NON-CHEMICAL TREATMENTS FOR DRIED FRUITS AND NUTS: A RETROSPECTIVE

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Introduction

Nearly all of the almonds, walnuts, pistachios, raisins, and prunes produced in the United States are grown in central California. Each year this diverse industry yields over 3.5 million tons of product, worth more than $7 billion, including $6 billion in exports (Table 1). Because these high-value products are often eaten out of hand as snack food, or used in confectionary items, tolerance for the presence of live insects is zero. Consequently, disinfestation of any postharvest pests is necessary for successful marketing. Methyl bromide was the treatment of choice in many cases, because the fumigant was effective, easy to use, and relatively inexpensive. While replacing methyl bromide with another fumigant may be the easiest alternative, several non-chemical methods show promise as well. Identifying those applications where non-chemical methods may be used requires familiarity with the processing and storage methods as well as the marketing constraints within the industry.

Non-chemical strategies

Harvest, dehydration, processing and storage methods within the industry vary widely. Some products are sun-dried and vulnerable to insect infestation during drying. Others are mechanically dehydrated at high temperatures, which may serve to disinfest product of field pests. The method of storage may directly affect the practicality of a treatment; dried fruits are stored stacked in bins, nuts may be in bins or silos. Cold storage used by some processors to maintain quality of tree nuts will also prevent reinfestation of product by storage pests. Another factor that must be taken into account is the huge volume of product that must be treated, often within a short period. This is of particular importance to walnut and pistachio processors, who require very rapid disinfestation treatments to meet the vital European holiday market.

USDA-ARS scientists have worked for more than 30 years on non-chemical treatment strategies for postharvest dried fruit and nut insect pests in the central

valley of California. The methods considered include ionizing radiation, various temperature treatments, modified atmospheres, vacuum, biological controls and combination treatments. The advantages and disadvantages of various non-chemical treatment methods are presented in Table 2.

Given the diversity within the industry, no single non-chemical treatment would be an effective stand-alone replacement for methyl bromide for all dried fruit and nut commodities. Some non-chemical treatments such as vacuum may be practical only for small processors. Most non-chemical treatments require more treatment time, storage space or investment in expensive equipment, and thus are not suitable for those applications that require rapid treatment of large amounts of product. Other proposed treatments are specific to a single pest species, and must be used in combination with other treatments. More research is needed to integrate non-chemical methods into dried fruit and nut processing protocols.

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Selected References

Burks, C.S. and Kuenen, L.P. (2012) Effect of mating disruption and lure load on the number of *Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae) males captured in pheromone traps. Journal of Stored Products Research 49, 189-195.

Jiao, S., Johnson, J.A., Tang, J., Tiwari, G. and Wang, S. (2011) Dielectric properties of cowpea weevil, black-eyed peas and mung beans with respect to the development of radio frequency heat treatments. Biosystems Engineering 108, 280-291.

Johnson, J.A. and Zettler, J.L. (2009) Response of postharvest tree nut lepidopteran pests to vacuum treatments. Journal of Economic Entomology 102, 2003-2010.

Wang, S., Monzon, M., Johnson, J.A., Mitcham, E.J. and Tang, J. (2007) Industrial-scale radio frequency treatments for insect control in walnuts: II: Insect mortality and product quality. Postharvest Biology and Technology 45, 247-253.

Johnson, J.A. (2007) Survival of Indianmeal moth and navel orangeworm (Lepidoptera: Pyralidae) at low temperatures. Journal of Economic Entomology 100, 1482-1488.

Johnson, J.A. and Valero, K.A. (2003) Use of commercial freezers to control cowpea weevil, *Callosobruchus maculatus* (Coleoptera: Bruchidae), in organic garbanzo beans. Journal of Economic Entomology 96, 1952-1957.

Wang, S., Tang, J., Johnson, J.A. and Hansen, J.D. (2002) Thermal-death kinetics of fifth-instar *Amyelois transitella* (Walker) (Lepidoptera : Pyralidae). Journal of Stored Products Research 38, 427-440.

Johnson, J.A., Vail, P.V., Brandl, D.G., Tebbets, J.S. and Valero, K.A. (2002) Integration of nonchemical treatments for control of postharvest pyralid moths (Lepidoptera : Pyralidae) in almonds and raisins. Journal of Economic Entomology 95, 190-199.

Johnson, J.A., Valero, K.A., Hannel, M.M. and Gill, R.F. (2000) Seasonal occurrence of postharvest dried fruit insects and their parasitoids in a culled fig warehouse. Journal of Economic Entomology 93, 1380-1390.

Johnson, J. and Marcotte, M. (1999) Irradiation control of insect pests of dried fruits and walnuts. Food Technology 53, 46-48, 50-51.

Johnson, J.A., Vail, P.V., Soderstrom, E.L., Curtis, C.E., Brandl, D.G., Tebbets, J.S. and Valero, K.A. (1998) Integration of nonchemical, postharvest treatments for control of navel orangeworm (Lepidoptera: Pyralidae) and Indianmeal moth (Lepidoptera: Pyralidae) in walnuts. Journal of Economic Entomology 91, 1437-1444.

Soderstrom, E.L., Brandl, D.G. and B.E. Mackey (1996) High temperature alone and combined with controlled atmospheres for control of diapausing codling moth (Lepidoptera: Tortricidae) in walnuts. Journal of Economic Entomology 89, 144-147.

Vail, P.V., Tebbets. J. Steven, Brandl, D.G. and Jenner, K.E. (1991) Efficacy and persistence of a granulosis virus against infestations of *Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae) on raisins. Journal of Stored Products Research 27, 103-107.

Soderstrom, E.L. and Brandl, D.G. (1984) Low-oxygen atmosphere for postharvest insect control in bulk-stored raisins. Journal of Economic Entomology 77, 440-445.

Table 1. Production, value and export of California dried fruits and nuts for 2012

Product	Production (tons)	Value ($million)	
		Total	Export
Almonds	1,000,000	4,347	3,387
Walnuts	470,000	1,363	1,112
Pistachios	275,500	1,113	1,073
Raisins	1,951,000	683	380
Dried Plums (Prunes)	125,000	156	177
Total	**3,821,500**	**7,662**	**6,129**

Table 2. Advantages and disadvantages for non-chemical alternative treatment strategies for dried fruits and nuts

Treatment	Advantage	Disadvantage
Radio frequency	Rapid, effective, safe, does not harm product	May be difficult to apply to dried fruits
Cold storage	Effective, safe, improves product quality	Long exposure times, expensive if not already in use
Modified atmosphere	Effective, safe, may be applied to stacks, does not harm product	Long exposure times, can require expensive retrofitting
Vacuum	Effective, safe, may be applied in cheap, flexible units	Long exposure times, difficulty in treating product in bins
Ionizing radiation	Rapid treatment, does not harm dried products	No immediate kill, possible problems with consumer acceptance, large capital expense may be required
Mating disruption	Effective, safe, no effect to product	Single species treatment, not a disinfestation treatment
Microbial insecticides	Effective protective treatment, safe, no effect to product	Single species treatment, not a disinfestation treatment, may be difficult to apply to product
Natural enemies	Useful in IPM programs, safe, effective in reducing pest populations	Single species treatment, not a disinfestation treatment, not yet allowable to use in dried fruits and nuts
Combination treatments	Useful in IPM programs, safe, combines disinfestation with protective treatments	Long exposure times may be necessary, may require expensive retrofitting,