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Bioconversion of organic waste using mealworms

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Introduction

Grape marc is the solid waste product from the wine-making process, comprising grape skins, seeds and stems. Grape marc presents an ongoing challenge in its disposal because of the quantities produced each year and its high acidity. In a previous, small-scale study, mealworms (larvae of the beetle *Tenebrio molitor*) were found to be able to digest and develop normally when fed primarily with grape marc. Feeding was assessed on diets comprising grape marc combined with other waste products, ground mussel shells, and winery lees (the dead yeast cells and particulates collected at the bottom of a vat after the fermentation and aging process; Figure 1).

Figure 1: Pinot noir winery lees.

Method

The organic wastes were sourced from Marlborough wineries certified by Sustainable Winegrowing New Zealand, and Greenshell™ mussel from Aroma NZ Ltd. Grape marc and winery lees were from Pinot noir grapes. Grape marc, lees, or mussel shells were provided individually or in combination to mealworms within small, vented boxes (15.1-cm l x 10-cm w x 4.8-cm h; Figure 2). Each box held approximately 100 mealworms and between 20 and 100 g of substrate/s. Because wholemeal flour is the primary food source for our laboratory mealworm colony, flour was also provided in some small boxes to compare the larval outcome with that from boxes containing organic waste only.

Results and Discussion

There was no noticeable difference in the feeding or development of mealworms on fresh or dried grape marc alone (Table 1; Figure 3).

The mealworm larvae died from excess moisture when fed with wine lees or when wine lees were added to grape marc + mussel shell, mussel shell alone, or wholemeal flour alone.

Only the mealworms fed on both wine lees + grape marc survived; however, no pupal development was observed over the trial period (Table 1).

Ground mussel shells appeared to result in a similar developmental delay of mealworm larvae, either when fed alone or with other substrates (e.g. grape marc and/or wine lees). However, development to the pupal stage was seen in the treatment provided with ground mussel shells and wholemeal flour, suggesting the developmental delay might be overcome by adding wholemeal flour (Table 1).

Our research suggests mealworm larvae can feed and survive on grape marc and, to some extent, on ground mussel shells. Wine lees were an inferior feeding substrate, and further investigation into pre-treatments would be advantageous.

Larger scale trials are now in progress.

Figure 2: Small-scale testing of ground mussel shell (top) or dried grape marc (bottom) consumption by mealworm larvae (*Tenebrio molitor*).

Table 1: Observations of a small-scale pilot study feeding by mealworm larvae (*Tenebrio molitor*) on different organic waste streams. Mealworms were provided with the indicated substrate for 12–15 weeks.

Fresh grape marc	Dried grape marc	Wine lees	Ground mussel shell	Wholemeal flour	Outcome
X		X			Mealworms active. No pupae observed.
X			X		Mealworms active. No pupae observed.
X		X	X		Some feeding; however, moisture and mould became an issue.
X		X		X	Mealworms active. Pupae observed.
	X				Mealworms active. Pupae observed.
	X			X	Mealworms active. Pupae observed.
	Ground marc				Mealworms active. Pupae observed.
	Ground seeds only				Mealworms did not appear as active as those fed on grape marc. Some death of small larvae.
		X			Mould a problem. Mealworms died. Box discarded after 12 d.
		X	X		Initially, mealworms appeared active. No mould observed, and health declined over 6 weeks. No pupal development.
		X		X	OK, for a short time. Moisture and mould became an issue. Box discarded after 12 d.
			X		Mealworms fed, but development was slow. No pupae observed.
			X	X	Mealworms active. Pupae observed.

Figure 3: Mealworm (*Tenebrio molitor*) life stages. From the top row larvae, pupae and adults.

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