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MAINE AGRICULTURAL AND FOREST EXPERIMENT STATION
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Maine Wild Blueberries Field Winnowing Systems

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INTRODUCTION

A significant portion of Maine wild blueberries destined for the fresh pack market are harvested by hand to reduce incidence of damage by mechanical harvesters. Hand-harvesting causes field debris (stems and leaves) to remain with the harvested berries. Field debris must be removed at a later processing point, either by being field winnowed or by a winnowing operation in a fresh pack operation. Debris removal used in the field is performed by one of two winnowing systems (D. Emerson, pers. comm.).

One field winnowing system (cam system) uses an offset cam vibration mechanism to bounce the berries down a slight incline. The other system (conveyor system) uses two conveyors in association with an air blower to remove debris. Wild blueberry producers in Maine and Canada have used the conveyor system for field winnowing operations for nearly 40 years. The cam system winnowers were developed approximately 20 years ago in response to a need for a winnower that could be moved around in the field by one person. Producers have been concerned that one winnower causes more damage than the other, and from information gathered, it seemed that the industry was split on the issue (J. Smagula, pers. comm.).

Field methods of mechanical separation in fruits and vegetables have received little research effort. Most separations are not required because in most cases the particular crop is cultivated and has little field debris. In other similarly harvested products that require removal of field debris, such as raspberries and blackberries, the removal is accomplished at the processing plant via forced-air systems (Takeda and Peterson 1988; Peterson et al. 1997).

The objective of this study was to determine if there were differences in berry quality between the two winnowing systems currently used in the Maine wild blueberry industry. The following experiment was performed three times during the 1997 field season.

MATERIALS AND METHODS

Field Sampling

Blueberry plots, nominally 15 m^2 (161.4 ft^2), were randomly selected among the irrigated and non-irrigated fields at the University of Maine Blueberry Hill Experiment Station in Jonesboro, Maine. In locating the research plots, care was taken to minimize within-field and within-plot variation among samples. A randomized complete block design was used with three treatments and nine replicates explained as follows. Nine plots each in the irrigated and non-irrigated blueberry fields were selected as replicates. Three different experiment dates or testing systems (considered different weeks during the harvest cycle) were performed during the 1997 harvesting season (early, August 11–12, 1997; mid, August 18–19, 1997; and late, August 24–25,1997), where plots from each field type were hand-raked and tested. An experiment consisted of two consecutive days, where the irrigated plots were raked one day and non-irrigated plots the following day.

A two-compartment field box of berries (approximately 13.6 kg or 29.9 lbs) was hand-raked from each plot and weighed to establish an initial weight. Prior to winnowing, two samples of approximately 30 g (0.066 lbs) were taken from each field box compartment for testing for anthocyanin leakage (leakage) and compressive force pre-treatment measurements. After sampling, each field box of berries was winnowed through one of the two different winnowers being tested and weighed for weight loss calculations. After winnowing, approximately 30 g (0.066 lbs) of berries were removed for each of the leakage and compressive force post-treatment measurements. Figure 1 is a flowchart of the field sampling scheme.

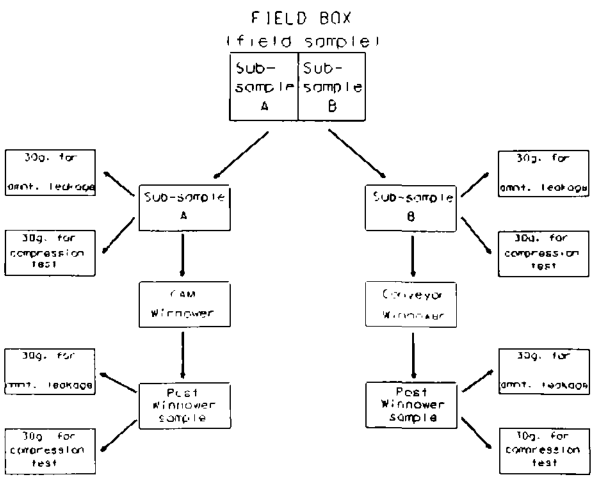

Figure 1. Flowchart of field sampling scheme.

Winnowing Systems

There are two types of winnowing systems currently used in the blueberry industry in Maine and Canada. The first type uses an offset-cam vibration system in conjunction with an air blower (cam system) to separate field debris and blueberries. The other winnowing system uses forced air and a conveyor system (conveyor system) to make separation possible. The current systems are the result of modifications over the last 15 to 20 years and are used in approximately 99% of the blueberry field operations in Maine.

In the cam system, hand-harvested berries are dumped on to a slightly inclined (8.9 % incline) catch basin, which is vibrated by an offset cam (offset 0.32 cm, 0.813 in, cam speed 720 rpm) driven by a 2.2 kW (3 Hp) gasoline engine. As the berries are bounced from the catch basin, they fall off the incline and are met by forced ambient air (speed = 6.6 m/s, 21.65 ft/s) flowing normal to their falling path. The forced air uses density and gravity to blow field debris away at the same time allows berries to continue falling a distance of 17.8 cm (7.01 in) to a second catch basin. Figure 2 shows the cam system as described here. The winnowed berries are then held in a field tote at ambient conditions for further processing or transport to a processing facility.

The other winnowing system uses two conveyors in association with an air blower to remove debris. Hand harvested berries are dumped onto a conveyor moving at 0.023 m/s (0.075 ft/s). The berries drop an average vertical 17.8 cm (7.01 in) from the dumping conveyor onto another receiving conveyor. The receiving conveyor is positioned at a 40 percent incline to allow the berries to roll into a receiving basin. The receiving conveyor moves at 0.23 m/s (.755 ft/s) in the opposite direction of the berry fall to carry debris away from the catch basin. During the vertical drop, the berries and debris are met by forced air (speed 4.6 m/s, 15.09 ft/s), flowing normal to the vertical fall, to blow the field debris away at the same time allows the berries to continue to roll in the opposite direction of the conveyor and drop (height of 36.8 cm, 14.49 in) into the catch basin positioned below. The conveyors and air blower are operated by a 1.5 kW (2 Hp) gasoline engine. Figure 3 shows the conveyor winnowing system. During experimentation, both winnowing systems were operated at the normal (full throttle) level of engine operation. This mode is characteristic of operating level in normal field operations.

Anthocyanin Leakage (Leakage) Test

Anthocyanin leakage was measured by the method of Sapers and Phillips (1985), with modification. Thirty grams of berries were suspended by nylon screen (Charcoal Fiberglass, Phifer Wire Prod-

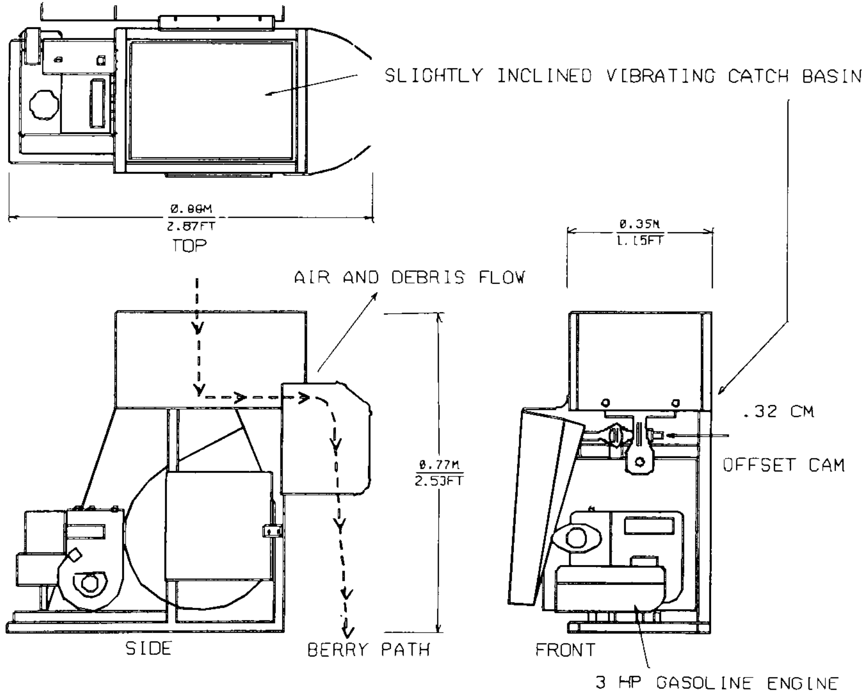

Figure 2. Sketch of cam winnower system.

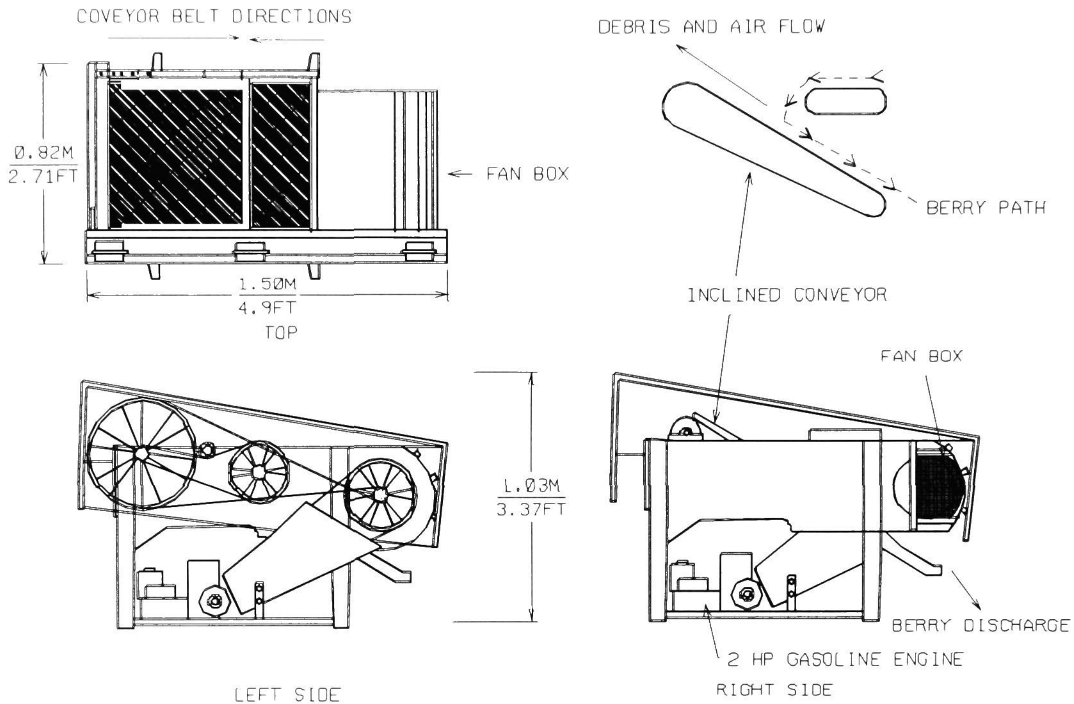

Figure 3. Sketch of conveyor winnower system.

ucts, Inc, AL) in a 300 ml (18.3 in^3) glass beaker. One hundred ml of buffer (potassium hydrogen phthalate, pH 3.0, Fisher Scientific Co., GA) were used as the extraction solution. A magnetic stirring bar was placed at the bottom of the beaker. Samples were immersed into the solution that was stirred for 10 min at a speed of 8 (approximately 100 rpm) on the magnetic stirrer (Fisher Thermix, Fisher Scientific Co., MA). Extract was vacuum filtered through Whatman No. 1 paper (Whatman Company, Atlanta, GA). Absorption of the extract was measured at 525 nm using a Beckman Spectrophotometer (DU-64 Spectrophotometer, Beckman Instruments, Inc., CA). Delphinidin-3-glucoside is the major pigment in blueberries, but it has a low molar absorbance, therefore based on Wrolstad's (1976) suggestion, the total anthocyanin leakage of blueberries was calculated in terms of malvidin-3-glucoside (MW = 493.5) by Beer's Law (extinction coefficient = 28,000).

Compressive Force Tests

From the 30 g (0.066 lbs) of berries sampled, 20 individual berries were randomly selected for the compressive force test. The test followed a standard compressive protocol described by ASAE (1995) and described by Donahue et al. (in press). An automated process using the Firmtech1® instrument and procedures (BioWorks, Inc., Stillwater, OK) was followed to allow for electronic collection of the required data. The berries were loaded onto a turntable, which would rotate to present berries one at a time and subject them to quasi-static compressive loading at the rate of 4 mm/s (0.16 in/s). For each berry, force vs deformation data were collected electronically by the instrument and stored in data files on a computer for later analysis. These data were used to calculate a firmness value, slope of the force-deformation curve (secant modulus), as described by Mohsenin (1986).

Statistical Analysis

To ascertain differences among treatments for each of the measures, the data were analyzed using analysis of variance techniques, general linear models, and means separation methods (Duncan's Multiple Range Test) using the Statistical Analysis System (SAS 1990).

RESULTS AND DISCUSSION

The dependent variables that measure damage due to winnowing and its associated systems are anthocyanin leakage and physical measurements of berry firmness. The means, standard deviations (s.d.) and number of observations (n) are given in Table 1 for the winnower analysis and presented graphically in Figures 4, 5, and 6. As seen in Table 1, the winnowers remove approximately 6.9% (overall average by weight, with a mean of 3.1% to 18.4%) mass. The mass loss, characterized by visual observation, was mostly in the form of field debris (sticks and leaves). There was a larger mass loss found in non-irrigated berries, as seen in Figure 4, which can be attributed to more field debris being present, because of drier field conditions.

Irrigation level (irrigated vs non-irrigated) was also significant ($p \leq 0.05$) with respect to weight loss, leakage, and the mechanical measurements and varied along with harvest date. Irrigation affects are pronounced in the anthocyanin data shown in Figure 5. As harvest date progresses the amount of leakage increases significantly ($p \leq 0.05$) for irrigated berries. The data also indicate that there is no significant damage ($p > 0.05$) (as measured herein) as a result of the winnowing operation with either winnowing system.

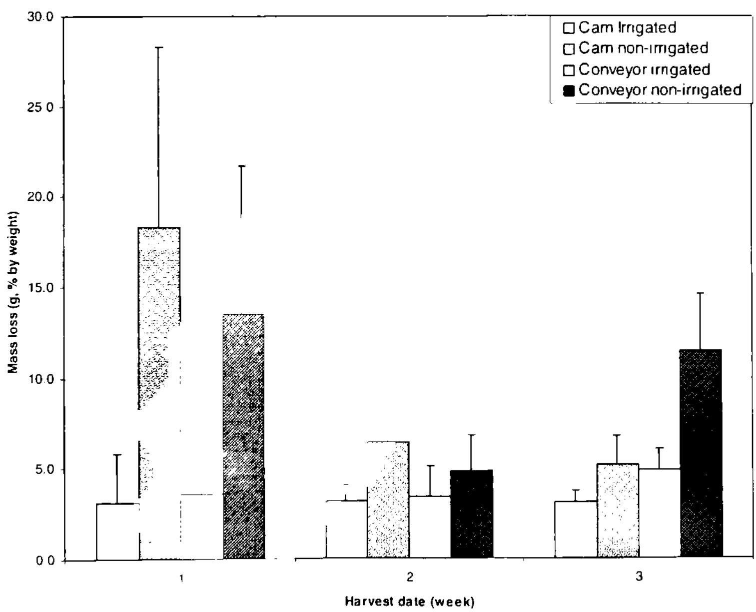

Figure 4. Mass loss (percentage by mass) versus harvest date for irrigation level within winnowing system

Table 1. Results of winnower analysis by date, irrigation level, and winnower used. Mean, standard deviation (s.d.) and number of observations (n) are given for each variable that was measured or calculated to determine winnower damage significance.

				Weight loss (percentage)			Anthocyanin leakage (mg/100 g berries)			Firmness – Modulus (N/m²)		
System	Process	Irrigation Level	Date[1]	Mean	s.d.	n	Mean	s.d.	n	Mean	s.d.	n
cam	before winnowing	Irr.	1	---	---	---	0.102	0.134	9	0.954	0.108	180
			2	---	---	---	0.309	0.389	9	0.370	0.061	180
			3	---	---	---	0.965	1.282	9	0.296	0.055	180
		Non-irr.	1	---	---	---	0.191	0.182	9	0.897	0.073	160
			2	---	---	---	0.084	0.044	9	0.370	0.052	180
			3	---	---	---	0.109	0.078	9	0.339	0.028	180
	after winnowing	Irr.	1	3.2	2.6	9	0.134	0.151	9	0.906	0.163	140
			2	3.2	0.9	9	0.140	0.144	9	0.352	0.070	160
			3	3.1	0.6	9	0.729	0.541	9	0.285	0.037	80
		Non-irr	1	18.4	9.9	9	0.124	0.074	9	0.763	0.138	160
			2	6.5	3.2	9	0.079	0.041	9	0.367	0.053	180
			3	5.2	1.6	9	0.172	0.116	9	0.343	0.036	180
conveyor	before winnowing	Irr.	1	---	---	---	0.087	0.057	9	0.883	0.143	180
			2	---	---	---	0.284	0.501	9	0.375	0.073	160
			3	---	---	---	0.596	0.411	9	0.296	0.060	180
		Non-irr	1	---	---	---	0.145	0.086	9	0.865	0.129	140
			2	---	---	---	0.108	0.054	9	0.371	0.041	180
			3	---	---	---	0.174	0.187	9	0.345	0.029	180
	after winnowing	Irr.	1	3.6	2.5	9	0.130	0.084	9	0.913	0.108	180
			2	3.4	1.7	9	0.319	0.324	9	0.336	0.060	180
			3	4.9	1.1	9	0.925	0.784	9	0.307	0.036	100
		Non-irr.	1	13.6	8.1	9	0.109	0.049	9	0.785	0.152	160
			2	4.9	1.9	9	0.094	0.035	9	0.337	0.049	180
			3	11.5	3.1	9	0.104	0.067	9	0.325	0.044	180

[1] = date 1 = 11–12 August 1997, date 2 = 18–19 August 1997; date 3 = 24–25 August 1997.

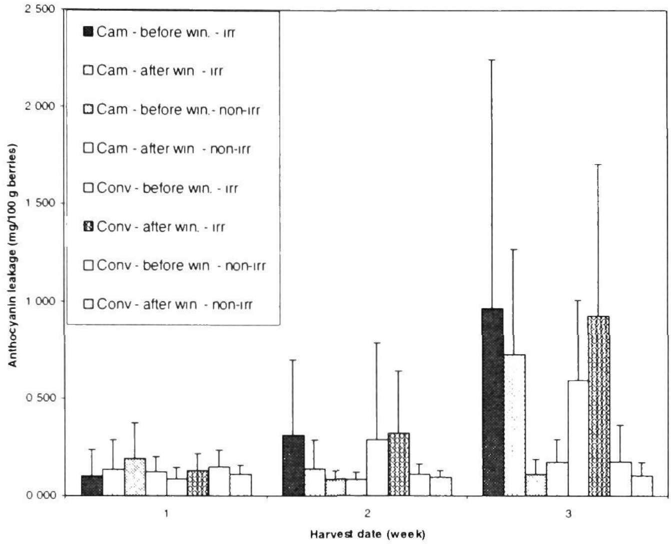

Figure 5. Anthocyanin leakage versus harvest date for irrigation level within winnowing system

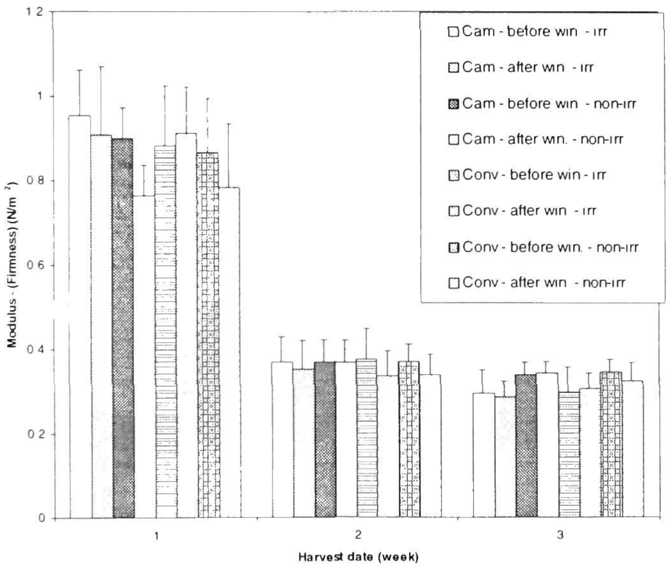

Figure 6. Firmness modulus versus harvest date for irrigation level within winnowing system.

To better understand the variation in physical measurements, an analysis of variance (AOV) was performed using SAS (1990). The winnower system (cam or conveyor) used to winnow the berries was not significant ($p > 0.05$) with respect to any of the measured variables. The large variation due to harvest date is seen graphically in the anthocyanin leakage data and firmness data, Figures 5 and 6, respectively. The harvest date was significant ($p \leq 0.05$) in the analysis with a trend in the mechanical physical measurements towards softer berries as the harvest date advances, as seen in Figure 6. In harvest date 3, the leakage is much higher than in dates 1 or 2. This is an indication of softer berries towards the end of the harvest season.

CONCLUSIONS

The early portion of the 1997 field season was unseasonably dry with significantly lower than average rainfalls prior to the beginning of harvest (D. Emerson, pers. comm.). Between weeks 1 and 2 and weeks 2 and 3 there was some rain; however, rainfall was still lower than normal. This random weather pattern may have an affect on the data variation, but not the trends exhibited herein. The results presented here indicate that there are no significant differences ($p > 0.05$) in the two winnowing systems (cam and conveyor) used in the field to separate debris from berries. Therefore, either system could be used in field separation operations. It is also noteworthy that neither winnowing system resulted in increased damage due to the winnowing operation. Based on the findings of the study, the claims by various blueberry industry persons that one winnower does more damage than the other are unsubstantiated.

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