



A FARM-TO-FORK APPROACH TO OPTIMISE ENVIRONMENTALLY-SUSTAINABLE AND PROFITABLE PROTEIN PRODUCTION USING *VICIA FABEA* L. (FABA BEAN).

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Introduction

The socioeconomic potential of whole legume grains as a food and feed source may be substantially less than the sum which could be achieved using legume grain fractions which may help diversify the range of legume-based products across the whole agri-food chain. Any consequent increase in gross margins would also encourage greater uptake of legume supported cropped systems that are also more environmentally sustainable. Towards that end, we report on the potential of faba beans to empower sustainable protein production in farm-to-fork analyses that is centered on the process of “air classification”: a low cost method which uses a vertical cyclonic air stream to separate finely ground dehulled milled faba beans (kernels) into bean protein- and bean starch-concentrates (BPC and BSC, respectively).

Materials and Methods

In addition to faba bean yield, we determined: the proportion of nitrogen (N) derived from air (%Ndfa); biological nitrogen fixation (BNF; Unkovich et al., 2008), the associated *Rhizobium leguminosarum* bv. *viceae* (*Rlv*) molecular diversity (Haukka et al., 1998; Versalovic et al., 1994; Tian et al., 2007). These attributes were monitored in response to ‘conventional’ and ‘sustainable’ growing regimes at the James Hutton Institute Centre for Sustainable Cropping (CSC; <http://www.hutton.ac.uk/about/facilities/centre-sustainable-cropping>), using 5 varieties over three growing seasons (2011-2013). The standardised ileal digestibility (SID) of BSC essential amino acids (AA) was determined in 28-d old birds and 70-d old pigs. In a study conducted in freshwater, Atlantic salmon parr, initial body weight 1.5 g were fed one of 18 feeds for 56 d. In a sea water study, Atlantic salmon post-smolts, initial body weight 1,276 g were fed one of nine feeds for 112 feeding d. In these studies growth, feed efficiency and intestinal inflammation was monitored. The potential of whole faba beans and BSC was assessed as an adjunct using serial combinations with malted barley in ale brewing trials at laboratory and pilot-brewery scale.

Results and Discussion

In field data: %Ndfa values were higher under the sustainable management regime (no fertiliser/compost only), with cultivar (n=5) averages for %Ndfa, and %Ndfa increase above that for beans grown conventionally were: 2011, 87%, +11%; 2012, 91%, +8%; 2013, 87%, +6%). BNF was also higher under sustainable treatment with an average of 25 kg ha⁻¹ more N remaining in the soil in response to sustainable practice. BNF ranged from 150–300 kg N ha⁻¹ with 70 - 90% of the fixed N removed in grain and 25 – 80 kg ha⁻¹ remaining in-field. Eighteen distinct molecular *Rlv* types were discerned and functional characterisation is on-going. **Salmon feeding:** both salmon studies show that growth is faster or feed conversion more efficient when compared to feeds without any BPC. Intestinal health of fish was not compromised at levels below 30% inclusion of BPC. Hence BPC made from faba beans is a good ingredient in salmon feeds. **Pigs and poultry trials:** SID of BSC's essential AA averaged 84.8±1.6 and 83.3±2.0 % in pigs and poultry, respectively. Provided its relatively low methionine content is corrected through additional supply from other feed ingredients, BSC may be an attractive alternative protein source to reduce reliance on soya bean meal for pigs and poultry. **Brewing trials:** different fermentation methods and enzymatic combinations have been tested that culminated in a novel zymology based method to produce an ale of 5.0% ABV with good sensory characteristics using 25% [w/w] BSC. The approach has been developed further for use in distillation and neutral spirit production.

Conclusions

Scottish grown faba beans show high levels of BNF and these are greatest under low input, non-inversion tillage systems where compost if incorporated as part of a sustainable management regime. BPC can enable fish feed companies to reduce the inclusion of soy and fishmeal products without any impact on fish growth, feed efficiency or health. While BPC has good potential as a pig and poultry feed, the price of BSC must increase to justify the increased demand by fish feed companies. Towards that end, BSC can also support the production of high value products targeted to the human food chain from the brewing and distilling industries whose byproducts could also be recycled into aquaculture (e.g. <http://horizonproteins.com/>).

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