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Cassava grit weight losses and management options against African honeybees (*Apis: mellifera)* in Mtwara region, Tanzania

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Abstract

Field trials to estimate post-harvest cassava grits losses caused by honeybees (*Apis mellifera* L.) were conducted from July to November 2016 in Mtwara region, Tanzania. The aim of this study was to quantify cassava grit weight losses due honeybees and its management options. Four treatments were applied including cassava grits with an agro-net, cassava grits supplied with sugar solution, cassava grits supplied with cashew apple juice and artificial hornet's nests. Uncovered cassava was used as control. In each treatment about 10kg of cassava grits were placed on a black polyethylene plastic sheet at exactly 10:00am- 16:00pm and the experiment was repeated daily for 16 weeks. The results showed that honeybees caused an average loss in cassava grit weight of about 31.28%. Of the treatments tested, no weight loss as result of honeybees was observed on cassava grits covered with agro net. The results also showed that in grits supplied with sugar solution only 2.2% was lost due to honeybees while loss in those supplied with cashew juice and artificial hornet's nests were 20.31% and 10.72%, respectively. It is concluded that cassava grits can be effectively prevented from honeybees drying weight losses through covering with agro nets or only allow about 2.2% of loss by supplementing cassava grits with sugar solution during drying process. Therefore, agro-nets and sugar solution supplement are recommended to prevent *Apis mellifera* during sun drying of cassava grits in Mtwara region, Tanzania.

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Introduction

Cassava (*Manihot esculenta* Crantz) is one of the most important staple root crops for about sixty percent of the population in Sub-Saharan Africa (Onyenwoke *et al.,* 2014). In Africa cassava is mainly grown in Benin, Togo, Nigeria, Zambia, Kenya, Tanzania, Uganda, and Ghana (FAO and IFAD. 2005; Adebowale *et al.* 2008; Omotesho and Oyedemi. 2013). In Tanzania, cassava is one of the most important food crop for the people along the Coastal, around Lake Victoria, Lake Tanganyika and Lake Nyasa (Jeremiah. 2005; Lazaro *et al.* 2007). Popularity of cassava in these locations as in other parts of the world is due to ability of the crop to grow in poor soils and drought prone areas. Other factors include flexibility in planting and harvesting time and low demand of agronomic inputs such as fertilizers and pesticides Adebowale *et al.* 2008.

In addition, cassava has the potential in export market where besides using it directly for food, it can serve as raw material for food industries in making products such as glucose, alcohol and starch (Team *et al.* 2010). Despite its role in food and industry, cassava faces a big post-harvest handling and processing challenge, for instance, cassava harvesting involves uprooting which should then be followed by direct consumption if not processed, growers are compelled to sell the crop at a low price very quickly to avoid losses which can be caused by decaying of the roots (Olaleye *et al.*, 2013; Onyenwoke and Simonyan, 2014). In efforts to address this post-harvest challenge, farmers process cassava into grits and dry them to increase storability of the produce (Kwikwega, 2005). However, farmers usually lack knowledge on how to produce high quality cassava flour high quality cassava flour. Essential steps of making high quality cassava flour involves uprooting, peeling, washing, grating, pressing to reduce water content, drying and then milling (Nanam *et al.* 2003).

These steps require certain level of understanding of correct moisture content Stein and Anders Nielsen (2009). If not properly dried, the grits easily allow growth of mould some of which may be producers of harmful lethal chemicals namely mycotoxin (Tivana, 2012).

The correct moisture content of grits has been reported to be between 13-16% as this can prevent grits not only from mould infestation but also insect damage Mlingi and Ndunguru (2007); Gizachew *et al.* (2015).

In locations such as Mtwara where farmers are already informed on steps and how to produce high quality cassava flour, another serious grit loss problem caused honeybees during cassava grit drying has been noted where they have been accused of carrying a considerable amount of grits which needed to be quantified. It is already known that post-harvest losses from known factors such as decay, insect damage and fungal infestation on the produce are estimated to be 50% in most locations of the African continent (Nelleman *et al,.* 2009). If losses due to honey bee's visitation is added, higher post-harvest losses can be experienced in areas such as Mtwara region. Post-harvest losses due to honeybees visitation is a new and insignificantly researched problem, but it has been reported from some countries including Madagascar (FAO 2010; Ranaivoson and Adebayo 2010), and Malawi. Bees collect the grits on their pollen combs (coricular hairs) in the same manner they collect pollen before leaving the processing site, as they do cause significant loss in weight of cassava grits.

Thus this study was carried out to quantify the cassava grits losses caused by African honeybees and to develop appropriate management options in Mtwara region, Tanzania.

Materials and methods

Location of the study

The study was conducted in Mtwara region, southern Tanzania (40°09´ 57.05" E, 10°21´ 22.49" S) and the region is characterized by unimodal type of rainfall ranging between 810 to 1090mm, with mean temperature of 27°C (Offenberg *et al.,* 2015). The experiments were carried out at three main cassava growing villages of Mbawala, Narunga and Mtendachi in Mtwara rural district which is about 40km from Mtwara municipality centre.

Materials

An agro-net (A-net) (2mm in diameter) with a length of 5m and width o f2.5m bought from A to Z – industry, Arusha, Tanzania. Sugar solution (SS) made from 500g brown sugar: litre of tap water +0.0125g of honey; Artificial hornet's nest (A-Nest),with length and depth of 30cm and 22cm, respectively, and in each end four holes (each 7cm in diameter) coated with a scaring red color cashew apple juice (CA) made from ripe cashew apples extracted using home blender (distributor was Jumia, Nikai Blender made in China), cassava grits (grits) processed from cassava roots by the aid of grinder and presser machine (distributed by Internet Company from Morogoro-Tanzania); Moisture meter (Model; MB25, supplied by Ohaus Corporation in USA); Trial and Game automated camera (CCBetter Trail Camera, supplied by Amazon, UK); white-colored disposable plate (with 22.9cm (width) and 5cm (depth) from AJM packaging Corporation, Bloom field hills, MI 48302 in U.S.A); Thermometer (Normal field thermometer), a black polyethylene plastic sheets (bought from a local market with length and width of 20m x 5m, respectively) and Cool bag (Supplied by Amazon, UK); dp (disposal plate).

Experiment setups

A randomized complete block design with three replications was set up in each village with four treatments namely grits covered by A-net, grits supplied with SS, grits supplied with CA and grits supplied with A-Nest. Cassava grits with no supplement or cover was used as control. The treatments were applied exactly from 10:00h to 16:00h every day for six weeks continually. The treatments were set as follows: on the first black polyethylene sheet with 10kg of cassava grits- A-net was placed on raised six (6) wooden poles of height 2m which were positioned; four at the corners and two other poles at the two middle ends. On the second black polyethylene sheet with 10kg of cassava grits, a SS supplement of about 1500ml (distributed around the cassava grits on disposable plates (dp) each filled with 150ml x 10dp around the grits and refilled two times per day) was added.

In a similar setting, on the third black polyethylene sheet with 10kg of cassava grits, CA (150ml per dp + three to four pieces of apple x 10 dp, also refilled two times per day) juice was supplied. On the fourth black polyethylene sheet with 10kg cassava grits, the A-Nest was hang on a wooded pool (2m high) aside the cassava grits. On the fifth black polyethylene sheet with 10kg of cassava grits, no cover or supplement was included as this was used as a control.

From each experimental unit, temperature, moisture content and bee visitation rates were determined hourly from 10:00am to 16:00pm. Temperature determination was done with the help of field thermometer and moisture content was determined on using a Moisture Metter on Model; MB 25, supplied by Ohaus Corporation in USA); 4g of sampled cassava grits was placed into the machine under temperature of 120°C for approximately 15-20 minutes. The amounts drown from each units for moisture content determination were all returned to their appropriate experimental units and mixed toughly.

Bees counting involved the estimation of patterns in the number of honeybees visiting the uncovered rack. Measurement was carried out using digital imaging (Trail and Game automated camera). The camera was trimmed to a gooseneck arm on an adjacent rack so as to capture the entire observation rack on an hourly basis also from 10:00am to 16:00pm. Photographs were then downloaded from the cameras to a computer, and the numbers of bees present on the rack were counted manually.

The weight loss of moisture were estimated by the difference between the weight before drying and that after drying, while loss due to honey bees were estimated by the difference in percentage weight loss covered cassava grits and uncovered grits after drying the formulas used were as follows:.

1) Estimated % Weights loss uncovered=

$$\left(\frac{r-s}{r}\right) x\,100\,\% \ldots\ldots\ldots\ldots\ldots U$$

2) Estimated % Weights loss Covered=

$$\left(\frac{r-t}{r}\right) x\,100\% \ldots\ldots\ldots\ldots\ldots\ldots\ldots V$$

3) % Weight loss due bees = $U - V$

Where, r = Standard weights (Kg) before drying.

S = Weight (Kg) of control after drying

t = Weight (Kg) of grits covered with Agro-net after drying

U= Estimated %Weights loss uncovered (control)

V= Estimated % Weights loss Covered

Statistical analysis

All data were analyzed with Genstart program 15th edition (version 4) of 2014. The Duncan Multiple Range Test (DMRT) was used to compare treatment means at p-values of <.05*, <.01** and <.001***.

Results

Cassava grits weight loss (%) due to honeybees in mtwara region

The results obtained in this study show that there was highly significant difference (P<0.05) on percentage cassava grits loss due to honeybees recorded in the different study locations in Mtwara region (Table 1).

The highest (22.25%) cassava grit loss due to honeybees was recorded at Mtendachi village followed Mbawala (14.93%) and lastly by Narunga (14.32%) (Table 1).

Table 1, Estimated cassava grits weight loss due to honey bees in the study villages during the July to November 2016 season.

Village	Standard weights (Kg) before drying=r	Weight (Kg) of control after drying=s	Weight (Kg) of grits covered with Agro-net after drying=t	Weights loss (%) of control [(r-s)/10]*100 =u	Weights loss (%) of grits covered with Agro-net[(r-t)/10]*100=v	Estimated weight loss (%) due to honeybees [u-v]
Mbawala	10	5.25a	6.74a	47.49a	32.56ab	14.93a
Mtendachi	10	5.24a	7.46b	47.63a	25.38a	22.25b
Narunga	10	6.10b	7.54b	38.95b	24.63b	14.32a
Mean	10	5.53	7.25	44.69	27.52	17.17
CV%	na	10.03	9.37	12.49	24.51	31.3
LSD	na	0.46	0.57	4.64	5.66	6.4
Ftest (0.05)	na	***	**	***	**	***

Means followed by the same letters within a column are not significantly different based on Duncan's Multiple Range test at p= 0.05. Each value is a mean of three replications x 16 weeks. **, *** = significant at p< 0.01 and p < 0.001, respectively.

Efficacy of treatments applied on preventing cassava grits weight losses in relation to honeybees foraging.

Results showed that there was a highly significant difference (P<0.001) among the four treatments on the efficacies of controlling cassava grit loss due to honeybees (Table 2). Loss (%) of cassava grits used as control seemed to be the highest (58.34%) with a specific loss due honeybees of about 31. 28% (Table 2).

The results showed cassava grits covered with agro-nets totally and of course prevented from honeybees resulting in 0% cassava grit loss compared with when the cassava grits were supplemented with sugar solution which seemed to result a 2.2% weight loss due to honeybees followed by cassava grits supplied with artificial hornet's net (10.72%) (Table 2).

Table 1. Effects of different management options on bees in the study villages during the July to November 2016 season.

Treatments	Standard weights (Kg) Before drying=r	Final weights (Kg) after drying=s	Weights loss (%) [(r-s)/10]*100=t	Estimated weight loss (%) due to honeybees
Grits supplied with SS	10	7.074a	29.26b	2.2^{u}
Grits supplied with A-Nest	10	6.222b	37.78a	10.72^{v}
Grits supplied with CA	10	5.263b	47.37a	20.31^{w}
Grits covered with Agro-net	10	7.211a	27.06b	0^{x}
Uncovered grits (Control)	10	4.11b	58.34a	31.28^{y}
Mean	10	5.976	39.96	12.90
CV %	na	10.4	16.1	na
LSD	na	0.2881	2.993	na
F-test (0.05)	na	***	***	na

Means followed by the same letters within a column are not significantly different based on Duncan's Multiple Range test at p=0.05. Each value is a mean of three replications x 16 weeks, SS = Sugar solution, A-Nest = Artificial hornet's nests, CA = Cashew apple juice, ***; significant at p< 0.001. [u,v,w,x,y]= estimated weight loss (%) due to honeybees obtained by subtracting weights (%) of variables of weights t by weight recorded under variable "Grits covered with Agro-net, na=not applicable.

Effects of moisture content on honeybees visitation on cassava grits

Results for estimation of effects of moisture content on honeybees visitation on cassava grits showed that, a moisture content range of between 14 to 58% was associated with higher visitation rates by honeybees (Fig. 1). The highest approximated point of number of honeybees (approximately (4250) was noted at the moisture content of about 18% (Fig. 1).

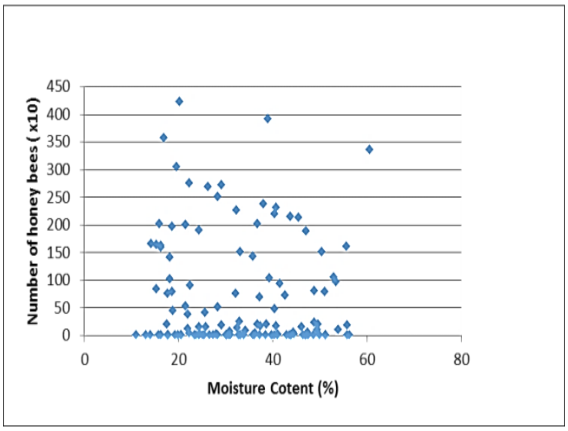

Fig. 1. Relationship between number of honeybees and moisture content of cassava grits.

Effects of temperature on honeybees' visitation on cassava grits

Results for estimation of effects of temperature on honeybee's visitation on cassava grits showed that, a temperature range between 25 to 34°C was associated with higher visitation rates by honeybees (Fig 2). The highest approximated point of number of honeybees (approximately 4250) was noted at the temperature of about 30% (Fig. 2).

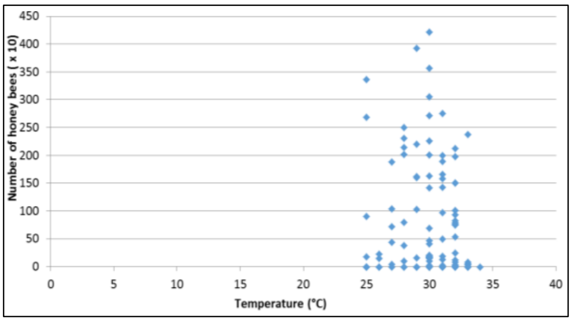

Fig. 2. Relationship between number of honeybees and temperature on cassava grits.

Discussion

In sub-Saharan Africa cassava processing mostly take place during the dry season (Tivana, 2012). Processors across multiple countries experience losses during harvesting, transportation, processing, packing, storage and marketing (Team, 2010; Ranaivoson and Adebayo, 2010). In Tanzania post-harvest loss due to honeybees is the first time to be investigated in cassava growing areas, where the level of honeybee's visitations on cassava grits is extremely highest.

This study has revealed that there is a loss of cassava grits due to honey bees in Mtwara region. This loss has shown to be different in three southern villages in Tanzania where the loss was significantly highest. Overall, post-harvest weight loss estimated for this study which conducted for cassava grits in Mtwara rural district, Tanzania were in range of 17.17% - 31.28%, under open air drying and was observed to be contributed by honey bees. Honey bees visitation was noticed to cause losses on cassava grits as they fed on it and carry the grits away with their feet. Similar results were reported by Ranaivoson and Adebayo, (2010) and FAO (2010), although the weight loss was not quantified. The differences in cassava grit loss amongst the villages in the study areas might be due to absence of natural feeding materials during the dry period which honeybees feed on. This also confirms results obtained on studies of honeybees forages by Abou-shaara, (2013) and (2014); Prasannakumar, (2015) also reported that honeybees prefer to forage on the collection of water, nectar, pollen, plant flower and resin and indicated that the insects prefer continuous water sources than stable ones. Therefore, the absence of their natural feeding materials, suffer significantly with food stress.

This study also focused on, management strategies that included agro-net, sugar solution, cashew apple juice and artificial hornet's nests as agents to limit further grits loss due to honeybees. Comparing the losses of cassava grits due to honeybees, with and without interventions, showed that all the interventions implemented resulted in significant reduction in losses. This is because the grits loss for each of the interventions (agronet=0%, sugar solution=2.2%, cashew apple juice=20.31% and artificial hornets' nest=10.72%) is less than the grits loss when no interventions are made (31.28%). It can however be indicated that the use of agronets is the most effective as this results in no losses at all. The effectiveness of the agro-net was due to the fact that, nets do not allow honeybees to access the cassava grits. In a similar study done by Majumdar and Powell (2010) reported that nets reduce insect-pest penetration in high value vegetables by 82% to 100%. However, the three other interventions i.e. sugar solution, cashew apple juice and artificial hornet's nests, allowed weights loss to occur. Grits supplied with sugar solution resulted in lowest weight loss of 2.2% compared to cashew apple juice and artificial hornet's nests (20.31% and 10.72% respectively).

The effectiveness of sugar solution on weight loss reduction was probably due to fact that the sugar solution attracted more honeybees to feed on it instead of cassava grits, as it contained sugar and honey which are making sugar solution sweeter to honeybees. This is in agreement with the study findings by Somerville, (2014), who reported that sugar solution is a remarkable supplement to feed honeybees during the shortage of plant flower, honey, nectar and pollen. Whereas, grits supplied with cashew apple juice and artificial hornets nests' experienced significant increase in weight loss due to honeybees. Cashew apple juice is not preferred by honeybees for feeding as alternative food materials as a result honeybees seemed to continuously feed on cassava grits, as fresh juice it contained astringency taste (Uma *et al,* 2012), which probably was not attractable to honeybees.

The same opinion applies for artificial hornet's nests which failed to scare the honeybees to stay away from feeding cassava grits.

The study also sought to determine the field temperature and cassava grit moisture content at which the honeybees prefer to consume the cassava grits. With moisture content of grits ranging between 14% and 58% respectively, it was observed that honeybees preferred to feed on the grits probably due to their ability to extract starch or glucose from the cassava grits. At moisture levels of below 14% the grit particles stick together while above 58% grits are more watery and cannot easily be eaten by bees. Similar, studies by Adebowale *et al.*, (2008); Stein and Nielsen, (2009) and Girma *et al.,* (2015), reported that cassava grits with moisture content around 16% to 60% freshly can be eaten or destroyed by fungal , animals, birds and pests.

Furthermore, it was revealed that honeybees (*Apis: mellifera)* preferred to feed on the cassava grits with temperature range, of 25°C to 34°C. This seemed to be the situation at the study areas, although bees seemed to be active and concentrated more on temperature of around 30°C. This finding is in agreement with the study by Harbo, (2000), who indicated that the best temperatures for the bees activities range from 25°C and 35°C, and that ambient temperature has a great effect on foraging activity. High temperature however, has a negative effect on bee foraging. Moreover, very low temperature below 10°C prevents flight activity (Abou-shaara *et al.,* 2012). Cool and rainy days keep bees inside the hive because bees cannot move in complete darkness or under rainy condition as they lose balance (Delaware *et al.*, 2000). In the study areas, temperature was above 25°C probably due to the fact that Mtwara region is located near the ocean where constant warm temperatures are a common feature.

Findings of this study have provided a better understanding of the efficacy of alternative methods in honeybee's management in the field during the drying season.

The continuous use of chemical fumigation and natural insecticides are extremely discouraged since the residues have health risks to human beings and destroy ecosystems. The use of sustainable methods can be considered as alternatives to chemicals for the insect pests' management both in the field during the dry time. Alternative methods have numerous advantages which include; affordability, rapid biodegradation, low risks to the environment, and to food contamination. Besides this, they are the easier to obtain and prepare. The use of agro-net and sugar solution showed effectiveness as alternative method for preventing and minimizing cassava grits loss due to honeybees (*A. mellifera)* during the drying period, since these are significantly economically viable, acceptable, affordable and accessible as a pest management strategy for smallholders farmers especially those with low incomes. Previous studies suggest that uptake of improved management practices for pre- and post-harvest loss control depends very much on affordability by smallholder farmers in sub-Saharan African countries such as Tanzania. Therefore, agro-net and sugar solution may be ideal methods for protecting cassava grits against loss due to honeybees during sun dry. Their application showed clearly that they could effectively prevent the cassava grits loss against honeybees. However, care should be taken on the use of sugar solution in terms of the amount to use and its application.

The ability of agro-net to protect efficiently honeybees' from accessing and eventually leading to weight losses of cassava grits was proved. Commercialization of the affordable and yet of high quality agro nets is important if weight losses of cassava grits is to be reduced at the study sites and elsewhere. A further study is recommended to assess separately the direct and indirect effects of temperature or climate change for honeybee's exploration on cassava grits. In addition, further studies, to address cassava grits loss in Africa, characterization of other loss agents such wind would be required.

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References

Abou-Shaara HF. 2014. The foraging behaviour of honey bees, *Apis mellifera:* A review. Veterinarni Medicina **59(1).**

Abou-shaara HF. 2013. Wintering Map for Honey Bee Colonies in El-Behera Governorate, Egypt by using Geographical Information System (GIS). Journal of Applied Sciences and Environmental Management **17(3),** 403-408.

Abou-shaara HF, Al-ghamdi AA, Mohamed AA. 2012. Tolerance of two honey bee races to various temperature and relative humidity gradients. Env. Exp. Biol **10,** 133-138.

Adebowale AA, Sanni LO, Onitilo MO. 2008. Chemical composition and pasting properties of tapioca grits from different cassava varieties and roasting methods. African Journal of Food Science **2(7)**, 077-082.

Delaware W, Maryland, New Jersey, Pennsylvania, Cooperating WV. 2000. Bee aware: Notes and news on bees and beekeeping, MAAREC Publisher.

FAO. 2010. World bank workshop on reducing post-harvest losses in grain supply chains in Africa on 18-19 march, 2010 in Rome, Italy.

FAO and IFAD. 2005. A review of cassava in Africa with country case studies on Nigeria, Ghana, the United Republic of Tanzania, Uganda and Benin. In Proc. Valid. forum Glob. cassava Dev. Strateg.. Rome: International Fund for Agricultural Development/Food and Agriculture Organization of the United Nations.

Girma G, Bultosa G, Abera S. 2015. Effect of cassava (*Manihot Esculenta* Crantz*)* variety, drying method and blending ratio on the proximate composition and sensory properties of cassava-wheat composite bread **3,** 41-54.

Harbo JR. 2000. Heating adult honeybees to remove *Varroa Jacobsoni*. Journal of apicultural research **39(3-4)**, 181-183.

Kwikwega HM. 2005. Evaluation of farmer knowledge on *Cassava* brown streak disease (CBSD) in the roman catholic church diocese of Tunduru- Masasi in South Eastern Tanzania. M.Sc thesis, The open university of Tanzania and Southern new hampshire.

Jeremiah SC, Mkamilo GS. 2005. Current status of *Cassava* improvement programme in Tanzania. In African crop science Conference proceedings **7,** 1311-1314.

Lazaro EA, Lisasi H, Assenga A. 2007. Cassava in Tanzania: A famine or commercial reserve? In Proceedings of the 13th ISTRC Symposium (pp. 614-621).

Majumdar A, Powell M. 2011. Net house vegetable production: Pest management successes and challenges. Journal of the NACAA **4(1)**.

Mlingi NV, Ndunguru GT. 2007. A review of post-harvest activities for cassava in Tanzania. In R. Kapinga, R. Kingamkono, M. Msabaha, J. Ndunguru, B. Lemaga and G. Tusiime, Tropical root and tuber crops: opportunities for poverty alleviation and sustainable livelihoods in developing countries. Proceedings of the 13th triennial symposium of the ISTRC 506-513.

Prasannakumar NR, Chander P, Kumar PK. 2015. Role of pollinators in Broccoli seed production. Pest Management in Horticultural Ecosystems **21(2),** 187-189.

Nanam D, Andrew GEO, Boateng EO. 2003. Production of high quality cassava flour. TECA (http://teca.fao.org).

Nellemann C. (Ed.). 2009. The environmental food crisis: the environment's role in averting future food crises: a UNEP rapid response assessment. UNEP/Earth print.

Nene WA, Rwegasira GM, Offenberg J, Mwatawala M, Nielsen M. 2015. Mating behavior of the African weaver ant, *Oecophylla longinoda* (Latreille) (Hymenoptera: Formicidae). Sociobiology **62(3),** 396-400.

Olaleye OO, Otunola ET, Oyebanji AO, Adetunji CO. 2013. Effectiveness of trench and moist sawdust as storage methods for maintenance of moisture contents and micro-organisms of cassava roots by variety. Journal of Food Science **2,** 19-22.

Onyenwoke CA, Simonyan KJ. 2014. Cassava post-harvest processing and storage in Nigeria. A review. African journal of Agriculture research **9(53),** 3853-3863.

Muhammad-Lawal A, Omotesho OA, Oyedemi FA. 2013. An Assessment of the Economics of Cassava Processing in Kwara State, Nigeria. In invited paper presented at the 4th International Conference of the African Association of Agricultural Economists.

Onyenwoke CA, Simonyan KJ. 2014. Cassava post-harvest processing and storage in Nigeria: A review. African Journal of Agricultural Research **9(53),** 3853-3863.

Ranaivoson RL, Adebayo A. 2010. High quality cassava flour, promising raw material for bread, biscuit and pastry industries: lessons from a pilot study in Madagascar.

Somerville D. 2014. Feeding sugar to honey bees 2-7.

Stein J, Anders NAL. 2009. How does climate warming affect plant-pollinator interactions? Ecology letters **12(2),** 184-195.

Team MD, Olapeju O, Moutairou E, Nankagninou D, Komlaga GA. 2010. Training manual (draft) processing of *Cassava* into gari and high quality cassava flour in West Africa.

Tivana LD. 2012. Cassava processing: safety and protein fortification.

Uma T, Rama R, Khamis BS. 2012. Clarification, preservation, and shelf life evaluation of cashew apple juice. Food Science and Biotechnology **21(3),** 709-714.