

## Development and sensory assessment of a new faba bean protein supplement

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### Abstract

Pulses have nutritional properties and are known as functional foods due to their content of bioactive compounds. In this study, a shake (SPF) was prepared from faba bean protein concentrate (*Vicia faba* L.), whose aminogram was evaluated by ion exchange chromatography, and its acceptability was evaluated through sensorial tests, using as controls a shake based on vegetable protein (SPV) and a whey protein (SWP). The SPF formulation is sufficient in seven of the 10 essential amino acids evaluated. The sensory tests showed that the SPF was better evaluated in terms of appearance, color, and aroma compared with the control samples. The SWP was better evaluated in terms of flavor and texture, which can be explained by the gritty texture and beany flavor characteristic of legumes; however, there was no significant difference in the preference ordering test, hedonic scale, and purchase intention.

**Keywords:** functional food; sensory analysis; plant-based; whey protein; *Vicia faba* L.; vegetable protein.

**Practical Application:** A shake prepared from faba bean protein concentrate is an alternative source of vegetable protein.

## 1 INTRODUCTION

According to the data from the United Nations (UN, 2015a), it is estimated that the world population will reach approximately 10 billion people in 2050, a scenario that suggests an increase in the global demand for food production to secure the demands of the production system and current consumption dynamics, considering the maintenance of the current food system (FAO, 2011). In this context, the UN (2015a) Sustainable Development Goals (SDGs) broadly address the need to ensure sustainable production and consumption patterns, highlighting the efficient use of natural resources, the reduction of food losses and waste along the production chain, together with the promotion of awareness among different populations about responsible consumption, as well as investment in scientific and technological strengthening (UN, 2015b).

Considering the above, to envisage a more sustainable future, contemplating social and economic development, a food transition should be considered, regarding protein intake, with a greater diversity of more sustainable protein sources (Pyett et al., 2019; Willett et al., 2019). In this regard, a gradual transition from an animal-based diet to a plant-based diet among consumers worldwide would contribute to a greater awareness of health issues, especially considering cardiovascular risks and other noncommunicable diseases, in addition to new sensorial experiences, which have been guiding innovation to command the portfolio of the food industry (Köllmann et al., 2023).

Thus, plant-based formulations represent a category that has been gaining more and more space in supermarkets because they are considered more natural and nutritious, in addition to offering functional benefits (Dhakal et al., 2023).

Legumes, due to their high nutritional value, low production cost, and higher shelf life, in addition to their consumption associated with numerous health benefits, dominate the plant-based market, especially soy-based products (*Glycine max* L.) and pea (*Pisum sativum* L.) (TechnavioPlus, 2017). However, as the demand for these products is growing, it becomes necessary to diversify and propose new sources, among which faba beans (*Vicia faba* L.) stand out. Nutritionally, faba beans are an excellent source of vegetable protein (20–41%) and provide good amounts of lysine, arginine, and leucine (Millar et al., 2019; Pulkkinen et al., 2019; Walter et al., 2022). Beyond aminoacidic composition, its bioactive compounds stand out, by their impact on nutrition and medicine in the prevention and treatment of chronic noncommunicable diseases (Ferreira et al., 2024; Abu-Reidah et al., 2017).

Faba beans can contribute to the human and animal food industry not only as a cheap source of nutrients but also by benefiting human health (Bashi et al., 2019). Therefore, in recent years, the food industry has been in search of the nutritional potential of these grains, which are becoming popular as a sustainable source of vegetable protein both in the development of products for nutritional enrichment, as well as formulations of products for easy and fast consumption on a day-to-day

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basis. Faba bean proteins have been used for the preparation of protein concentrates and isolates for food supplementation and in numerous applications as a partial or total protein substitute in the development of various food products, such as pasta, biscuits, mayonnaise, sausages, and similar products (Dangi et al., 2022; Vioque et al., 2012).

Moreover, it is known that these products are proposed to achieve a consumer profile that seeks healthiness combined with flavor, good sensory experience, practicality, and affordable costs (Hamed et al., 2023; Onwezen et al., 2021). In this way, an additional challenge is that legume proteins generally do not have a neutral taste, exhibiting a distinct flavor, characterized as a beany flavor, contrasting with the industry's desire for its products in sensory terms. Therefore, it is essential to focus on using strategies that can meet consumer taste expectations (Chandra-Hioe et al., 2016; Trindler et al., 2021), making the development of plant-based products complex, necessary, and convenient.

The aim of this research was to develop a *plant-based* protein food supplement, in powder form, for the preparation of shakes, which could be used as an alternative to traditional animal proteins, especially whey proteins, which is the leader in the food supplements market.

## 2 MATERIAL AND METHODS

### 2.1 Development of faba bean protein shake

The supplement was developed using commercial samples of faba bean protein concentrate (Vitaessence Pulse 3600 CT, clean taste version (Ingredion, 2023), which has a protein concentration of 60%, plus strawberry flavors and aromas, acidulant, antiwetting agent, natural strawberry dye, and sweeteners, to obtain a food supplement of plant origin for the preparation of a shake-type drink.

The final formulation of the faba bean protein shake (SPF) is composed of faba bean protein concentrate (75%), dried strawberry powder (15%), citric acid acidulant (2.5%), lactose (3.0%), strawberry flavor (2%), sucralose sweetener (0.2%), sweetener acesulfame potassium (0.3%), beet powder (1%), sodium chloride (0.5%), and silicon dioxide antiwetting agent (0.5%). The powder obtained was placed in the metal pouch, labeled with instructions for use and storage, and placed in a dry and airy environment until preparation for the study participants' tasting session.

### 2.2 SPF amino acid profile

The amino acid composition of faba bean protein shake was carried out using ion exchange chromatography Dionex DX 300 (Thermo Scientific, San Jose, CA, USA) coupled to a nanoelectrospray ions detector for peptides analysis, according to Spackman et al. (1958). The technique was based on protein hydrolysis (taking a sample containing the equivalent of 25 mg of protein) in an acid medium. The hydrolyzed amino acids were recovered in pH 2.2 citrate buffer (Pickering brand). A 25  $\mu$ L aliquot was injected in the ion exchange chromatography

and runs occurred at a flow rate of 0.3  $\mu$ L·min<sup>-1</sup> using a mixture of two solvents: (A) 2% (v/v) acetonitrile, 0.08% (v/v) formic acid, and 0.01% (v/v) trifluoroacetic acid (TFA) and (B) 95% (v/v) acetonitrile, 0.08% (v/v) formic acid, and 0.01% (v/v) TFA. The peptide concentration was determined using an amino acids standard curve of a standard mixture.

### 2.3 Sensory analysis

Acceptability of SPF was assessed by 52 untrained panelists recruited among UP staff from the Universidade Positivo, Curitiba, Brazil. The analysis was performed between 2 and 4 h after breakfast in a room at 24°C (+/- 3°C). For the tests, two commercial food supplements of good origin were used as standard samples, a vegetable protein shake (SPV) from the brand Eat Clean®, based on protein from rice (*Oryza sativa* L.) and pea (*Pisum sativum* L.), and a whey protein concentrate from the Performance® brand, called SPW (whey protein shake). All the products were dissolved in cold water (30 g/200 mL).

The samples were evaluated over a scale ranging from 0 to 10. For the parameters "color," "flavor," "appearance," "texture," and "aroma," a "5-point hedonic evaluation was requested: 0 meant "Not very nice" and 10 meant "Very nice." The purchase intention was performed using a form with a structured 5-point scale: 1 is "definitely would buy" to 5 is "definitely would not buy."

Participants were instructed to taste the samples from their left to their right and fill out the forms with the sample identification, double-blind, followed by the purchase intention. The time required to taste the samples and answer the questions was about 15 min.

The panelist signed a written consent form before participating in the analysis. The study was conducted in accordance with the Declaration of Helsinki, the norm 466/ 2012 (Brasil, 2012), and the protocol was approved by the Ethics Committee of Positivo University (reference number CAAE 52287221.5.0000.0093, 11/06/2021).

### 2.4 Statistical analyses

For sensory analysis processing, the Microsoft Excel® program was used. One-way analysis of variance (ANOVA) was applied to compare the different sensory parameters in all samples, followed by Tukey's test for multiple comparisons of means. In all cases, significance levels were established at  $p < 0.05$ .

Intended for the evaluation of the purchase intention, the Microsoft Excel® program was used. The Friedman test was used by the Newell and MacFarlane table to verify if there was a significant difference between samples ( $p \leq 0.05$ ).

## 3 RESULTS AND DISCUSSION

### 3.1 Development of faba bean protein shake

The SPF in 100 g contains: proteins (43.1 g), carbohydrates (24.5 g), fibers (11.0 g), sugars (1.0 g), lipids (3.0 g), and the energetic value (301.2 kcal), and as per the IN 28/2018 of ANVISA (Brasil, 2018), which establishes the minimum value of 8.4 g

of proteins/dose, the developed product can be classified as a “protein food supplement in a powder form.” Also, regarding composition and labeling requirements, SPF can be classified as low in lactose and “zero in sugars,” since the dose of the ready-to-eat product does not exceed 0.5 g of sugars (Brasil, 2018).

The commercial products used as controls in the sensory tests in this research had a higher amount of protein, providing 15.3 and 14.3 g of protein per 20 g of product powder shakes based on pea and rice and concentrated whey protein, respectively, both also categorized as “sugar-free.” For sensory analysis, the dose of protein was taken in count the dose of 30 g of the product, as the instructions of the producer indicated on the label of the commercial products.

Regarding the final composition of the SPF, it is important to mention that in the dose of 20 g, the product obtained has 0.522 and 0.207 mg of vicine and convicine, respectively, as per data from the Quality Methods and Analytical Science (QMAS) group of Ingredion® (Ingredion, 2023). Consequently, it is not indicated for those who have favism (Luzzatto & Arese, 2018).

### 3.2 SPF amino acid profile

In addition to the total amount of proteins, the importance of assessing the nutritional quality of the biological value is also highlighted; in this sense, the concentration of amino acids in the SPF was determined after the total hydrolysis of the sample to assess whether this vegetable protein is capable of meeting the recommended nutritional requirements regarding the presence of essential amino acids (FAO, 2002).

Faba beans are known to be a good source of quality protein and have a well-balanced overall amino acid profile similar to that of peas and soybeans (FAO, 2016; Jeganathan, 2022) containing a large amount of lysine, leucine, isoleucine, threonine, histidine, and aromatic amino acids. However, sulfur-containing amino acids (methionine and cysteine) and tryptophan are present in lower amounts (Millar et al., 2019), which is confirmed when comparing the SPF aminogram with the essential amino acid requirements recommended by FAO (2002), where SPF is shown to be sufficient in seven of the 10 essential amino acids evaluated, even with amounts well above the recommended minimum, but is limiting in methionine and cysteine (sulfur amino acids) and tryptophan (aromatic amino acid), similar to the composition of other legumes, which is explained by the low content of these three amino acids in globulins (Carbonaro et al., 2015).

However, as the amino acid profile of faba beans is complementary to cereals that are deficient in lysine but contain high levels of methionine and cysteine (Mattila et al., 2018), there is evidence of the growing interest of the industry in developing blends of faba beans with cereals in formulations of food products to optimize the composition of amino acids and obtain products of high biological value (Laleg et al., 2019). This is similar to what happens with industrialized products from other legumes, such as the SPV used in this study. In addition, considering that the purpose of this study is to offer a protein shake that is offered as part of a healthy diet, and not as an exclusive dietary source, which should include other animal

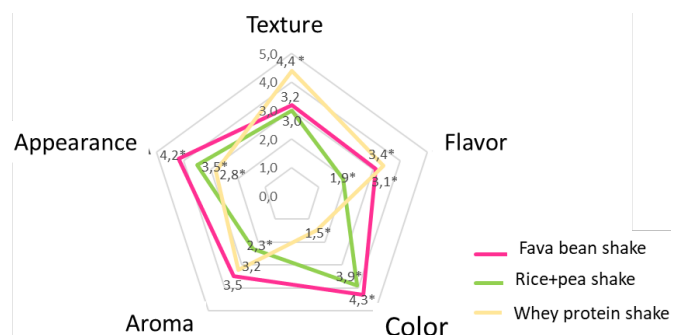
sources or even other vegetables, it is not considered a problem that this product exclusively not be classified as a protein of high biological value (HBV), since in the normal diet of an individual, several types of food are consumed simultaneously, and a complementary effect may occur in terms of essential amino acids, which, if in balanced proportions, can have nutritional value, from the protein point of view, equivalent to that presented by animal protein origin (Laleg et al., 2019). Also, the intention was to develop a product with low carbohydrate concentration and measure faba protein benefits, without the interference of other cereals, in human health.

### 3.3 Sensory analysis

Fifty-two untrained tasters over 18 years of age participated in the sensory evaluation, 57.6% female and 42.3% male, most of whom declared themselves as nonconsumers of protein shakes (34.6% consume eventually and 55.77% never tried it), which certainly interfered with the acceptability of the products offered.

The results of the ANOVA of the scores attributed by the tasters to the descriptors of the classification test: profile of characteristics are presented in Figure 1 as the means and standard deviation of each attribute evaluated in the samples.

The result obtained by the characteristics profile test indicates that the SPW obtained the highest averages in the flavor and texture attributes, and the worst grades in the color and appearance attributes, since it does not have a “pink” coloration, used as a characteristic descriptor of the strawberry flavor, which must have reflected negatively in the evaluation of these two attributes. SPF, on the other hand, in addition to being evaluated as having the best appearance among all, stands out as the favorite also in the aroma attribute, although without significantly differing from SPW. The vegetable samples were the worst evaluated in the texture attribute, without differing significantly from each other, since the whey-based product was more homogeneous and less “gritty,” in addition to the fact that the vegetable shakes, after some time, presented separation between the aqueous and lipid phases, making the product less attractive to the consumer (Dhakal et al., 2023).



\*Significant difference ( $p < 0.05$ ) by the Tukey test between groups.

**Figure 1.** Characteristics profile (texture, flavor, color, aroma, and appearance) for the samples of rice+pea shake (SPV), faba bean shake (SPF), and whey protein shake (SPW), strawberry flavor.

Although the taste of SPF and SPV was less accepted than SPW, there is a significant difference at the 5% level in acceptance between the two plant products, where SPF is better evaluated in this attribute than SPV. In this sense, it is believed that the use of the clean taste version of faba bean protein concentrate, which is the basis of the SPF formulation, has favored its acceptance, as it has a less residual flavor and “beany” flavor characteristic of legumes, normally pointed out as a depreciation factor sensory.

The profile of each of these samples is shown graphically in Figure 1, where the mean value attributed by the tasters to each descriptor is marked on the corresponding axis. The center of the figure represents the zero point of the scale used in the evaluation, whereas the intensity of the attribute increases from the center to the periphery. Thus, the sensory profile is revealed when connecting the dots.

Although the SPF has a better overall performance, the flavor attribute is usually a determining factor when choosing products, and how the products are based on whey protein are already well known by consumers and widely used, the familiarity with the flavor can justify the better performance of SPW in this attribute.

Through the effective test of the Hedonic Scale, it was concluded that the rice+pea shake (SPV) differed significantly at a 5% level from the faba bean shakes (SPF) and whey protein shakes (SPW), which did not differ from each other. The rice+pea shake obtained the worst grades, that is, it was the product least accepted by the evaluators with hedonic frequency at level 1 (40.4%), corresponding to “I hated it.” On the other hand, whey and faba bean shakes were more frequent at level 4 (46.1 and 36.5%, respectively), corresponding to “I liked it,” without differing significantly from each other.

According to the results of the preference ordering test, the SPW ranked first the most times; however, without significantly differing from the SPF, the SPV was the least accepted, as it was the lowest number of times in first place, and most times in third place.

Regarding the purchase intention, considering that the research was carried out with a population that mostly does not consume this type of product, the answer “definitely I would not buy it” was the most frequent for the SPV (53.8% of the tasters), who had the worst performance in sensory tests and differed significantly from the other two samples. SPW, on the other hand, had most of the responses as “maybe yes/maybe I would not buy” (34.6% of the fitting rooms) and for the SPF the highest rate of responses was for the option “probably would buy” also for 34.6% of the fitting rooms, which reinforces the

greater global acceptance of whey protein among the three offered. However, there was no significant difference at the 5% level in purchase intent between SPF and SPW.

Also, when the purchase intention test was described, there was the observation that the analysis should take into account the offer at competitive prices, since the market costs of plant-based products are higher compared to dairy products, thus providing the creation of a barrier in the purchasing power of these products to the detriment of dairy products (Millar et al., 2019). Even so, with the population's increasing demand for a more beneficial and healthier lifestyle, there is often a preference for purchasing products of plant origin (Pyett et al., 2019; Švarc et al., 2022). The good sensory acceptance of the SPF may indicate its potential in future commercialization feasibility studies.

Such results are in line with the results of the affective tests described below, where the SPV sample was the worst evaluated among the panelists, and the SPF and SPW samples were the preferred ones in the affective and preference tests (Table 1).

## 4 CONCLUSION

The results demonstrated that, compared with the commercial vegetable shake (SPV) sample used for comparison in the sensory analysis, the SPF showed superior sensory acceptability, without significantly differing from the SPW in the preference ordering test, Hedonic Scale, and purchase intention, which can be considered quite optimistic. However, adjustments in the formulation can be made to improve the texture and flavor attributes, thus improving its sensory acceptability and evaluating strategies regarding its commercialization.

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**Table 1.** Means and standard deviation of the values attributed by the tasters in the Hedonic Scale and Ordering Tests, of the rice+pea shake (SPV), faba bean shake (SPF), and whey protein (SPW) samples.

Samples	Hedonic Scale*(mean ± SD)	Sorting Tests** (mean ± SD)
SPF	3.33a ± 1.08	1.62a ± 0.63
SPV	1.87b ± 0.86	2.75b ± 0.52
SPW	3.31b ± 1.09	1.63b ± 0.71

\*Results are expressed as mean ± SD. Different lowercase letters express the significant difference ( $p < 0.05$ ) by Tukey\* and Friedman\*\* test between groups.

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