Abiotic factors and packing precipices on the infestation of cashew pests

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ABSTRACT

A detailed study was conducted to investigate the influence of modified atmosphere packaging in cashew processing unit on the infestation of *Tribolium castaneum* Herbst (Coleoptera:Tenebrionidae). Initial vacuum of 600/650mm Hg and final vacuum of 200 mm Hg filled with CO_2 and N_2 at 400/ 450mm Hg was used to evaluate their impact on the pest infestation at 0, 7, 35 and 45 days. Simultaneously observations like water activity, clumping, moisture content and levels of CO_2 and N_2 were evaluated. With in the week of experimentation the flexi packages showed high water activity. Clumping of cashew kernels was also observed and clumping was positively resulted with increase in initial vacuum. Reduction of CO_2 content was closely related with higher water activity. In this study flushing 250mm of CO_2 is suitable for kernels after borma. The results showed that the flushing 250mm of Co_2 is not suitable for kernels after slight cooling and also indicate that cashew kernel can effectively be disinfested with high CO_2 application in flexible units.

Keywords: Cashew kernels, gas testing and packing machines, *Tribolium* infestation.

INTRODUCTION

Cashew, *Anacardium occidentale* Linn. kernels are a high value agricultural commodity. Processed cashew kernels are highly susceptible for infestation by insects like *Tribolium castaneum* Herbst (Coleoptere: Tenebrionidae), *Lasiodserma sericorne* Fabricius (Coleoptere: Anobiidae) and *Euphestia cautella*Walker (Pyralidae : Lepidoptera (Singh, 1986; Sundararaju, 1993; McBratney *et al.*, 1999; Ajay and Rahman,2006) of these *Tribolium castaneum* is the most serious pest (Singh,1986; Campbell and Runnion , 2003).Use of pesticides is not permitted in cashew storage (Mc Bratney *et al.*, 1999). The real break through in insect–free storage came when packing of cashew kernels in an atmosphere of carbon dioxide was introduced in 1920s. This process in which the air in the container is removed and replaced with CO_2 prevented the development of infestation and made it possible for cashew kernels to be stored without fear of quality deterioration for long periods and enabled large scale shipments to various parts of the globe. The most of the cashew processing industries in India uses tins/flexi pouches flushed with Co_2 or N_2 and then sealed. Initially the air is evacuated from the bags and then Co_2 or N_2 is added and then the bag is sealed. However, in using the process of gas flushing, 90% of the processors use Co_2 and the remaining processors use CO_2 and N_2 (Mc Bratney *et al.*, 1999*).*

Fumigation of dried fruits with methyl bromide (MB) upon arrival at the packing plant effectively controls infestation and also causes a high proportion of larvae and adults to emigrate from the fruit before they succumb (Donahaye *et al.*, 1991, 2007; Navarro *et al.*, 1989). In recent year's reliance upon fumigation as an overall solution to infestation problems in durable agricultural products has become questionable. The influence of different controlled atmospheres (CAs) in causing emigration of *Carpophilus* spp. larvae from dates was compared with that of MB (Navarro *et al*., 1989, 2001, 2002; Donahaye *et al*.,1991). The influence of low O_2 or high Co_2 atmospheres as alternatives to fumigation of dried fruits has been studied (Donahaye *et al*., 2007; Soderstorm, 1984; Soderstorm *et al.*, 1986; Tarr *et al.*, 1994). Recommended dosages to obtain mortality of most stored product pests using high CO_2. CAs require exposure to >60% CO_2 for at least 11 days (Navarro *et al*., 1990; Emekci *et al*., 2007). The current practice of infestation control is only the spraying of the premises using an insecticide. For storage of cashew kernels in tins CO_2 is being used as the inert atmosphere. The development of leakness in tins or inadequate vaccumisation and infusion of CO_2 make the process of "vitapacking"of little value in controlling insect infestation. Studies on the use of alternative inert gases have shown that Nitrogen is more efficient as an inert gas for control of insect infestation when used as inert atmosphere for hermetic storage. 100% mortality of all life

stages of *Tribolium castaneum* could be achieved when 100% N_2 was infused in to evacuated tins/bags containing cashew kernels and stored hermetically for 43 hours. By virtue of the sorption of CO_2 by cashew kernels and consequent reduced pressure in the sealed tins/pouches the trade have a preference for the use of CO_2 along with other inert gases in vita/ flexi packing of cashew kernels . The present study was undertaken to evaluate the effectiveness of current packaging practices on control of infestation and blocking issues in cashew slated for export.

MATERIALS AND METHODS

Cashew kernels were supplied by Kerala State Cashew Development Corporation, Kollam and used for this study. Water activity meter (Rotronic : Hygropalm) was used to find out the water activity of kernels. About 60 cartons of cashew kernels divided in to two batches. The samples were mixed thoroughly and checked the water activity of samples by random sampling, and also checked the moisture of kernels of batch one. The other batch consisting of 30 cartons of cashew kernels is subjected to borma drying at 70°C for half an hour to lower the moisture. Similarly the gas cylinders (KSCDC-Supreme gas industries) were checked for their purity level. Both CO_2 and N_2 gas are above 99% pure. All the specifications are presented in table 1.

First set of the experimentation with IV. 600 Hg, N_2-450mm, Co_2-200mm by packing some trial packets and the following gas composition is used O_2 content range 7.4 to 8.3 & Co_2 range 31.6 to 33.2. While the settings of the machine were changed to IV-650 mm of Hg, N_2-450mm, Co_2-200mm. The gas composition is O_2 content range 6.0 to 7.0% and Co_2 range 30.0 to 33.0%.All the pouches were sealed by double sealing and Cryovac brand pouches were used for flexi packing. After 24 hrs the water activity of kernels was evaluated (three replications).Three 50lbs bags were set aside the above settings for checking the gas composition. (IV-600, N_2-450, Co_2-200) and twelve bags of 50 lbs bags were packed in the above settings were treated with insects in the following order: Five *Tribolium* adults male beetle (11-17 days old), five *Tribolium* larvae (4-5 wk old larvae) and five kernels infested with *Tribolium* eggs.

These flexi bags were packed in cartons and labeled as PRI-aw1and PRI- aw II (Table 1). These bags are kept in the packing centre. In the second set PRII-aw1and PRII-aw II (Table -1). The gas composition is O_2 content ranged 6.0 to 6.6 and Co_2 ranged 30.0 to 31.6 and the insects were released in the same order as in the case of PRI-aw1and awII. These bags were kept in the packing center of the storage hall. As the water activity of kernel found varying and to make it constant by Spreading the kernels on a table below fan to increase the water activity value. After one hour, the water activity was checked. The water activity of the kernels for the experimentation was kept at 0.4 and 0.45 until unless stated otherwise. Control experiments without insects keeping other above mentioned settings were carried out for comparison. All the data derived and prescribed are the average value of three experiments (subject the results with ANOVA and TMRTest).

RESULT AND DISCUSSION

Perfect relation between the moisture content and insect infestation could be observed. Higher the water activity higher the infestation in kernel was noticed. The tests showed that the Infestation is retained in packets with high water activity even after one week (Table-2). It is generally accepted that a_w is more closely related to the physical, chemical, and biological properties of foods and other natural products than is total moisture content. Specific changes in colour, aroma, flavor, texture, stability, and acceptability of raw and processed food products have been associated with relatively narrow a_w. Water activity is a measure of the energy status of the water, differences in water activity between components is the driving force for moisture migration as the system comes to equilibrium. Heavy insect infestation also causes moisture migration as a result of heat and moisture given off by the insects. Thus water activity is an important parameter in controlling water migration of multi-

Table 1. Specifications used for the management of pests

Treatments	Initial Vacuum (mm of Hg)	N_2 level (mm of Hg)	CO_2 level (mm of Hg)	Water Activity (initial)
PR-Ia_{w1}	600	150 (vacuum 450)	250 (upto 200)	0.4 (kernels after borma)
PR-Ia_{w2}	600	150 (vacuum 450)	250 (upto 200)	0.45 (kernels after slight cooling / humidification)
PR-IIa$_{w1}$	650	200 (vacuum 450)	250 (upto 200)	0.4
PR-IIa$_{w2}$	650	200 (vacuum 450)	250 (upto 200)	0.45

Table 2. Effect of different treatments on O_2 range, CO_2 range, blocking infestation and water activity on *T. castaneum infestation* (in %)

Observation	O_2 range (%)				CO_2 range (%)				Blocking				*T. castaneum* Infestation				Water Activity			
	PR I		PR II		PR I		PR II		PR I		PR II		PR I		PR II		PR I		PR II	
	a_{w1}	a_{w2}	a_{w1}	a_{w2}	a_{w1}	a_{w2}	a_{w1}	a_{w2}	a_{w1}	a_{w2}	a_{w1}	a_{w2}	a_{w1}	a_{w2}	a_{w1}	a_{w2}	a_{w1}	a_{w2}	a_{w1}	a_{w2}
Initial	7.4 - 8.3	7.3 - 8.2	6.0 - 6.6	6.1 - 6.6	31.6 - 33.0	30.6 - 33.7	30.1 - 33.4	31.5 - 33.4	nil	nil	nil	nil	0	0	0	0	0.41	0.48	0.4	0.51
After one week	8.5 - 8.9	8.3 - 9.1	6.8 - 7.2	6.8 - 7.4	30.2 - 31.7	29.0 - 29.2	30.0 - 32.1	21.5 - 23.4	Free flowing	Slight	Free flowing	Slight	0	100	0	80	0.41	0.53	0.4	0.5
After one Month	9.5 - 10.6	9.7 - 10.7	9.1 - 9.8	9.4 - 9.9	20.6 - 25.7	16.9 - 24.4	20.5 - 24.3	17.4 - 25.2	Free flowing	Moderate	Free flowing	High	0	0	0	0	0.41	0.52	0.41	0.5
After one and half month	10.3 - 11.0	10.1 - 11.2	10.1 - 10.8	9.7 - 10.2	19.2 - 22.2	16.5 - 17.3	19.9 - 23.6	16.9 - 17.3	Free flowing	High	Free flowing	Very High	0	0	0	0	0.41	0.53	0.4	0.5

Machine used - SE-PACK (SEVANA), Flexy Pouch -CRYOVAC

component products. Some foods contain components at different water activity levels such as filled snacks or cereals with dried fruits. By definition water activity dictates that moisture will migrate from a region of high water activity to a region of lower water activity but the rate of migration depends on many factors. Undesirable textural changes can result from moisture migration in multi-component foods. Generally infestation with increased number of adults and larvae are detected in leaky pouches.

For modified / control atmospheres to have any insecticidal effect, it is necessary that certain levels of gas tightness must be achieved. The results (Tables 3 and 4) show that the dead insects are found as dark colored fragments. Mortality increases with decreasing relative humidity, that is decreasing grain moisture content (Jay *et al.*,1971*)*. Usually insect mortality increases with decreasing O_2 concentration and increasing CO_2 concentration, increasing exposure time and increasing temperature (Harein and Press, 1968). An important consequence of increased CO_2 concentration is the permanent opening of the spiracles, which induces water loss, and may cause mortality. The water loss is higher at high CO_2 concentrations and more pronounced at low relative humidities. Increasing CO_2 or N_2 combined with decreasing O_2 results in increased mortality of adult *Tribolium castaneum* and *Tribolium. confusum* (Jay and Pearman,1971).An importance Insect mortalities increase with increasing temperature from 16 to 27^0c and decreasing relative humidity. Insect mortality increases with increasing temperature and decreasing moisture content of the grain.(i.e. decreasing water activity) (Banks and Fields, 1995; Jayas *et al*., 1995). Blocking is observed in kernels with high water activity.

The results showed that Intensity of blocking is increased with increase in initial vacuum (600mm of Hg to 650mm of Hg).Water activity is an important factor affecting the stability of powders and dehydrated products during storage. Controlling water activity in a powder product maintains proper product structure, texture, and stability, density and re-hydration properties. Knowledge of the water activity of powders as a function of moisture content and temperature is essential during processing, handling, packaging and storage to prevent the deleterious phenomenon of caking, clumping, collapse and stickiness. Caking is water activity, time and temperature dependent and is related to the collapse phenomena of the powder under gravitational force. Lowering of CO_2 level is also observed in pouches with high water activity. Water activity influences not only microbial spoilage but also chemical and enzymatic reactivity. Water may influence chemical reactivity in different ways it may act as a solvent, reactant or change the mobility of the reactants by affecting the viscosity of the system. Water activity influences non-enzymatic browning, lipid oxidization degradation of vitamins and other nutrients, enzymatic reactions, protein denaturizing, starch gelatinization and starch retro degradation (Rockland *et al.*,1980). Typically as the water activity level is lowered, the rate of chemical degradative reactions decreases. In both the programmes the data show the great benefit of the modified atmospheric packaging treatment are effective for packing of kernels with water activity 0.4 (moisture 4%).

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