leaves of *V. amygdalina, S. californica, C. papaya* and *C. sinesis* peels were obtained from Olabisi Onabanjo University, Teaching and Research Farm and air dried. The identification of the plants was confirmed by the Agronomist in the Crop Department. The collected leaves and citrus peels were washed and air dried at ambient temperature for 20 days under a shade in order to prevent the degradation of bioactive compounds by sunlight. After drying, the leaves were ground into powder using an electrical blender. To obtain the finest particles, the powders were passed through a 300µm sieve (Loko *et al.* 2017). The powder obtained from each plant species was put in separated air tight container in cool and dry place until use.

Culture of the experimental insects

Plantain chips infested with *T. castaneum* were obtained from Ayetoro Market, Yewa North, Ogun State, Nigeria. These were maintained at an ambient temperature of 27-30°C and relative humidity 75 ± 5%. The emerged adults were sub-cultured in a glass jar in the laboratory, till new insects emerge. The glass jars were covered with a net for aeration and to prevent the insects from escaping. The insects used for this experiment were taken from this culture as necessary.

Plantain chip treatment and introduction of test insects

The uninfested chips are kept in the fridge for 24 hours in order to minimize any microbial activities. Thirty (30) grams of plantain chips were weighed with a sensitive balance scale into transparent plastic cage (size) replicated thrice for each of the four plant powders at two different concentrations (5g and 10g). The plantain chips were then separately mixed with the plant powder and the contents of each plastic cage were mixed thoroughly to allow even distributed of the powder in the whole mass. Synthetic insecticide (Aluminium phosphide) at recommended dose and untreated plantain chip treatment were used as standard and control respectively. Matured insects (5 male and 5female) were introduced into the plastic jars containing plantain chips using camel hair brush. The jars were placed in the shelves at a temperature of 28±2°C and relative humidity of 70±5% for 28 days in a completely randomized design (CRD). Mortality was assessed at the end of the 28th day of exposure using the technique of Ceruti and Lazzari (2005) and Nukenine *et al.* (2011).

Data collection and Statistical Analysis

Data collected at the end of the storage intervals included the weight of chips; percentage chips infestations, total insect counts and weight of damaged chips. Data collected were analysed using the Statistical analysis Software (SAS, 2002). Means were separated using the new Duncan's Multiple Range Test at P<0.05.

Results

The effect of the botanical leaf and synthetic powders on live rate *Tribolium castaneum.*

Table 1 shows the effect of the botanical powders leaf and synthetic on the adult mortality of *T. castaneum* at 28 days. Increase in live insect is shown in zero treatment followed by those dried chip treated with *C. papaya* at 5% conc. whereas least value was recorded for those chip applied with synthetic and *S. californica* slightly follows. However, for non-damaged chip, it was revealed that highest value was recorded for those chip applied with synthetic, followed by *S. californica* and *V. amygdalina* at 5% and 10% conc. whereas those on *C. papaya* (5% and 10%), *C. sinensis* at 10% and zero treatment were least values recorded for non-damages chip.

Adult mortality and mean weight of chip left on *Tribolium castaneum* as affected by botanical leaf powders at 28 days.

Table 2 revealed that the value obtained for dead insect was highest in those chips with synthetic in which *S. californica* follows whereas least value was recorded for zero treatment and *C. papaya* at 10% conc. It was revealed that *S. californica* at 5 and 10g were most effective in number of dead insect (*T. castaneum*) when compared with other botanicals at 5 days. Whereas, *C. sinesis* and *V. amygdalina* at 5 and 10g follows while *C. papaya* having the least values for number of dead *T. castaneum* insect. The value recorded for damaged done by *T. castaneum* on the chip was highest at *C. sinesis* at 10g application. The lowest value was recorded for control and synthetic while plant extract *S. californica* follows. However, the weight of chip left was highest follows the same trend with that of number of dead insect and damaged chip. In which out of the botanical applied, *S. californica* tends to have appreciable weight when compared with other botanical and the synthetic.

Discussions

It is revealed from this study, that insect pest infestation are the most important constraint to stored dried plantain chips which have adverse effect on low quality and reduced its quantity due to its hygroscopic nature which prone to damage by insect pest (Halliday *et al.* 1967, Braimah and Popoola 2019). However, it is noted that one of the most occurrence and abundance of insect pest such as *T. castaneum* is prominent part for pest management most especially for dried produce. It was revealed in the present study that stored dried plantain chips are not immune *T. castaneum* infestation. This support the report of Chukwulobe and Echezona (2014) who stated that losses caused by *T. castaneum* in dried produce are very high with about 70% recorded of farm storage. Moreover, the findings in these trials showed the potentials of aqueous extracts of pawpaw, sweet orange, figwort, bitter leaf and synthetic (Bom) in controlling insect pest on storage plantain chip. In the present study, the botanical pesticides figwort (*S. californica*) tends to reduce the population of *T. castaneum* at both 5 and 10% concentration level. This agrees with the findings of Campolo *et al.* (2018) that demonstrated the effectiveness of a botanical leaf extract against the lesser borer, obtaining the highest repellency percentage. This also supports the findings of Scott *et al.* (2005, 2007). The insecticidal constituents of many plant extracts and essential oils are monoterpenoids. Due to their high volatility, they have fumigant activity that might be of importance for controlling insect pest invading grains, pod plants and stored-product insects (Romeilah *et al.* 2010). This agrees with the report of Pasdaran and Hamedi (2017) who noted that the activity of figwort have been attributed to various chemical compounds which include triterpenes, triterpenoid glycosides, alkaloids, diterpenoids and essential oils. However, these bioactive compounds are said to act in concert

Table 1: Mean effect of the botanical leaf powders on live adult of *Tribolium castaneum* at 28 days.

Treatments	Conc. Level (g)	Mean number of live insect	Non-damaged chip (g)
Carica papaya	5	9.00[ab]	10.67[d]
	10	9.87[b]	10.67[d]
Citrus sinensis	5	6.67[c]	12.15[c]
	10	6.00[cd]	9.60[e]
Scrophularia californica	5	3.67[d]	13.00[bc]
	10	2.33[e]	14.72[b]
Vernonia amygdalina	5	6.67[c]	14.00[b]
	10	7.00[bc]	12.33[c]
Zero treatment	-	12.78[a]	8.00[f]
Synthetic		0.00[f]	20.00[a]
Standard Error of the Mean		0.85	1.39

Values followed by the same letters in superscript in a column are not significantly different from each other (Duncan's Multiple Range test) at 5% level of probability.

Table 2: Mean adult mortality rate and mean weight of chip left on *Tribolium castaneum* as affected by botanical leaf powders at 28 days.

Treatments/powders	Conc. Level (g)	Mean number of dead insect	Damaged chip (g)	Mean weight of chip left (g)
Carica papaya	5	1.00[gh]	9.33[ab]	9.93[e]
	10	1.33[g]	9.33[ab]	10.11[d]
Citrus sinensis	5	3.33[e]	7.33[bc]	9.65[e]
	10	4.00[d]	10.33[a]	11.97[c]
Scrophularia californica	5	6.33[c]	7.00[c]	13.44[b]
	10	7.67[b]	6.67[d]	14.82[b]
Vernonia amygdalina	5	3.00[ef]	6.00[d]	11.02[c]
	10	3.33[e]	7.67[b]	11.52[c]
Zero treatment	-	0.78[f]	9.98[f]	8.90[f]
Synthetic		10.0[a]	0[e]	20.00[a]
Standard Error of the Mean		0.91	1.34	0.73

Values followed by the same letters in superscript in a column are not significantly different from each other (Duncan's Multiple Range test) at 5% level of probability.

thereby giving no room for development of pest resistance (Romeilah *et al.* 2010). They exhibit significant antifeedant, pesticidal, microbial and inert growth disrupting properties.

The results obtained from this work confirmed that botanical extracts (figwort) can be as effective as synthetic bom in chips storage. Although, synthetic (bom) use had proved more effective in the control of insect pest of plantain chip. Moreover, the appropriate use of it in storage produce might be of great hazard, when used in high quantity as the effect might be deleterious when human consumed such produce. This have call for alternate use of plant extract such as *S. californica* since it compared favourably with the synthetic (bom) in chips protection from *T. castaneum* attack, with low toxicity, cost and easily accessible.

It is therefore recommended that the botanical figwort (*S. californica*) with either 5 or 10% concentration used in this study can serves as a good substitute to the synthetic insecticide for chips storage since its fumigant activities can penetrate the crevices made by the pests on chips to affect the hiding stages.

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