Research article

Received: 12 November 2018 Accepted: 4 March 2019 Published online in Wiley Online Library

(wileyonlinelibrary.com) DOI 10.1002/jib.568

Faba bean as a novel brewing adjunct: Consumer evaluation

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The starch in the grains of legumes, such as faba bean (*Vicia faba* L.), offers an environmentally sustainable raw material for the brewing industry as their entire nitrogen fertiliser requirement can be provided by the natural process of biological nitrogen fixation. Faba bean is, therefore, distinguished from species such as spring barley (*Hordeum vulgare* L.), which require large amounts of synthetic nitrogen fertiliser. Consumer analysis of beer produced with faba bean as an adjunct compared with barley malt beers has not previously been assessed. This study evaluated the potential of beers brewed using 30% (w/w) dehulled bean (kernel) flour as an adjunct to malted barley, using a series of quantitative sensory tests. The first, a blind acceptance test with inferred preference, found no statistically significant difference in the taste score of the bean kernel flour adjunct beer when compared with conventional beer. In the second acceptance test, the knowledge that the beer was produced using beans did not affect the overall consumer impression of the beer, regardless of how this information was presented. These results suggest that the use of faba beans in brewing does not impact negatively on the taste or acceptability of the resultant beer. © 2019 The Institute of Brewing & Distilling

Keywords: legume; *Vicia faba*; brewing adjunct; sensory

Introduction

In 2017, of the 509 k ha of Scottish agricultural land used to grow crops, 57% (291 k ha) was sown with barley of which 84% was spring barley *(1)*, the main raw material utilised in the brewing and distilling industries. The Scottish spring barley crop destined for malting requires about 111 kg nitrogen (N) ha^{-1}, which is mostly supplied as inorganic fertiliser (2013–2017, 5 year mean) *(2)*. Seeds of legumes, such as faba bean (*Vicia faba* L.), are also rich in fermentable starch and, in contrast to barley, legumes do not require the application of inorganic fertiliser, instead satisfying their entire nitrogen requirement via biological nitrogen fixation, a natural process that converts atmospheric nitrogen gas into biologically available forms of nitrogen. This process is mediated by bacteria, collectively referred to as rhizobia, which reside within nodules on the root of the legume *(3)*. The biologically fixed nitrogen, and carbon from photosynthesis, is partitioned in the grains as protein and starch, which comprise about 25 and 60% (w/w) of the whole grain, respectively. Average yields of faba beans in the UK are around 4.5 t ha^{-1}. The nitrogen-rich stem and root residues that remain in the field after cultivation of legumes can offset the nitrogen requirements of non-legumes which follow them in the cropping sequence. Thus, legume-supported cropped systems offer a more sustainable cropping system, helping to minimise inorganic nitrogen inputs, lower carbon footprint, encourage natural chemical cycling and safeguard soil qualities *(4–7)*. Legumes may offer an environmentally friendly option to complement non-biological nitrogen-fixating species such as barley in the brewing industry. However, this opportunity will in part be determined by consumer perceptions of the novel legume-based beverage.

It is not uncommon in the brewing industry for malted barley to be partially replaced with alternative starch sources ('adjuncts'), which provide a low nitrogen starch source whilst adding flavour and benefits such as improved head retention. Adjuncts include cereals such as non-malted barley, wheat and oats but more commonly maize, rice and sugar syrups. Although historical records show legume use in beer production as far back as the seventeenth century, with Markham *(8)* in The *English Housewife* referring to a 'peck of pease' being required to brew the 'best March beer', in modern times their use is seen infrequently. Varying beer tax rates, dependent on the ratio of malt used, have driven brewers in Japan to look to alternative, more experimental, raw materials, producing 'third-category' alcoholic beverages, where no malt at all is used. Two of the largest brewers in Japan have produced products utilising soy and peas. Both, however, use the protein from the legumes rather than the starch, thus contributing to the mouthfeel and head retention of the beer versus the alcohol yield. The 2016 International Year of Pulses saw some limited releases using lentils *(9,10)* in Australia and Canada, but again these were used for flavour and head retention rather than alcohol yield from the starch present.

The sensory experience of drinking beer is a complex process which begins long before the first sip is taken. The initial

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appearance is assessed via colour, clarity, carbonation and head foam quality, followed by the aroma from the volatile compounds. On drinking, these aromas combine with the taste profile to produce a complex array of flavours, impacted by the ethanol content and bitterness. All are further affected by mouthfeel, the texture and body (or viscosity) of the liquid itself. All these factors influence a consumer's drinking experience, whether assessed by a professionally trained panel or, as in this instance, an average consumer. The palatability and acceptability of food and drink are, however, further determined by consumers' 'experience' and the 'information' available to them. These are commonly referred to as 'bottom-up' and 'top-down' determinants, respectively *(11)*. Allison and Uhl *(12)* demonstrated that removing the information that typically accompanies beer, primarily the labels, resulted in favourites being forgotten and new preferences being made. This switch was solely a consequence of the environment in which the beer was consumed. Wolfson and Oshinsky *(13)* found that a chocolate drink could be rated two points higher on a nine-point preference rating scale if labelled as 'space food' versus 'unknown'. In addition, Lee *et al*. *(14)* found that the timing of the provision of information could determine consumers' preferences. In this instance, information shared prior to consumption (the 'disclosure condition') influenced the experience itself, determining expectations, whether positive or negative. In contrast, sharing information after consumption had less of an impact on the pre-formed, experience driven rating. Thus, our reaction to food and drink is not simply down to palatability but is also influenced by many other factors *(15)*.

The impact upon consumers of including beans as an alternative starch source in beer production is unknown. Using a commercially available dehulled bean (kernel) flour, beer taste and acceptability were assessed via tests conducted on different consumer cohorts in 'blind' and 'disclosure' conditions. The disclosure condition consisted of a positively and negatively positioned offering. These tests were justified on the basis that knowledge of legumes as a 'sustainable option', may be counteracted by the more common association of bean consumption with flatulence *(16)*. The positively positioned product used language that aimed to raise curiosity whilst appearing sophisticated, offering an enticing and 'exotic' product implying high quality, sustainability and healthy ingredients. For the negatively positioned product we wished to capture the negative associations of beans. The association of beans with flatulence has been prevalent for millennia, as exemplified by ancient Greeks referring to beans as containing 'the breath of life' *(17)*.

Materials and methods

Two quantitative affective tests were performed:

- Test 1 was a blind acceptance test with inferred preference to assess the taste experience only. The test beer, 'Beer 1', was compared with an existing product, 'Beer 2', and a nine-point hedonic scale used to indicate the degrees of poor to good. No ingredient information was provided to the participant. This allowed the establishment of a baseline preference rating in comparison with a similar commercially available product.
- Test 2 was a marketing position acceptance test under three conditions – (1) with positive positioning, (2) without positioning and (3) with negative positioning. This test provided ingredient information prior to tasting and assessed the participants' overall impression of the beer and how this was impacted by the 'positioning' condition of the ingredient.

Participants

The experiments were conducted as part of two different events at the Edinburgh International Science Festival held in Edinburgh in April 2015. Because the experiment was conducted at public events, the participants did not sign a standard consent form. However, all were given an information sheet to read prior to taking part in the experiment explaining the purpose of the experiment and the procedure to be followed. Participation was voluntary.

One hundred and nineteen consumers (73 women, 44 men, two who failed to specify) aged between 19 and 64 years [17 failed to specify, mean (*M*) = 31.6, standard deviation (SD) = 9.0] took part in test 1. One hundred and twenty-six consumers (44 women, 79 men, three who failed to specify) aged between 20 and 77 years (17 failed to specify, *M* = 36.8, SD = 12.4) took part in test 2.

Beverage stimuli

Both beers utilised were produced by Barney's Beer, Edinburgh, Scotland, UK. At the time of the study 'Beer 2' was available commercially; 'Beer 1' was released following the completion of this study (Figure 1). Beer 1, '*Fe Fi Fo*', was a modified version of 'Beer

(a) (b)

Figure 1. Packaging of beers as available commercially: (a) Beer 1 – 'Fe Fi Fo', a modified version of Beer 2, where 30% by weight of the malted barley has been replaced by bean kernel flour; and (b) Beer 2 – 'Volcano', an India pale ale used as the control beer in the blind condition.

2′ where 30% by weight of the malted barley had been replaced by bean kernel flour (broad bean flour – obtained by milling of broad/faba bean) and the percentage of darker malts increased to compensate for any loss in colour owing to malt reduction. The bean kernel flour was precooked to achieve gelatinisation of the starch prior to following the standard brewery mashing regime. Beer 2, 'Volcano', an India pale ale was used as the control. Both beers were 5% alcohol by volume; however, they varied in other quality attributes (Table 1).

Beer 1 production

Bean kernel flour (40 kg, Gemef Industries, France) was mixed with water and α-amylase (HT Alpha Amylase – Grade P, SPL International, UK) and held at 80°C for 1 h. This slurry was then mixed, along with additional water (67°C), with malted barley (Pale, 60 kg 308 L^{o}kg; Munich, 20 kg 305 L^{o}kg; Crystal, 3.2 kg, 280 L^{o}kg; Caramalt, 1 kg 280 L^{o}kg – all supplied by Bairds Malt, UK) and held at 64°C for 75 min. After separation the wort was boiled for 60 min during which time hop (Charles Faram, UK) additions were made at 0 and 60 min. Following cooling and transfer to the fermenter, the wort (original gravity 1.0407) was pitched with yeast (Fermentis US05 strain) and fermentation in cylindrical tanks for ~6 days at 21°C until reaching a gravity of 1.010. Following cooling (11°C) and addition of processing aids (Brewers Clarity, Murphy & Sons, UK), the beer was shipped to a third-party bottle contractor for cooling and storage (0°C, 2 weeks) prior to sterile filtration and packaging (330 mL bottles, carbonated to 2.2 volumes).

Beer 2 production

Beer 2 was produced as for Beer 1 but without the precook or addition of bean kernel flour.

Analytical methods

All analyses were performed by Brewlab Ltd, Sunderland according to the Analytica EBC recommended methods *(18)*. The analyses were original and packaged gravity (EBC 9.4), alcohol by volume (EBC 9.2.1), pH (EBC 9.35), colour (EBC 9.6) and bitterness (EBC 9.8).

Beer quality attributes

Test 1 – a 50 mL sample of both 'Beer 1' and 'Beer 2' – was prepared in clear plastic cups for each participant. The order in which participants received the two beer samples was alternated throughout the experiment. Participants were given no information regarding what the two beer samples were.

Table 1. Standard quality attributes of Beer 1, faba beer, and Beer 2, 'Volcano', conventional beer

	'Beer 1' – Fe Fi Fo	'Beer 2' - Volcano
Original gravity	1.0406	1.0466
Packaged gravity	1.0045	1.0082
Alcohol by volume	4.68	4.98
pH	4.66	4.33
Colour (EBC)	22.2	11.5
Bitterness (EBU)	43.7	42.7

Test 2 – one 50 mL sample of 'Beer 1' – was prepared in a clear plastic cup for each participant.

Procedure

The participants were instructed to read an information sheet and complete the first section of a questionnaire to determine if there was any reason they could not take part in the study.

For test 1 (blind condition), each participant was instructed to taste each beer in turn and rate the taste on an anchored nine-point category scale *(19)* on a pencil and paper questionnaire. The rating scale included the following question/response scale for each beer: 'on a scale of 1 to 9, how would you rate the taste of the beer?', with nine response options where 1 = very poor, to 5 = average and 9 = very good. The tasting lasted <5 min.

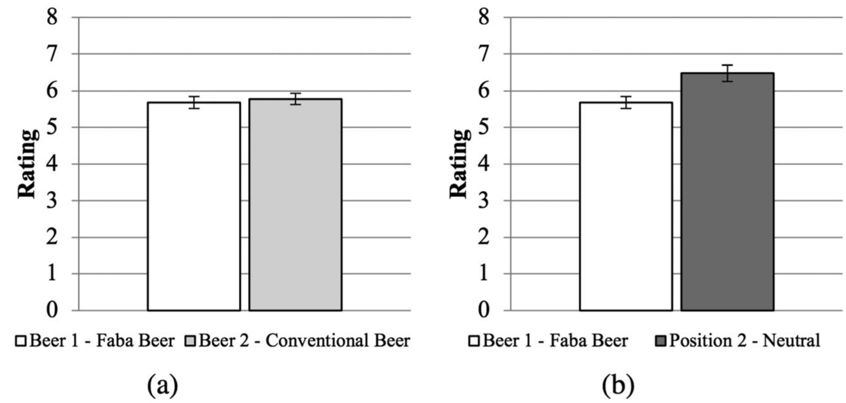
For test 2 (disclosure condition), each participant was presented with one of three positioning sheets (see Figure 2) and instructed to taste the beer and rate how much they liked the beer on an anchored nine-point category scale *(19)* on a pencil and paper questionnaire. The rating scale included the following request/response scale: 'taste the beer and tell us your overall impression'. The nine response options were 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely. The study lasted <5 min.

Position 1 Positive	**Fabale** *Earth Friendly Beer* Start drinking with the environment in mind. Recent raw material innovations have developed faba beans, a sustainable and environmentally friendly crop to grow, as an ingredient that can potentially challenged current brewing tradition, embracing pulses as a largely all-but-forgotten source of fermentable sugar. In the brewing of this ale 30% of the malted barley has been replaced with faba flour to yield an ale that is slightly darker and more rounded in body to compliment the naturally nutty flavour of the beans. Ingredients 30% farine de fève 70% malted barley

Position 2 Neutral	**Trial Beer** Ingredients 30% broad bean flour 70% malted barley

Position 3 Negative	**Has Bean** *Beans, beans, are good for your heart! The more you eat, the more you….* Start drinking like a 17th century Londoner! For this beer we have revisited brewing traditions of old and have thrown in some tic beans to the normal malted barley mix. Brewing records as far bask as 1615 show the use of peas and beans in brewing; we are not sure why their use died out but we think the taste is worth any potentially gaseous side effects! In the brewing of this ale 30% of the malted barley has been replaced with tic bean flour to yield an ale that is slightly darker and more rounded in body to compliment the naturally nutty flavour of the beans. Ingredients 30% tic bean flour 70% malted barley

Figure 2. Text for the three different positions presented in the marketing position acceptance test, of which only one was presented to each participant.



	Beer 1	Beer 2	Neutral
Mean	5.68	5.78	6.48
Standard Deviation	1.77	1.66	1.42
Standard error of the mean	0.16	0.15	0.22

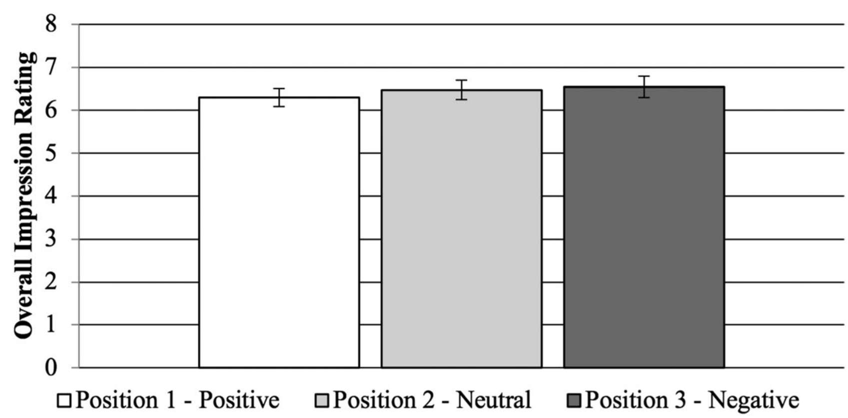
Figure 3. Participants' rating of the beer brewed using faba bean kernel flour: (a) blind vs. a conventional malted barley only beer; and (b) vs. itself when the ingredients are known. The scale was an anchored nine-point category scale in the blind condition assessing taste with 1 = very poor to 9 = very good. In the disclosure condition the scale assessed the overall impression of the beer with 1 = dislike extremely and 9 = like extremely. Data for Beer 1 and Beer 2 presented as means of 117 ratings and Position 2 as means of 41 ratings with whiskers indicating the standard error of the means.

Results and discussion

Two separate analyses were conducted. First, the participants' blind taste ratings of the beer made using bean kernel flour (Beer 1) versus the conventional beer (Beer 2) were compared (Figure 3-a). Also, the participants' ratings of the beer made using bean kernel flour in the blind condition versus the neutral disclosure condition were compared (Figure 3b). Secondly, the overall impression ratings of the beer under different disclosure conditions were compared (Figure 4).

Blind acceptance test

Taste assessment and inferred preference. The mean taste ratings of the blind preference test (Figure 3a) show both beers rating slightly above the midpoint (5 = average). A Wilcoxon signed rank test did not elicit a statistically significant change in the taste rating ($Z = -0.374$, $p = 0.728$) for beer made using bean kernel flour ($M = 5.68$, SD = 1.775), and the conventional beer ($M = 5.77$, SD = 1.665). Indeed, the median taste rating was 6.0 for both beers and no preference was inferred. A linear mixed model (for repeated measures) also demonstrated that there



	Positive	Neutral	Negative
Mean	6.30	6.48	6.55
Standard Deviation	1.32	1.42	1.59
Standard error of the mean	0.21	0.22	0.25

Figure 4. Marketing positioning acceptance test: participants' rating of the beer made using bean kernel flour under three disclosure conditions in the form of a positively, neutrally and a negatively positioned accompanying information sheet. The scale was an anchored nine-point category scale ranging from 1 = dislike extremely through to 9 = like extremely. Data are presented as means of 40, 41 and 44 ratings respectively with whiskers indicating the standard error of the means.

were no significant effects of beer type, age or gender on the acceptance score, nor were there any interactions. These results suggest that the inclusion of bean kernel flour to a level of 30% (w/w) with malted barley does not detrimentally affect the taste of beer.

Acceptance test – ingredient disclosure. This comparison aimed to determine whether awareness that beans were used as part of the raw materials impacted the acceptability of the beer. The mean taste ratings of the beer made using bean kernel flour in the blind condition and when the ingredients were presented in a neutral fashion can be seen in Figure 3b. A Mann–Whitney test was conducted which concluded that the rating of the beer in the disclosed condition was statistically significantly higher than that in the blind condition (U = 1773, p = 0.011). These results indicate that prior knowledge of bean kernel flour as an ingredient did not impact on the acceptability of the product and, in fact, had a positive impact possibly owing to the consumers believing that they were trying a novel drink.

Marketing position – acceptance test. The mean taste ratings of the positioning test are shown in Figure 4. A Kruskal–Wallis H test – a non-parametric alternative to the one-way ANOVA – showed that there was no statistically significant difference in the overall impression rating between the two beers, χ^2 (2) = 1.273, p = 0.529, with a mean rank score of 58.04 for the positive position, 64.07 for the neutral position and 66.51 for the negative position. A linear mixed model (for repeated measures) also demonstrated that there were no significant effects of age or gender on the acceptance score, nor were there any interactions. These results suggest that advertising the potentially positive and negative attributes of beans does not impact the acceptability of the bean kernel flour-based product.

The results of this study demonstrate that the replacement of part (30% w/w) of the malted barley with bean kernel flour in the grist does not detrimentally affect the flavour of the beer for the typical beer drinker. Nor does the knowledge that beans have been used negatively impact the drinkers' overall impression of the beer. Accordingly, the application in the brewing process of using a environmentally sustainable legume as an adjunct has been demonstrated.

Acknowledgements

This research is supported by: a joint PhD studentship between Abertay University and The James Hutton Institute; the Scottish Government, Rural and Environment Science and Analytical Services (RESAS), Strategic Research Programme; the InnovateUK-funded project beans4feeds, www.beans4feeds.net; the EU-FP7 project www.legumefutures.eu; and the European Union Horizon-2020 project 'TRansition paths to sUstainable legume-based systems in Europe' (TRUE, www.true-proejct.eu), grant agreement 727973. Our thanks are also extended to Gemef Industries for providing the bean kernel flour, Barney's Beer for the use of their brewery, Professor Charles Spence (Department of Experimental Psychology, University of Oxford) for guidance on gathering sensory data, and the Edinburgh International Science Festival for hosting the data collection activities.

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