IMPACTS OF INDUSTRIAL FOOD WASTES ON NUTRITIONAL VALUE OF MEALWORM (*Tenebrio molitor*) AND ITS GUT MICROBIOTA COMMUNITY SHIFT

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Abstract

The extensive investigation into the capacity of mealworms to digest diverse food by-products, as well as plastic wastes, has been a focal point in recent years. The transition from traditional diet sources like brans to food wastes has the potential to impact the physiological properties of mealworms. This study explored the utilization of various industrial food wastes such as okara, barley spent grain (BSG), sesame oil meal (SOM), and spent coffee grounds (SCG) as feed alternatives, and reports on their survival rate, biomass variations, and nutritional composition. In additional, the shift in their gut microbiota was also assessed. Among the range of industrial food wastes, mealworms exhibited the most robust growth performance when nourished with BSG. This particular group showed a survival rate of 98.33% and a biomass increase of 23.06%. In contrast, mealworms fed with SCG demonstrated the lowest survival rate and experienced a significant reduction in biomass. Although the groups fed with okara and SCG displayed moderate growth performance, both exhibited protein levels comparable to those observed in the oatmeal-fed group (used as the positive control). Notably, the inclusion of BSG in the mealworm diet exhibited the potential to enrich their omega-3 fatty acid content, suggesting potential benefits for applications as animal feed or even human consumption. Furthermore, an analysis of the gut microbiome was conducted to investigate the associations between specific diets and the composition of mealworm gut microbiota. In summary, food wastes such as BSG may be repurposed as feed substrates for mealworms before converting them into an alternative source of protein.

Results

Growth performance of mealworm fed on different industrial food wastes

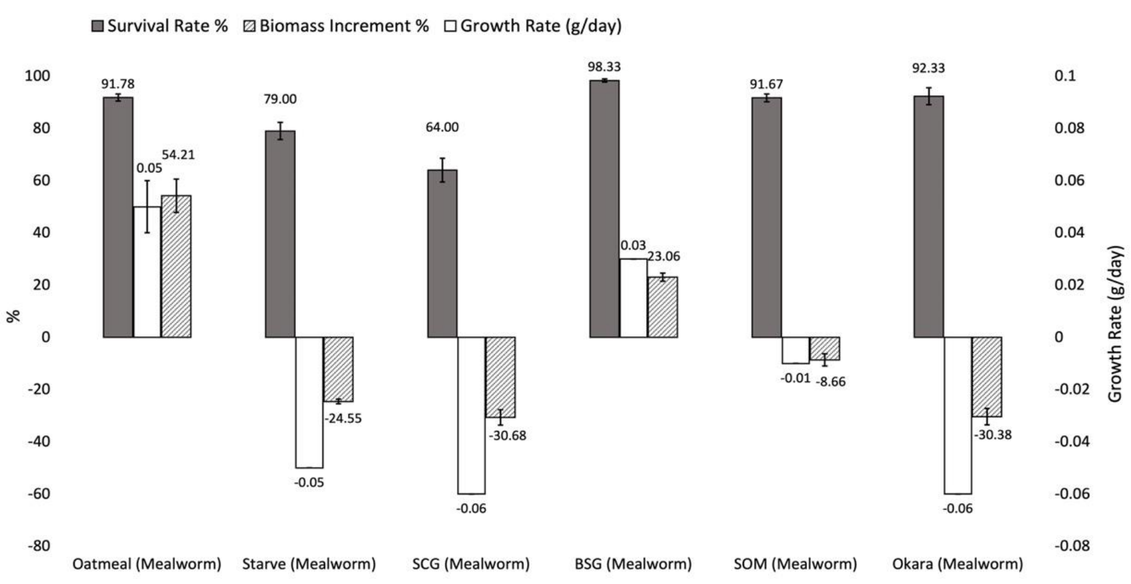


Figure 1. Survival rate, biomass increment, and growth rate of mealworms fed with different industrial food wastes.

Biochemical compositions of mealworms fed with different industrial food wastes

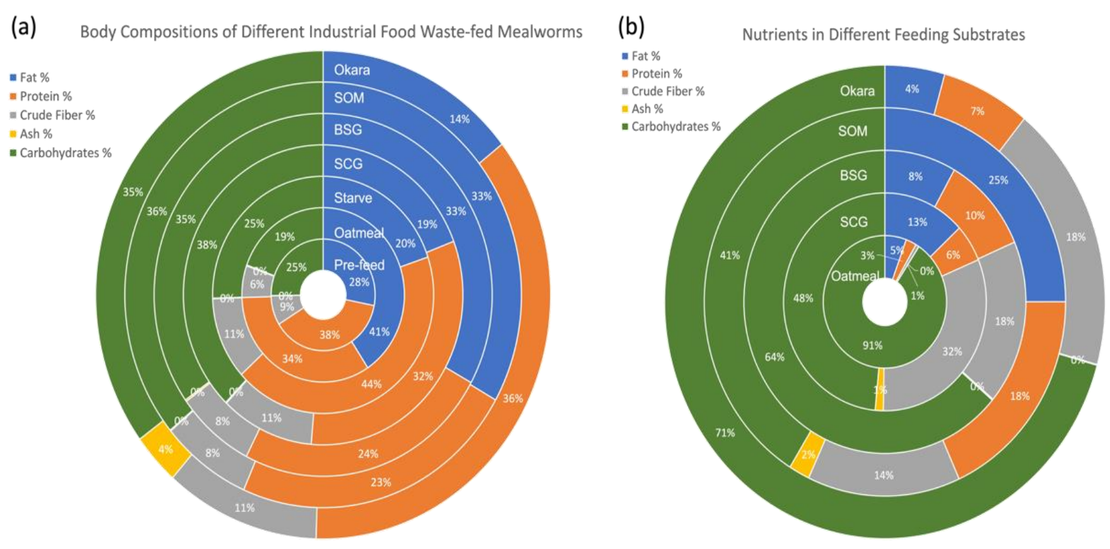
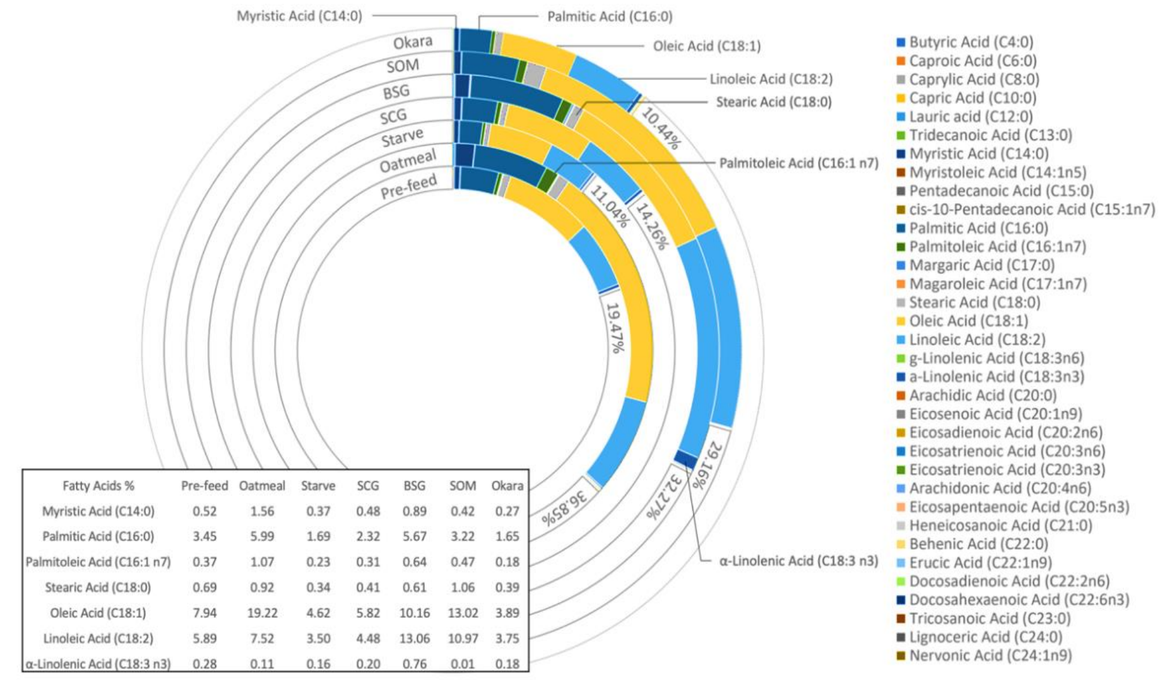


Figure 2. (a) Body compositions of mealworms fed with different industrial food wastes, and (b) nutritional analysis of food wastes.



Fatty Acids %	Pre-feed	Oatmeal	Starve	SCG	BSG	SOM	Okara
Myristic Acid (C14:0)	0.52	1.56	0.37	0.48	0.89	0.42	0.27
Palmitic Acid (C16:0)	3.45	5.99	1.69	2.32	5.67	3.22	1.65
Palmitoleic Acid (C16:1 n7)	0.37	1.07	0.23	0.31	0.64	0.47	0.18
Stearic Acid (C18:0)	0.69	0.92	0.34	0.41	0.61	1.06	0.39
Oleic Acid (C18:1)	7.94	19.22	4.62	5.82	10.16	13.02	3.89
Linoleic Acid (C18:2)	5.89	7.52	3.50	4.48	13.06	10.97	3.75
α-Linolenic Acid (C18:3 n3)	0.28	0.11	0.16	0.20	0.76	0.01	0.18

Figure 3. Fatty acid profile of mealworms fed with different industrial food wastes

Metagenomic analysis of different waste-fed mealworm guts

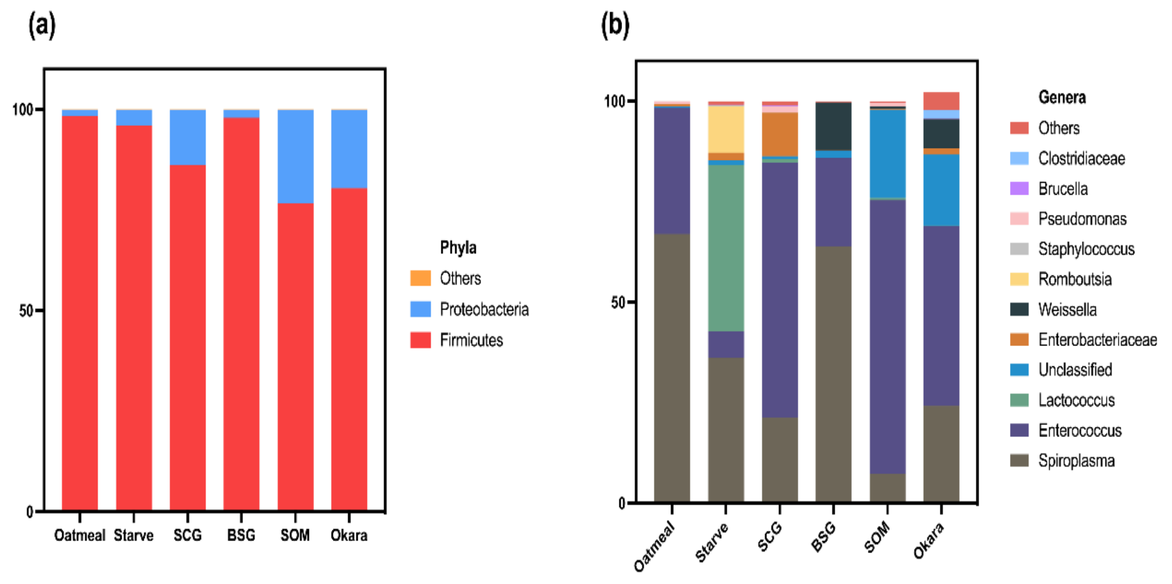


Figure 4. Gut microbiota analysis of different industrial food waste-fed mealworms at (a) Phylum-level community composition, and (b) Genus-level community composition.

Table 1. Pairwise ANOSIM analysis of gut microbiota of mealworms fed with different industrial food wastes using Bray-Curtis similarity

	Oatmeal		Starve		SCG		BSG		SOM	
	R*	p#	R*	p#	R*	p#	R*	p#	R*	p#
Oatmeal										
Starve	0.628	0.011								
SCG	0.208	0.107	0.772	0.009						
BSG	−0.006	0.435	0.778	0.009	0.516	0.015				
SOM	0.712	0.009	0.940	0.008	0.572	0.013	0.692	0.010		
Okara	0.500	0.010	0.776	0.008	0.508	0.017	0.376	0.025	0.152	0.162

*The R value falls within a range of 0 to 1. When the R value approaches 0, it indicates that the difference between groups is less significant in comparison to the differences within each group. Conversely, an R value approaching 1 signifies that the difference between groups is highly significant compared to the differences within each group.

p value indicates the statistical credibility, $p < 0.05$ indicates the result is statistically significant.

Conclusion

- Mealworms fed on BSG and SOM demonstrated strong adaptability, with survival rates of 98.33% and 91.67%, respectively.
- BSG feeding notably enhanced omega-3 and omega-6 PUFAs content, including a twofold increase in ALA and linoleic acid compared to pre-feeding levels.
- Presence of caffeine and ANFs in SCG and okara may negatively influence the mealworm digestion process.
- Both the quantity and quality of carbohydrates in diets had a direct impact on mealworm fat and protein levels, as well as their utilization rate of dietary proteins.
- *Spiroplasma* bacteria within the mealworm gut seemed to play a significant role in harnessing nutrients found in oatmeal and BSG, effectively converting them into biomass.
- Compared to groups fed with oatmeal and BSG, the microbial communities from mealworms fed with other substrates displayed comparatively lower efficiency in energy transformation

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Publication

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