EFFECTS OF ADDITIVES AND MOISTURE LEVEL ON CRIMPED ENSILED FABA BEAN COMPOSITION AND DEGRADATION OF ANTINUTRITIONAL FACTORS

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ABSTRACT

Wider use of crimping and ensiling as a preservation method of grain legume seeds could increase local production of protein feeds and improve the resilience of European livestock production. This experiment evaluated the effects of moisture level and formic acid addition on fermentation quality and vicine & convicine degradation of crimped ensiled faba beans. In addition, a by-product from grass protein extraction, grass whey or brown juice, was used as a novel component to improve fermentation by adding moisture and nutrients to the faba beans. All samples showed good preservation quality with limited protein breakdown and no presence of butyric acid. Higher moisture content promoted lactic acid production and decreased pH of the samples. On average 60% of the original vicine & convicine was degraded during ensiling indicating that the preservation method can be used to improve the feeding value. Use of grass whey showed potential as a feed component included in crimped ensiled seeds that can promote fermentation and recycle the nutrients in the whey back to the food chain.

Keywords: *Vicia faba* L., fermentation quality, formic acid, green biorefinery by-product, vicine, convicine

INTRODUCTION

Europe is heavily dependent on imported protein feed supplements, which poses a threat to food security. Grain legumes such as faba beans and peas can replace imported soya bean and rapeseed protein, and their use should be encouraged. The lack of suitable protein supplements is particularly high in organic pig and poultry production, where the antinutritional factors of faba bean limit the use of it. Crimping and ensiling is a method commonly used for grain preservation with benefits related to economics, work efficiency and smaller weather dependency. The fermentation process may also positively affect the digestibility of nutrients (Soares *et al.* 2026) and degrade antinutritional factors (Rinne *et al.* 2020). The aim of the current experiment was to evaluate the effect of moisture content and additive application on the fermentation quality and degradation of vicine & convicine in crimped ensiled faba bean seeds. A by-product from grass protein extraction, grass whey or brown juice, was used as a novel component to improve fermentation by adding moisture and nutrients to the faba beans.

MATERIAL AND METHODS

The faba beans (variety Sampo) were combine harvested at Jokioinen Finland on 24 September 2024, and crimped using a farm scale crimper mill (Murska VMAX, Aimo Kortteen Konepaja, Ylivieska, Finland). The grass wheys were obtained from another experiment (Ayanfe *et al.* 2026) where an organically produced red clover grass was separated by screw-pressing into liquid and solid fractions. The true protein from the juice was precipitated in buckets either without any additive or using a formic acid based additive (FA, AIV 2 Plus Na, Eastman, Oulu, Finland). The liquid on the top, or grass whey as we call it, was collected from the buckets to yield WheyC (without additive) and WheyFA (with additive) that were used in the current trial. The crimped faba beans were ensiled in laboratory scale using the following treatments: water, WheyC, WheyFA and formic acid (application rate 3 litres per ton), all at two levels of liquid (7.5 and 15 %). In addition, freshly harvested beans without any additive were used resulting in 9 treatments in total. Each 3 kg replicate (4 per treatment) received the additive individually and was sealed into a vacuum plastic bag for 3 months. After opening, the samples were analysed using routine laboratory methods for fermentation quality, and for vicine & convicine concentrations. The statistical analysis was conducted using SAS statistical package, and treatment effects were evaluated using contrasts as well as using Tukey's test.

RESULTS AND DISCUSSION

The faba bean raw material had a moisture content of 218 g/kg, and vicine & convicine concentrations were 6.80 and 5.49 g/kg DM, respectively. The DM concentrations of WheyC and WheyFA were 39 and 43 g/kg. WheyC contained 100 g lactic acid/kg DM but in WheyFA the fermentation had been restricted (2 g lactic acid/kg DM). The FA content in WheyFA was 5.4 g/kg so that the application of FA in it was negligible. All samples showed good preservation quality (Table 1) with limited protein breakdown and no presence of propionic or butyric acid. Higher moisture content promoted lactic acid production and decreased pH of the samples. At similar moisture level, grass wheys promoted fermentation compared to water only while FA efficiently restricted fermentation. On average, 60% of the original vicine & convicine was degraded during ensiling indicating that fermentation during ensiling can act as a means to improve the feeding value.

CONCLUSION

Under humid harvesting conditions, crimping and ensiling can be used as a low-cost flexible feed preservation method compared to drying, with additional benefits in feed quality. This approach could be of particular use in increasing the protein self-sufficiency of organic farms when including grain legumes in their crop rotations, and their use could be extended from the ruminant sector to diets of monogastric farm animals. Use of grass whey showed potential as a feed component included in crimped ensiled seeds that can promote fermentation and recycle the nutrients in the whey back to the food chain.

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Tab. 1: Composition of the crimped ensiled faba bean seeds

	Moisture, g/kg	pH	Ammonia-N, g/kg N	In dry matter, g/kg					
				Ethanol	Lactic acid	Acetic acid	Propionic acid	Vicine	Convicine
Treatment[1]									
1. Water0	210^{g}	6.09^{a}	4^{d}	0^{e}	0.2^{e}	0.1^{e}	0.2	2.65^{c}	2.20^{de}
2. Water1	261^{e}	5.73^{b}	12^{c}	9.5^{ab}	6.7^{e}	1.7^{de}	0.5	3.77^{b}	2.93^{b}
3. Water2	302^{b}	4.98^{d}	25^{b}	10.6^{a}	21.5^{d}	3.1^{cd}	0.3	2.32^{cd}	2.82^{bc}
4. WheyC1	253^{f}	4.67^{e}	25^{b}	4.0^{cd}	30.4^{c}	4.1^{c}	0.4	1.76^{d}	2.50^{bcd}
5. WheyC2	290^{c}	4.41^{f}	35^{a}	4.3^{cd}	54.6^{a}	5.8^{ab}	0.1	0.66^{e}	1.70^{e}
6. WheyFA1	250^{f}	4.84^{de}	22^{b}	6.4^{abc}	27.8^{cd}	4.5^{bc}	0.2	1.71^{d}	2.29^{cd}
7. WheyFA2	291^{c}	4.39^{f}	27^{b}	6.1^{bc}	45.0^{b}	6.2^{a}	0.3	0.82^{e}	2.27^{cd}
8. FA1	266^{d}	5.42^{c}	8^{cd}	0.6^{de}	0.3^{e}	0.3^{e}	0.2	5.82^{a}	4.09^{a}
9. FA2	312^{a}	5.28^{c}	10^{c}	1.1^{de}	1.3^{e}	0.6^{e}	0.1	2.15^{cd}	2.20^{de}
SEM	1.2	0.052	1.4	0.96	1.70	0.37	0.17	0.187	0.129
P-values for contrasts[2]									
Water Lin	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.444	0.198	0.001
Moisture 1 vs 2	<0.001	<0.001	<0.001	0.534	<0.001	<0.001	0.526	<0.001	<0.001
Whey C vs FA	0.383	0.128	<0.001	0.018	<0.001	0.200	0.980	0.762	0.116
Water vs Wheys	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.285	<0.001	<0.001
Water vs FA	<0.001	0.827	<0.001	<0.001	<0.001	<0.001	0.123	<0.001	0.027

[1]Treatments: Water0, 1 and 2: Addition of tap water at 0, 7.5 or 15 %; WheyC1 and 2: Addition of Grass whey without additive at 7.5 and 15 %; WheyFA1 and 2: Addition of Grass whey with formic acid at 7.5 and 15 %; FA1 and 2: Addition of formic acid with tap water at 7.5 and 15 %.

[2]Contrasts: Water Lin = 1 vs 3; Moisture 1 vs 2: 2, 4, 6, 8 vs 3, 5, 7, 9; Whey C vs FA: 4, 5 vs 6, 7; Water vs Wheys: 2, 3 vs 4, 5, 6, 7; Water vs FA; 2, 3 vs 8, 9.

Means in columns with different superscript letters differ statistically significantly (P<0.05).

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