DEVELOPMENT OF RADIO FREQUENCY TREATMENTS FOR DRIED PULSES

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Dried pulses are valuable export commodities in the US Pacific Northwest but infestation by insect pests may cause importing countries to require phytosanitary treatments before shipment. Typically, chemical fumigants are used to disinfest product, but the industry is exploring non-chemical alternatives. One possible alternative is the use of radio frequency (RF) energy to rapidly heat product to insecticidal levels. The development of RF treatments requires identification of the most heat tolerant insect stage under RF conditions. The cowpea weevil is a primary pest of concern to countries importing lentils, green peas and chick peas, although laboratory infestation rates in these products are very low. Black-eyed peas and mung beans were identified as better hosts of cowpea weevil, but their response to RF energy must be compared to the target products before their use as surrogate hosts in RF tests. Another issue to be addressed is the possible escape of active cowpea weevil adults as product heats during RF treatments. This paper compares the heating rate of black-eyed peas and mung beans to chickpeas and lentils during RF treatments, determines the relative response of different cowpea weevil stages to RF energy, and examines the behavioral and mortality response of adult cowpea weevil to sudden high temperatures.

Comparison of the heating rate of surrogate and target legumes

Surrogate legumes were placed in small cups on the surface of their target legumes (black-eyed peas in chickpeas, and mung beans in lentils) and subjected to RF heating at 27 MHz. At comparable moisture content, black-eyed peas and mung beans heated faster than chickpeas and lentils, respectively (Fig. 1). However, to achieve conservative results in efficacy studies, the surrogate legumes should heat more slowly than the target products. Examination of the dielectric properties of the legumes indicated that the heating rate of black-eyed peas and mung beans could be lowered by reducing the moisture content. When the moisture content of black-eyed peas and mung beans was reduced to 2.6 and 3.7% w.b., respectively, their heating rate was less than that of their target legumes (Fig. 2).

Relative response of cowpea weevil life stages to RF energy

Mung beans infested with different stages of cowpea weevil (eggs, small larvae, large larvae, pupae and adults) were placed in nylon socks and buried within 3kg

mung bean samples for RF treatments. Treatment schedules were 54°C for 7 minutes, 56°C for 5 minutes and 58°C for 3 minutes, each replicated 3 times. Mortality of immature stages was estimated from adult emergence; adults were evaluated for signs of life 24 hours after treatment. Adults showed the highest mortality at all treatments, while young larvae were the most tolerant. This is different from that obtained earlier with a heat block system, where pupae were found to be the most tolerant.

Response of adult cowpea weevil to sudden high temperatures

Because the proposed RF treatment will include hot forced air at 60°C, nylon bags containing adult cowpea weevil were dropped through a vent into a hot-air oven and held at 60°C for 90-120 seconds. At all exposures, adults dropped to the bottom of the bag, and appeared unable to walk or fly. Observations were also made of individual adults within a small glass-topped chamber placed on the bottom of a heat block and heated to 60°C. Adults began rapid walking and attempts to escape the chamber at 40-45°C, and appeared to enter heat stupor at temperatures of from 56-60°C. Slower heating rates cause adults to enter heat stupor at lower temperatures. Adults in nylon bags were placed in the heat block and exposed to 58, 59 and 60°C for 6, 12, 18 and 24 seconds, with a heating rate of 15°C/minute from a starting temperature of 25°C. Complete mortality was only reached at 60°C for 24 seconds (Table 1).

Conclusions

- Studies of the dielectric properties and relative heating rates of surrogate legumes (black-eyed peas and mung beans) and their target products (chick peas and lentils) showed that by reducing the moisture content of the surrogate legumes, conservative heating rates could be obtained. This will allow the use of the surrogate legumes in subsequent studies.
- Relative tolerance of different life stages of the cowpea weevil heated using RF energy suggests young larvae may be most tolerant of the treatment.
- Although active adults may attempt to escape from elevated temperatures, they enter heat stupor very near the proposed treatment temperature of 60°C. Because the proposed treatment will include forced 60°C air, as adults leave the rapidly heating product they will be directly exposed to these temperatures, and should enter heat stupor rapidly. Plans have been made to examine the behavior of free adults within the product during RF treatments, to determine if escape from the treatment is possible.

Acknowledgements

This research was supported by grants from USDA-CSREES (2008-34103-19091). We would like to thank Karen Valero and Curtis Koga for their technical assistance.

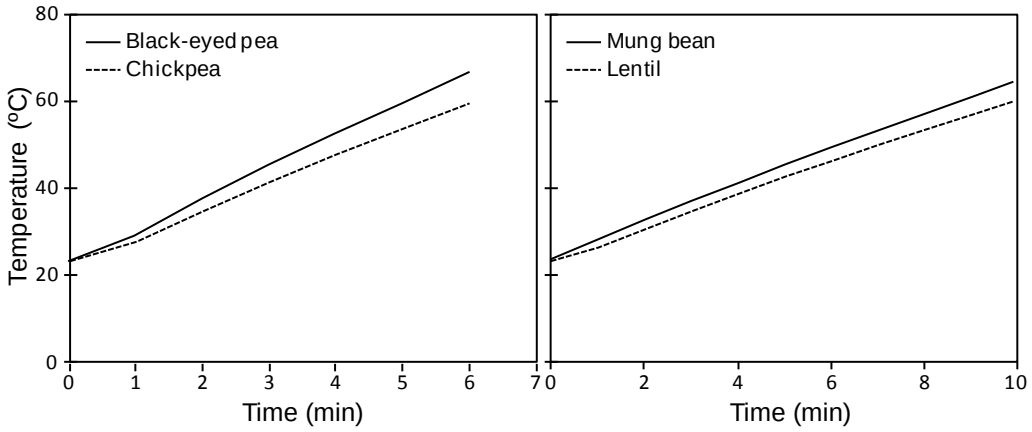

Fig. 1. Heating rate profile of surrogate legumes and their target products in RF system; moisture content (%w.b.) of black-eyed peas, mung beans, chickpeas and lentils were 8.8, 10.2, 7.0 and 7.1, respectively. Note that surrogate legumes (black-eyed peas and mung beans) heated faster than their target products.

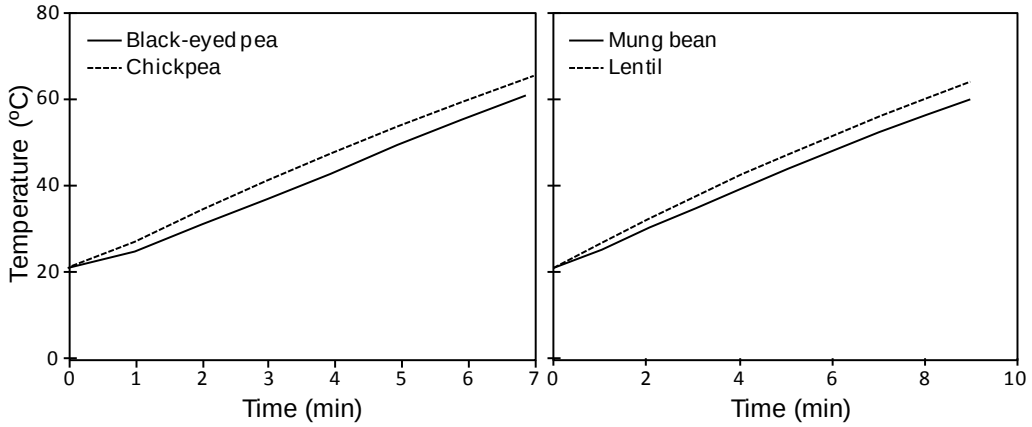

Fig. 2. Heating rate profile of surrogate legumes and their target products in RF system; moisture content (%w.b.) of black-eyed peas, mung beans, chickpeas and lentils were 2.6, 3.7, 7.0 and 7.1, respectively. Note that target products heated faster than the drier surrogate legumes.

Table 1. Mortality (%) of adult cowpea weevils exposed to high temperatures for short periods of time in heat block.

Exposure (sec)	Temperature (°C)		
	58	59	60
6	30.9	76.7	65.3
12	47.2	83.0	88.9
18	68.6	91.8	97.4
24	91.2	95.2	100.0