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Faba beans-Noval approach for animal protein feeding

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Abstract
Vicia faba L. (faba bean) is a flowering plant species in the Fabaceae family that is the fourth most widely grown winter season legume after pea, chickpea, and lentil. Faba beans are a good source of crude protein and starch. Along with the essential nutrients present in faba beans such as proteins (36-39%), starch 86 (42-47%), minerals, vitamins and polyphenols, some anti - nutritional factors (ANF's) are also present. These are tannins, lectins, trypsin inhibitors, vicine and convicine. Therefore, to alleviate these anti - nutritional factors, various treatments such as boiling, soaking, pressure cooking, germination, fermentation etc. have been studied. Dehulling is a mechanical process in which the hulls are removed from the beans, which mainly consists of the tannins. Soaking was done in an incubator at 30°C for 12 hours with double deionised water in a 1:5 w/v ratio. After soaking for 12 hours, there was 32.7 and 47 percent decrease in phytic acid and condensed tannins, respectively. All cooking methods, including cooking, autoclaving, regular cooking, and microwave heating, reduced TIA activity by 40%. Fermentation is defined as the process of chemical breakdown of a substance, mainly by microorganisms. Extrusion cooking is a batch process which combines mixing, heating, drying and forming with single equipment. So, it can be concluded that different treatments to faba beans helps lessen the level of anti - nutritional components in faba beans and can be a good alternative to use in dairy ration as cheap protein source.

Keywords: Faba, anti - nutritional factor, beans, protein

Introduction
Legumes are plants in the family Leguminosae/Fabaceae, the third largest angiosperm family, with over 16,000–19,000 species in 750 genera (Allen & Allen, 1981) [4]. Legume production in the world averaged 96 MT (FAOSTAT, 2017) [8]. *Vicia faba* L. (faba bean, broad beans, or horse bean) is a flowering plant species in the Fabaceae family that is the fourth most widely grown winter season legume after pea, chickpea, and lentil (FAOSTAT, 2018). It had been recorded that global acreage of Faba bean (*Vicia faba*) dropped from 3.7 to 2.1 million ha between 1980 and 2014, and productions are highly variable within specific countries (FAO, 2017) [8]. In spite of the decreasing acreage, however, per area production had increased, due to a reduced vulnerability to abiotic and biotic stresses (Singh *et al.*, 2012). Carbohydrates are abundant in faba bean seeds (51–68%), and the major carbohydrate is starch (22–45% Hoover & Sosulski, 1991) [11]. Ross and Davies (1992) reported 35% starch and 36% protein in faba beans. The faba bean (*Vicia faba* L.) is a legume seed well adapted to most climatic areas of Europe and North America, and it is widely used for animal feed. It contains several other bioactive compounds, such as polyphenols, carotenoids, and carbohydrates (Landry *et al.*, 2016). Faba beans, like other legume crops benefit soil fertility by fixing nitrogen and improve soil properties as a catch crop (Kudlinskiene *et al.*, 2018) [14]. Depending on the cultivar of bean, faba beans are a good source of crude protein (260–300 g kg-1 DM) and starch (400–480 g kg-1 DM) (Makkar *et al.*, 1997; Goelema *et al.*, 1999) [19, 9]. Furthermore, faba beans have a relatively high lysine content and a relatively low methionine content (Makkar *et al.*, 1997) [19], making them an appealing supplement for dairy cow diets. High-yielding dairy cows' diets should include ruminal undegradable protein, which provides an animal with adequate amounts of essential amino acids. Thermal treatment of protein feeds is common in feed manufacturing to increase the amount of rumen by-pass protein to meet protein requirements for milk production (Aguilera *et al.*, 1992) [1]. Iron content in faba beans (15.18 mg/100g) is comparatively greater than that in soybean (6.64 mg/100g), pea (7.36 64 mg/100g), chickpea (6.96 mg/100g dry seeds), etc. Although faba beans are high in minerals, they have low absorption due to phytate and Fe binding polyphenols (Sandberg, 2014) [22]. Mineral availability improved as anti – nutritional factors such as phytates and tannins that formed complexes with minerals were reduced.

Along with the essential nutrients present in faba beans such as proteins (36-39%), starch 86 (42-47%) (Alghamdi, 2009) [2], minerals, vitamins and polyphenols, some anti – nutritional factors (ANF's) are also present. These are tannins, lectins, trypsin inhibitors, vicine and convicine (Jezierny, et al., 2010) [12]. Out of these anti – nutritional factors, tannins are responsible for reducing both energy and protein digestibility. Vicine and Convicine causes lethal disease Favism, due to insufficiency of enzyme glucose-6-phosphate dehydrogenase. It leads to hemolytic anemia i.e. loss of red blood cells (reduced glutathione).

Lectins reduce the polysaccharide and mineral bioavailability. It also contains phytic acid, tannins and protease inhibitors, reducing the digestibility of seeds or leading to some pathological conditions (Multari *et al*., 2015) [20].

Therefore, to alleviate these anti - nutritionalfactors, various treatments such as boiling, soaking, pressure cooking, germination, fermentation etc. have been studied. anti - nutritionalfactors can also be termed as biologically active non-nutritive components (BANS). Undoubtedly, they are undesirable, some studies found them as beneficial, as trypsin inhibitors form complexes with trypsin reducing protein digestibility so helps in preventing or inhibiting the formation of cancer-causing cells. Also, lectins, as it form complexes with α-amylase, lead to reduction in the level of glucose in blood, therefore considered beneficial in diabetic patients (Borowska, *et al*., 2003) [6]. Discrete treatments such as soaking, boiling, pressure cooking, air classification, extrusion, heat treatment, and others have been used to reduce the level of antinutritional components. Also, some bioprocessing procedures such as fermentation, germination, and enzyme treatments have been used (Alonso, *et al*., 2000; Jezierny, *et al*., 2010) [5, 12].

Previous studies revealed that it could be an alternative to other protein feeds without affecting intake or milk yield of the dairy cows. An *in vitro* study by Vaga *et al*. (2017) [23] demonstrated that optimum heat treatment is an effective way to increase the content of utilizable crude protein in legumes. This is because legumes are low in sulphur-containing amino acids like tryptophan, cysteine, and methionine but high in lysine, whereas cereals are the vice-versa (Ali *et al.*, 2014) [3]. So different methods are discussed below:

Dehulling and Soaking

Dehulling is a mechanical process in which the hulls are removed from the beans, which mainly consists of the tannins. It is most widely used pretreatments for legumes. It was observed that phytic acid was increased as per unit mass decreased tannin and polyphenol content was reduced after dehulling (largely present in the hull itself). After dehulling treatment, condensed tannins reduced by 92% and polyphenol content were reduced by 81%.

Leaching out effect was principally responsible for the reduction in phytic acid content during soaking.

Soaking was done in an incubator at 30°C for 12 hours with double deionised water in a 1:5 w/v ratio. After soaking for 12 hours, there was 32.7 and 47 percent decrease in phytic acid and condensed tannins, respectively. However, after soaking, there was almost no difference in polyphenol content (Alonso, *et al*., 2000) [5].

Cooking, Autoclaving and Irradiation

The reactions involved in thermal degradation involving deamidation splitting of covalent bonds, hydrolysis of peptide bonds at aspartic acid residues, interchange or destruction of disulfide bond (Alonso, et al., 2000; Luo & Xie, 2013) [5, 16, 17]. Cooking was carried out at 100^0 C for 30 minutes with a 1:10 w/v ration of beans and distilled water. All cooking methods, including cooking, autoclaving, regular cooking, and microwave heating, reduced TIA activity by 40%. (Luo & Xie, 2013) [16, 17]. With a 1:10 w/v ratio of beans and distilled water, autoclaving of faba beans was carried out at 1.6 $*10^6$ Pa (121ºC) for 20 min. With a 1:10 w/v ratio of beans and distilled water, using a domestic microwave, the treatment was applied for 6 min after which, the beans were dried in hot air oven for 12 h at 50ºC. All cooking methods increased the level of phytic acid in the range of 7.9-10.9%, because of heat stable nature of phytic acid (Luo & Xie, 2013) [16, 17]. In case of tannin content, cooking methods significantly depreciated it by 14.9-17.8% in white faba beans but did not affect tannin content in green faba bean. For lectins, autoclaving was the most effective for reducing lectin activity by 75-100% in green faba beans and 87-100% in white faba beans (Luo & Xie, 2013) [16, 17]. Cooking methods also improved the *in vitro* protein digestibility. The sequence of autoclaving, soaking, and dehulling was most efficient in improving IVPD by 17.4 and 11.2% respectively in green and white faba beans (Luo &Xie, 2013) [16, 17].

Fermentation

It is defined as the process of chemical breakdown of a substance, mainly by microorganisms. Faba beans fermentation was carried out by lactic acid bacteria *Lactobacillus Plantarum* VTT E 133328 to observe whether the chemical changes occurring during fermentation affect the anti – nutritional factors present in faba beans. It was found that, fermentation was effective in reducing the anti – nutritional factors present in faba beans.

Enzymatic Treatment

Enzymatic treatment is more widespread due to several factors such as mild processing conditions, easily controlled reaction, minimal by-product formation, etc. Phytase treatment is principally applied to reduce the phytic acid content in faba beans (Karsma, 2015) [13].

Germination/ Sprouting

Germination softens cotyledons, shortens cooking time, reduces anti – nutritional factors, and boosts the overall nutritional value of pulses (Vidal-Valverde *et al*., 1998) [24]. Furthermore, it can promote the development of desirable aroma and flavour, thereby improving organoleptic properties. They were germinated for 6 days to make sprouts at 2, 4, and 6 days. These were added to faba bean flour, which was incubated at 30°C for 30, 60, 90 and 120 minutes with shaking. The best combination for obtaining maximum phytic acid reduction level (265 to 66 mg/100g) was four-day old sprout added to faba bean flour with incubation time of 120 minutes (Luo *et al*., 2013) [16, 17].

Extrusion

Extrusion is a high-temperature, short-time process used in the commercial production of high-value cereal-based expanded breakfast and snack foods. Extrusion cooking is a batch process which combines mixing, heating, drying and forming with single equipment (Karsma, 2015; Lillford, 2008) [13, 15]. It reduces the microbial population, inactivates enzymes, and reduces nutrient and flavour losses. Extrusion

like treatments are largely used in the feed industry to improve starch digestibility and reduce the rumen solubility, nitrogen solubility and degradability of plant proteins. In case of faba beans, this process increased starch enzymatic digestibility from 11.39% to 85.05% (Masoero et al., 2005) [18].

Conclusion

Faba bean is important both as a pulse and a vegetable crop. The dry and fresh seeds or pods are recommended for cattle for dietary source of fiber and protein. By different treatments to faba beans like soaking, boiling, pressure cooking, air classification, extrusion, heat treatment, fermentation, germination, and enzyme treatments etc helps lessen the level of anti – nutritional components in faba beans and can be a good alternative to use in dairy ration as cheap protein source.

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