CALIFORNIA WALNUT BOARD
Research Proposal Cover Page

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Project Title:	Economical, high speed sorting of walnuts for removal of adhering hull and sunburn damaged nuts
Contract Period:	March 2009 through February 2010
Budget Amount:	$25,000
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Signature of Principal Investigator:	Ron Haff
Signature of Authorized Institution Rep:	11/20/08

University of California
Division of Agricultural Sciences

PROJECT PLAN/RESEARCH GRANT PROPOSAL

Project Year 2009/2010 Anticipated Duration of Project 1 yr

Project Leader Ron Haff Location USDA-ARS Western Regional Research Center

Cooperating Personnel Natsuko Toyofuku, Eric Jackson

Project Title Economical, high speed sorting of walnuts for removal of adhering hull and sunburn damaged nuts

Keywords
Commodity(s) sorting, adhering hull, sunburn, walnuts

Relevant AES/CE Project No.

Problem and its Significance:

Sunburn damaged walnuts and walnuts with adhering hull are routinely removed from the post-harvest process stream, either for disposal or re-hulling. Given the short harvest period of approximately two weeks per year, sorting equipment has traditionally been leased at relatively high cost and low sorting efficiency. Low cost, high speed optical sorting equipment would benefit the industry by eliminating the annual cost of leasing equipment. Consequently, one of the post harvest research priorities in the call for proposals for the California Walnut Board is to "develop lower cost, more effective electronic sorters for hulling operation".

Objective:

The objective of this research would be to develop a prototype for economical, accurate, and high speed sorting equipment for the removal of sunburnt and adhering hull walnuts from the post-harvest processing stream.

Plans and Procedures:

Determining Sorting Approach

1. Collect samples of walnuts containing defects to be removed from the processing stream.
2. Generate reflectance spectra for each sample using a spectrophotometer at wavelengths from 400 to 1700 nm.
3. Generate color images of each sample using high speed cameras.
4. Use Principle Component Analysis and/or Discriminant Analysis to determine optimal wavelengths for detecting unwanted nuts and derive the appropriate decision boundary for dual-wavelength optical sorting.
5. Plot pixels in 3D color space to determine which colors in the defect pixels can be differentiated from the colors of the rest of the nut and derive the appropriate decision boundary for color sorting.
6. Test large number of samples for sorting accuracies using the two methods and determine which is most appropriate.

Constructing prototype sorter (Dual-wavelength)

The prototype dual wavelength sorting device would resemble commercially available dual wavelength sorting equipment with a few important exceptions. Commercially available sorters are designed to be trained, so that the same optical equipment can be used for many different sorting tasks but is not optimized for any particular task. This is for the convenience of the manufacturer and results in higher cost and lower accuracy. The steps outlined above ensure that the device optics (filters and photodiodes) are optimal for the particular sorting task. In addition, commercial sorters use computers or the equivalent to process the signal and classify the signal. Here we use a simple electronic circuit to perform the classification, again significantly reducing the cost.

Referring to FIG. 1: Samples (**1**) to be sorted travel down a slide (**2**) in single file. At the end of the slide they are illuminated by a bright light source (**3**). Reflected light from the sample travels up the light tubes (**4**), through filters (**5**), and is incident on the photodiodes (**6**). Output voltage from the photodiodes **6** is input at the decision circuit (**7**), which drives the air ejection nozzle (**8**).

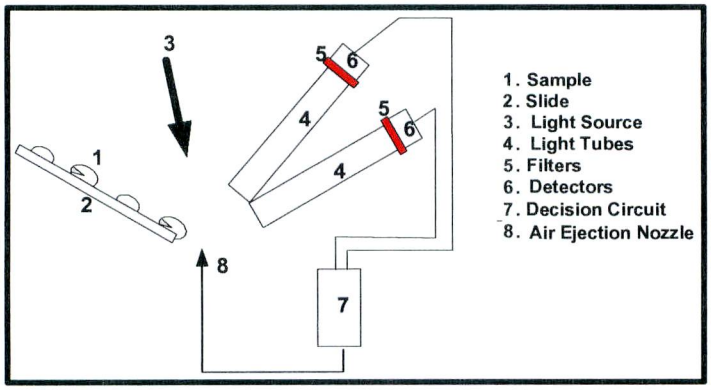

Figure 1. Prototype dual-wavelength sorting device.

A similar prototype device has been built in our facility[1] for separating in shell pistachio nuts from kernels. The development of the device followed the same procedures as outlined above. In addition, we have developed novel techniques for determining optimal wavelengths for sorting agricultural products[2] which can be applied to the current research.

Constructing prototype sorter (Color sorting)

Should the preliminary testing indicate that color sorting is better able to classify the samples, then a prototype sorting system similar to Fig. 2 will be constructed. The system shown was built for detection of blue eyed mold in popcorn and should be adaptable for sorting walnuts. The setup is similar to the dual wavelength device, but instead of filters and photodiodes there are three color cameras that image the entire surface of the nut.

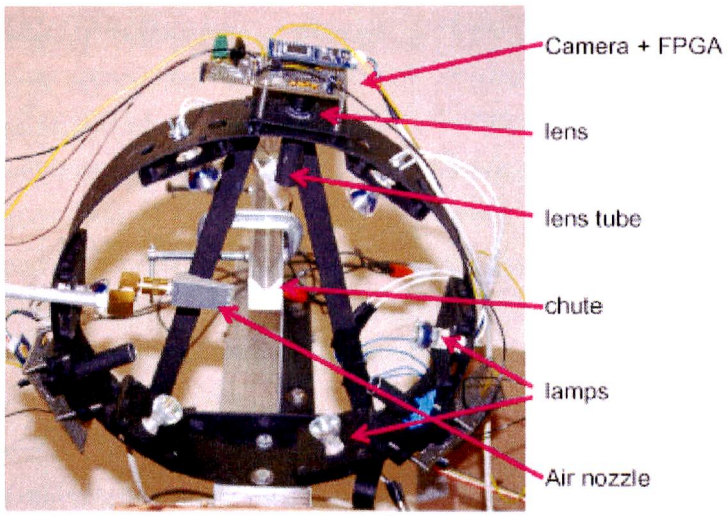

Figure 2. Prototype color sorting system

The cost of parts for the systems shown in figures 1 and 2 are less that $1000. These prototypes operate at speeds between 20 and 70 samples per second, depending on the nature of the samples. Both designs should be relatively easily adaptable to sorting walnuts.

References Cited

1. Haff, R.P. and Jackson, E.S. Low cost real-time sorting of in shell pistachio nuts from kernels. *Applied Engineering in Agriculture*. 24(4):487-490. 2008.

2. Haff, R.P. and Pearson, T.C. Spectral band selection for optical sorting of pistachio nut defects. *Transactions of the ASABE*. 49(4): 1105-1113. 2006.

BUDGET REQUEST Budget Year

Funding Source

Salaries and Benefits		
Postdocs/RA's		$ 17,500
SRA's		$
Lab/Field Assistance		$
Subtotal	Sub 2	$ 17,500
__Employee benefits	Sub 6	$ 5,000
__	SUBTOTAL	$ 22,500
Supplies and Expenses	Sub 3	$
Equipment	Sub 4	$
Travel	Sub 5	$ 2500
	TOTAL	$ 25,000

Department account number _____

_____ Date _____

Originator's Signature

COOPERATIVE EXTENSION
County Director _____ Date _____

Program Director _____ Date _____

AGRICULTURAL EXPERIMENT STATION
Department Chair _____ Date _____

LIAISON OFFICER
_____ Date _____

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