Nutritional composition of *Tenebrio molitor* larvae reared on substrates derived from by-products

Agnė Jankauskienė, Aistė Kabašinskienė

Department of Food Safety and Quality, Veterinary Academy, Lithuanian University of Health Sciences, Tilzes St. 18, Kaunas LT-47181, Lithuania

SBD CONFERENCE

Introduction

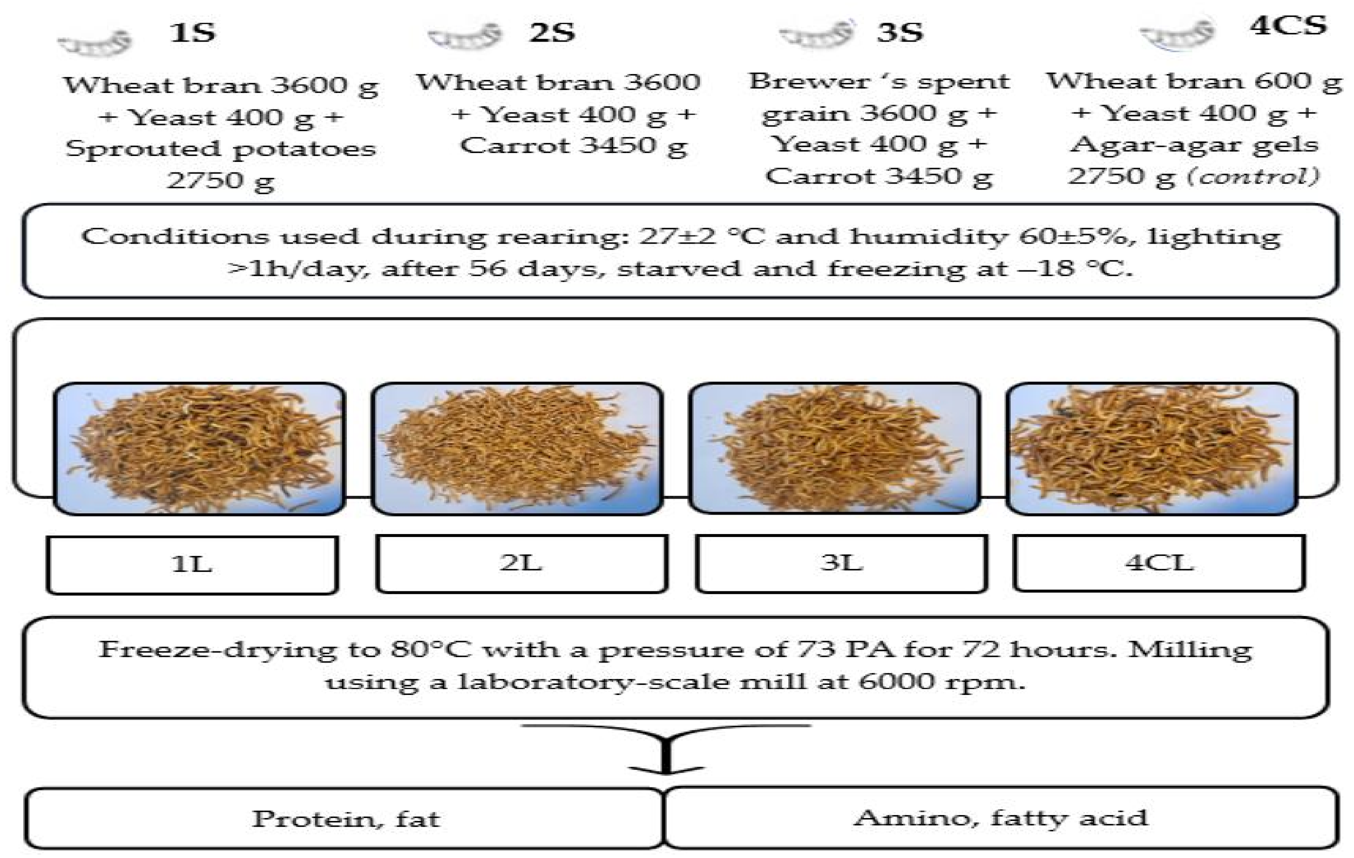
- It is projected that the world's population will reach nearly 9.8 billion people By 2050.
- Consequently, environmental sustainability concerns underscore the importance of developing alternative protein strategies, including new sources of high-quality proteins and fats. When rearing mealworms, it should be taken into account that they are grown quickly with the lowest costs and the resulting biomass is of high quality.
- The rearing of *Tenebrio molitor* larvae (Linnaeus, 1758), a member of the darkling beetle family (*Tenebrionidae*), using plant-based by-products offers multiple benefits.
- Together with a shift towards an economical, safe, and sustainable outcome, there is an increasing trend of attempting to rear mealworms using by-products from production and agriculture.
- The impact of these by-products on the mealworms themselves can vary, depending on the chosen raw materials and their proportions.
- Analyzing the nutritional value of mealworms, besides the quantity of proteins and fats, it's crucial to consider the specific AAs and FAs present.

This study **aims** to explore the potential of using local by-products or food residues as substrates in the mass production of *Tenebrio molitor* larvae (mealworms), focusing on achieving an optimal amino and fatty acid profile.

The **object** of this study encompasses the use of various plant-based by-products such as brewers' spent grain, wheat bran, and notably, sprouted potatoes, which are considered waste from farms and are no longer suitable for human consumption.

If it is a part of the project, please put here the information and logo

Methodology



1L—larvae (wheat bran + brewer's yeast + green potatoes); 2L—larvae (wheat bran + brewer's yeast + carrot). 3L—larvae (brewers' spent grain + brewer's yeast + carrot). 4CS—larvae, control (wheat bran + brewer's yeast + agar-agar gels); 1S—substrate (wheat bran + brewer's yeast + sprouted potatoes); 2S—substrate (wheat bran + brewer's yeast + carrot). 3S—substrate (brewers' spent grain + brewer's yeast + carrot); 4CS—substrate, control (wheat bran + brewer's yeast + agar-agar gels);

Figure 1. Chart illustrating the complete research procedure.

Results

Proteins and amino acids

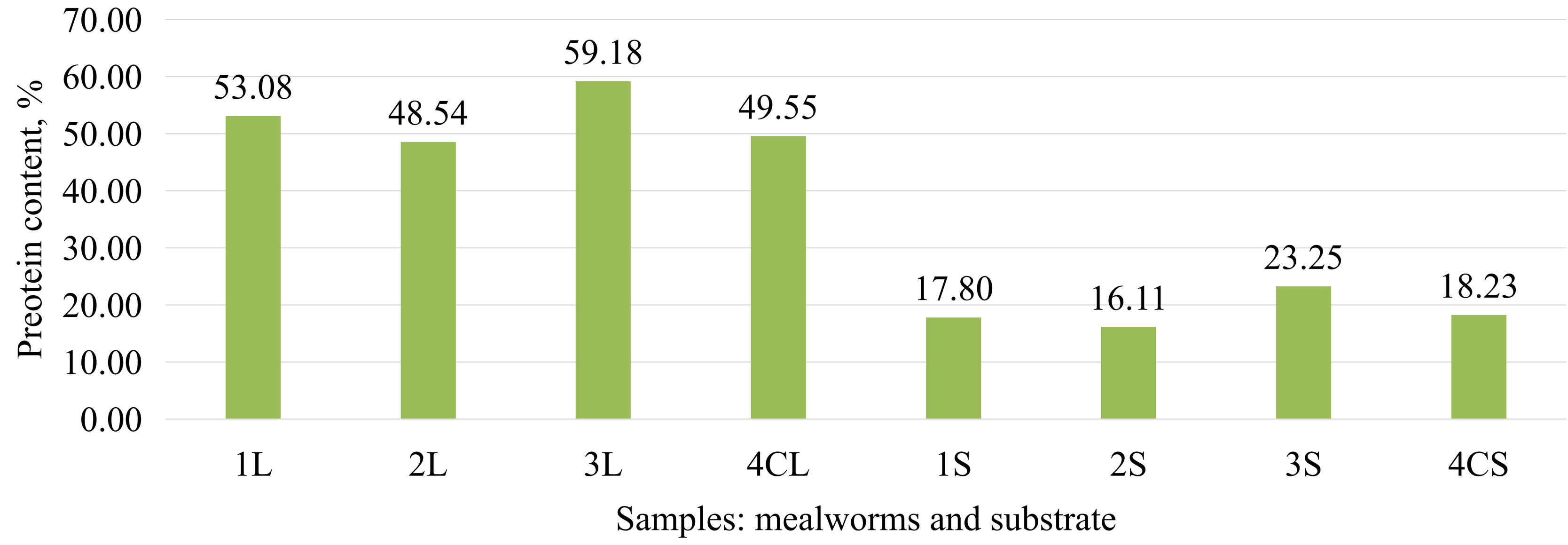


Figure 2. Protein content in substrate and mealworms

Table 1. Amino acid composition in lyophilized larvae and substrate, g/100g of dry matter, average ± standard error, n=3.

	Larvae				Substrate			
Samples	1L	2L	3L	4CL (control)	1S	2S	3S	4CS (control)
Valine	2.88±0.134 a	2.25±0.013 b	3.14±0.130 a	2.93±0.174 a	0.84±0.089 a	0.74±0.061 a	1.19±0.025 b	0.83±0.038 a
Leucine	3.54±0.130 a	3.02±0.002 b	3.79±0.183 a	3.45±0.262 ab	1.09±0.060 a	1.00±0.071 a	1.53±0.009 b	1.10±0.041 a
Isoleucine	2.01±0.104 a	1.61±0.011 b	2.14±0.096 a	2.02±0.111 a	0.63±0.085 ac	0.47±0.059 b	0.79±0.007 c	0.52±0.042 ab
Threonine	1.39±0.082	1.27±0.045	1.45±0.002	1.34±0.111	0.45±0.004 a	0.39±0.019 b	0.52±0.013 c	0.41±0.017 b
Methionine	0.60±0.027 a	0.46±0.044 b	0.62±0.023 a	0.57±0.026 ab	0.18±0.011 a	0.24±0.001 b	0.30±0.017 c	0.26±0.012 b
Phenylalanine	1.63±0.065 ab	1.63±0.039 ab	1.83±0.097 a	1.61±0.089 b	0.72±0.034 a	0.66±0.045 a	1.11±0.010 b	0.69±0.034 a
Lysine	2.73±0.060 a	2.46±0.016 b	2.92±0.152 a	2.80±0.075 a	0.80±0.048 a	0.87±0.044 ab	1.07±0.001 c	0.95±0.042 b
Histidine	1.60±0.116 abc	1.49±0.032 b	1.81±0.116 cd	1.89±0.009 d	0.83±0.005 a	0.61±0.021 b	0.71±0.008 c	0.67±0.002 d
Aspartic acid	3.92±0.132 a	3.21±0.035 b	4.30±0.257 a	3.78±0.306 ab	1.22± 0.056 a	1.10±0.051 a	1.47±0.048 b	1.19±0.060 a
Glutamic acid	5.88±0.238 a	3.73±0.121 b	6.49±0.903 a	6.17±0.046 a	3.86±0.254 a	2.80±0.199 b	3.67±0.171 a	3.00±0.081 b
Glycine	2.41±0.062 a	2.87±0.067 b	2.66±0.091 b	2.43±0.090 a	0.83±0.054	0.74±0.061	0.81±0.003	0.76± 0.03
Serine	1.55±0.116 ab	1.39±0.041 a	1.73±0.002 b	1.68±0.111 b	0.75±0.003 a	0.66±0.033 b	0.74±0.013 a	0.67±0.004 b
Alanine	3.35±0.109 a	3.38±0.094 ab	3.74±0.166 b	3.40±0.148 ab	0.80±0.05 a	0.72±0.046 a	0.99±0.029 b	0.79± 0.045 a
Proline	2.94±0.106 ab	2.67± 0.020 a	2.98±0.143 ab	3.09± 0.174 b	1.12±0.043 a	1.06±0.063 a	1.88±0.029 b	1.13± 0.025 a
Tyrosine	3.25±0.037 a	3.47±0.144 a	3.88±0.160 b	3.54±0.070 a	0.50±0.013 a	0.64±0.034 b	0.85±0.026 c	0.40±0.020 d
Cystine	0.38±0.005 a	0.20±0.005 b	0.37±0.013 a	0.38±0.007 a	0.34±0.014 a	0.50±0.001 b	0.50±0.001 b	0.48±0.013 b

a,b,c,d - means marked with different letters in the row (in the groups Larvae and Substrate separately) differed significantly (p<0.05, Fisher's LSD criterion); 1L—larvae (wheat bran + brewer's yeast + green potatoes); 2L—larvae (wheat bran + brewer's yeast + carrot). 3L—larvae (brewers' spent grain + brewer's yeast + carrot). 4CL—larvae, control (wheat bran + brewer's yeast + agar-agar gels); 1S—substrate (wheat bran + brewer's yeast + sprouted potatoes); 2S—substrate (wheat bran + brewer's yeast + carrot). 3S—substrate (brewers' spent grain + brewer's yeast + carrot); 4CS—substrate, control (wheat bran + brewer's yeast + agar-agar gels);

Results

Fats and fatty acids

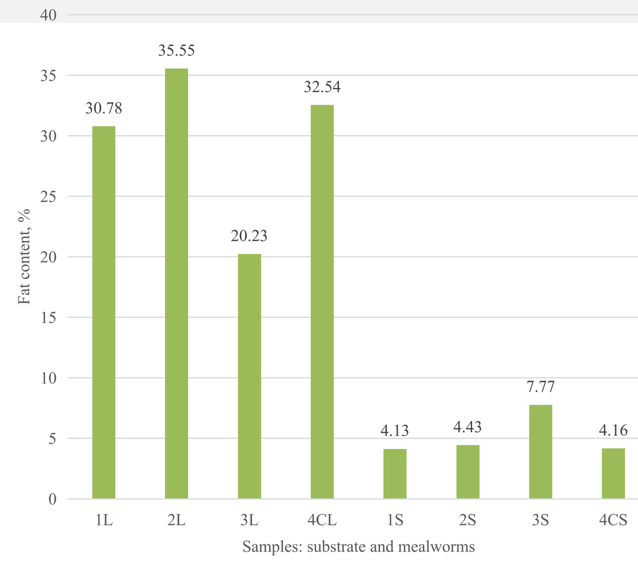


Figure 3. Fat content in substrate and mealworms

Table 4. Fatty acid ratio in lyophilized larvae and substrate, % of total FAs content, n=3.17

	Larvae				Substrate			
Samples	1L	2L	3L	4CL	1s	2s	3s	4cs
Total SFA	26.42 a	24.15 b	52.64 c	17.33 d	20.94 a	20.79 b	28.59 c	20.25 d
Total MUFA	45.12 a	38.02 b	35.89 c	43.37 d	24.64 a	28.47 b	24.13 c	24.18 d
Total PUFA	28.47 a	36.24 b	10.18 c	35.11 d	54.42a	50.74 b	44.63 c	54.05 d
Omega 6 FA	27.12 a	18.65 b	7.82 c	29.22 d	54.00 a	49.54 b	42.92 c	53.91 d
Omega 3 FA	0.32 a	4.39 b	1.69 c	6.99 d	0.03 a	0.29 b	2.65 c	1.53 d
Omega 6/3 FA	85.05 a	4.25 b	4.632 c	4.18 d	1838.83 a	170.51 b	16.20 c	35.34 d

a,b,c,d - means marked with different letters in the row (in the groups larvae and substrate separately) differed significantly (p<0.05, Fisher's LSD criterion); SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids;

Table 3. Comparison of fatty acid in lyophilized larvae and substrate, % of total FAs content, average ± standard error, n=3.

Fatty acids / Samples	C12:0	C16:1	C17:0	C18:0	C18:1 cis	C18:2 trans	c18:3 gama	C20:1	C20:3 w6	C22:1 w9	C20:3w3	C22:4 w6	C20:5 w3
Larvae	2.46 ±1.411***	1.90 ±1.373***	3.39 ±3.821*	4.48 ±3.960*	35.72 ±2.472***	0.46 ±0.613***	0.62 ±0.504**	1.41 ±0.431***	1.58 ±1.341**	1.32 ±1.294**	4.14 ±5.674*	2.03 ±2.027 **	1.49± 1.371**
Substrate	0.11 ±0.201	0.07 ±0.132	0 ±0	1.75 ±0.51	18.12 ± 1.273	0 ±0	0.14 ± 0.233	7.16 ±2.084	0 ±0	0 ±0	0.53 ± 0.411	0.03 ±0.062	0.08 ± 0.135

In the groups larvae and substrate separately differed significantly (* - p<0,05; ** - p<0,01; *** - p<0,001, Fisher's LSD criterion); 1L—larvae (wheat bran + brewer's yeast + green potatoes); 2L—larvae (wheat bran + brewer's yeast + carrot). 3L—larvae (brewers' spent grain + brewer's yeast + carrot). 4CL—larvae, control (wheat bran + brewer's yeast + agar-agar gels); 1S—substrate (wheat bran + brewer's yeast + sprouted potatoes); 2S—substrate (wheat bran + brewer's yeast + carrot). 3S—substrate (brewers' spent grain + brewer's yeast + carrot); 4CS—substrate, control (wheat bran + brewer's yeast + agar-agar gels);

Main conclusions

- **The results showed that the highest protein content (59.18 ± 0.07 %) was observed in samples grown on brewers' spent grain, while wheat bran yielded the highest fat content (34.22 ± 0.491 %).**
- **The amount of FAs in the larvae was influenced by the substrate used, with variations in monounsaturated, omega-3, and oleic acids.**
- **Notably, wheat bran showed the highest content of total polyunsaturated FAs (36.23 %). In the analysis of 16 distinct amino acids, a sample with brewers' spent grain, consistently demonstrated the highest content in 11 instances.**
- **This adaptation renders the larvae suitable for diverse purposes, including animal or human nutrition and health enhancement.**
- **In conclusion, our study underscores the significance of substrate optimization in harnessing the full potential of *Tenebio molitor* larvae for targeted applications.**