Quality of fermented and dried larvae of the black soldier fly

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Introduction

Demand for protein sources of animal origin will increase due to population growth, rising living standards as well as increasing meat consumption in developing countries (FAO, 2009). Insects offer a high protein content and are characterized by high feed conversion efficiency and growth rates, making them high-quality and potentially profitable feed for livestock (Veldkamp et al., 2012). The extent to which killed, non-degreased larvae of the black soldier fly (BSF, *Hermetia illucens* L.) can be preserved by means of ensiling, as an alternative to drying, and how their feed quality is to be assessed was investigated in three ensiling trials at AREC (Resch et al., 2020).

Material and Methods

The BSF larvae used for the experiments came from an Austrian company. They were stored at-20℃ after killing and thawed at a temperature of+4℃ two days before further processing. From two preliminary experiments, the most promising treatments were selected and ensiled again in a third experiment to be subjected to a comprehensive laboratory analysis. Finally, the experiment comprised the following treatments, each replicated three times: i) pure BSF larvae ensiled; ii) mixed silage of 60% BSF larvae+40% coarse-milled barley; iii) as ii + 0. 3% sodium nitrite; iv) as ii + 10 kg/t fresh matter of Silasil-Extra [Ingredients: Ca-formate, Na-benzoate, Na-chloride and homofermentative lactic acid bacteria (*L. plantarum*, *Pediococcus pentosaceus*)]; v) pure BSF larvae dried. The coarsely milled barley had a particle size of more than 1000 μm. In preparation for the different treatments, a total of 100 g of either solely BSF larvae or the different mixing ratios of BSF larvae and coarse-milled barley were packed airtight in a vacuum bag. The bags were then stored in the dark at room temperature of 16 to 18. 5℃ for 50 to 83 days. Chemical, microbiological, biogenic amines (BA) and amino acid analyses were performed by using wet chemical methods (VDLUFA 1976; VDLUFA 2007).

Results

Fermentation of pure, unchopped, non-degreased BSF larvae (treatment i) resulted in heavy formation of fermentation liquid, extremely strong spoilage odour and insufficient acidification. Compared to drying, 15 times more BA was formed in this treatment. As a percentage of total N, 32% ammonia-N indicates massive proteolysis during the anaerobic phase. The addition of highly fermentable barley (treatment ii) allowed for controlled lactic acid fermentation with a sufficient decrease in pH and resulted in significant changes in nutrient content. It seems likely that lactic acid bacteria (LAB), present in the microbiome of the digestive tract of BSF larvae, positively supported fermentation in the presence of fermentable carbohydrates. Additional application of sodium nitrite or LAB+chemical ingredients did not lead to any further improvements. The addition of barley led to a significant but unfavourable increase in BA compared to pure ensiled and dried BSF larvae.

Oven drying at 50℃ for two days (treatment v) gave the best overall conservation result, as the nutrient contents changed least compared to the fresh BSF larvae. The reduction of BA by 5 g/kg DM compared to the fresh larvae is to be seen as favourable, while the significant loss of ~10% of amino acids is to be considered negative (Table 1).

Table 1. Effects of fermentation and drying of black soldier fly larvae on various quality parameters

				treatments				
				i	ii	iii	iv	v
	unit	fresh	fresh	ensiled	ensiled	ensiled	ensiled	dried
content BSF larvae	%	100	0	100	60	60	60	100
content barley coarse-milled	%	0	100	-	40	40	40	-
silage additives		-	-	-	-	Na-nitrite	Silasil Extra	-
dry matter	g/kg FM	273. 7^{a}	917. 3^{c}	260. 3^{a}	531. 3^{b}	530. 0^{b}	536. 7^{b}	942. 7^{c}
crude protein	g/kg DM	499. 3^{d}	102. 3^{a}	455. 0^{c}	234. 3^{b}	238. 3^{b}	231. 3^{b}	494. 7^{d}

(continued)

				treatments				
				i	ii	iii	iv	v
	unit	fresh	fresh	ensiled	ensiled	ensiled	ensiled	dried
amino acids total	g/kg DM	402[e]	95[a]	319[c]	166[b]	174[b]	166[b]	364[d]
ammonia N	% of N_{total}	–	–	32.0[c]	13.7[b]	9.7[a]	12.6[ab]	–
biogenic amines	g/kg DM	11.7[b]	–	101.7[e]	24.3[d]	19.4[c]	27.1[d]	6.7[a]
crude fiber	g/kg DM	86.3[b]	51[a]	98.7[c]	57.7[a]	51.3[a]	55.0[a]	87.0[b]
crude lipids	g/kg DM	269.7[c]	21[a]	276.7[c]	95.0[b]	93.7[b]	98.0[b]	268.7[c]
crude ash	g/kg DM	69.7[d]	24.3[a]	72.0[c]	38.0[b]	41.0[b]	39.3[b]	65.0[c]
pH value		7.92[c]	–	6.77[b]	5.10[a]	5.17[a]	4.97[a]	–
lactic acid	g/kg DM	–	–	4.2[a]	29.9[b]	25.4[b]	30.4[b]	–
acetic acid	g/kg DM	–	–	10.4[b]	5.7[a]	5.2[a]	5.4[a]	–
propionic acid	g/kg DM	–	–	3.2[b]	0.8[a]	0.6[a]	1.0[a]	–
butyric acid	g/kg DM	–	–	3.2[b]	0[a]	0[a]	0[a]	–
ethanol	g/kg DM	–	–	2.6[b]	2.7[b]	1.0[a]	1.8[ab]	–
VOC total	g/kg DM	–	–	23.5[a]	39.1[b]	32.2[ab]	38.7[b]	–
bacteria	Cfu^{log}/g FM	6.8[b]	4.2[a]	7.0[ab]	6.9[b]	6.8[b]	6.8[b]	7.2[b]
leachate	weight%	–	–	10.1[b]	0[a]	0[a]	0[a]	0[a]
spoilageodour*	scale 0–6	1.0[b]	0[a]	5.0[e]	1.0[b]	2.0[d]	2.0[d]	1.3[c]

*scale spoilage odour: 0–not present 1–pleasant or typical product odour, 2–light, 3–moderate, 4–strong, 5–very strong, >5–extremly strong indices letters show significant differences at confidence–level 95% via method Tukey–HSD

Conclusions

The world's first comprehensive study on the fermentation of BSF larvae at AREC Raumberg–Gumpenstein showed that the ensiling of pure BSF larvae did not result in a suitable feeding–stuff for monogastric animals due to the strong degradation processes in the anaerobic phase. By adding 40% easily fermentable substrate (coarse–milled barley), a good fermentation success could be achieved even without silage additives. Nevertheless, even the best silage treatment could not keep up with oven drying in terms of product quality.

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