From Bitterness To Finesse

Enhancing the Flavor of Protein and Starch Concentrates from Legumes

A topic with great future potential is the deodorization and flavor debittering of legumes. Robert H. Spiegel, a freelance product and process developer from Germany, is researching relevant concepts. This article presents some of his latest findings.

With the growing awareness of sustainable and environmentally friendly nutrition, interest in plant-based products is increasing, but these must also deliver on taste to achieve long-term success. A key challenge is that legumes, a fundamental ingredient in many plant-based products, often have undesirable flavors and aromas that consumers find unappealing. These include an unpleasant bitterness for most consumers and a characteristic earthy-pea-like aroma. Additionally, anti-nutritional compounds such as saponins can limit market success. Here, thermal treatment of legumes offers an effective solution to significantly enhance consumer acceptance of these products.

Legumes should not be consumed raw by humans. Through thermal treatment, anti-nutritional proteins such as lectins and protease inhibitors can be inactivated, and the content of secondary plant compounds reduced. This method not only improves digestibility and mouthfeel but can also significantly reduce bitterness and undesirable aroma notes. Until now, legumes used for concentrate production have primarily been milled and then classified, often using dynamic air classification. This process yields two main fractions: a starch concentrate and a protein concentrate. While starch was traditionally used mainly for baked goods, the protein fraction is now gaining more attention.

The focus is particularly on applications in the area of meat substitute products. Since the late 1990s, pea protein concentrates have increasingly been used as a replacement for fish meal in salmon feed production. This shift was driven by several factors, including rising costs and limited availability of fish meal. Pea protein has proven to be a suitable alternative, providing the necessary nutrients for the growth and health of salmon while meeting the requirements of the food industry.

Challenge: Solubility The availability of concentrates that have undergone various thermal treatments broadens the range of technological applications. However, the protein solubility of debittered proteins is lower, which is a common issue with plant-based proteins. This reduced solubility presents a challenge, particularly in powders for sports nutrition and drinks, compared to whey-based raw materials. One possible way to improve solubility would be through hydrolysis.

Through thermal treatment, protein concentrates from legumes can be significantly improved in terms of sensory properties. Right: Vegan milk substitute products benefit from the debittered and deodorized raw materials

Sensory evaluation of thermally treated chickpea protein concentrate, where the differences were most pronounced.

Thermal Treatment (max. 140 °C)	yes	yes	no	no
Characteristics	Flavour bitter	Aroma earthy-pea-like	Flavour bitter	Aroma earhty pea-like
Tester	Intensity			
A	1	1	4	4
B	2	2	4	3
C	0	1	4	4
D	1	2	3	3
E	1	1	4	4
F	1	1	4	4
G	0	2	4	4
H	1	1	4	4

(Intensity scale: 0 not detectable, 1 very weak, 2 weak, 3 clearly detectable, 4 strongly detectable)

Bitterness: Before thermal treatment, the average score was 3.875, and afterward, it was 0.875. This represents a reduction in bitterness by 77.42 percent.

Earthy-pea aroma: Before thermal treatment, the average score was 3.75, and afterward, it was 1.375. This represents a reduction in the earthy-pea impression by 63.33 percent.

Dynamic air classification, also known as protein shifting, is gaining global importance in the production of protein and starch powders, primarily due to its lower technical complexity and reduced energy and water consumption compared to multi-stage wet chemical processes. The wet chemical method for protein extraction, which initially focused on starch, has become the dominant process for obtaining protein and starch fractions. Traditionally, proteins are extracted through chemical precipitation. However, this method is increasingly being replaced by protein shifting through dynamic air classification. Currently, approximately 150 projects for building classification facilities are in planning worldwide.

One advantage of the wet chemical process is the 'isolation' of proteins and starches with higher protein concentrations (usually over 80 percent), as well as the extraction of by-products such as fibers from within the seeds, which are highly suitable for use in the production of meat substitutes. However, the construction and opera-ting costs (energy, water) of such facilities are significantly higher than those of dynamic air classification. Dynamic air classification, however, has the drawback of not being able to alter the natural aroma and bitter taste of the native semi-finished products.

While wheat and soy proteins continue to dominate the plant-based market due to their technological advantages and price dominates the market of plant proteins they face increasing criticism, particularly due to imported soy and allergen labeling requirements. These challenges open up opportunities for alternative plant-based protein sources, such as domestic legumes. With targeted thermal treatments, legumes not only reduce bitterness and earthy aromas but also show promising technological properties for further processing into meat substitutes like textured vegetable protein (TVP) or high-moisture meat analogues (HMMA) via extrusion processes.

Reduction of Bitterness

Heating reduces the bitter taste and characteristic pea-like aroma of legumes. Frequently, any remaining undesirable flavors and aromas are further masked by the addition of flavorings and spices. Baking and cooking also contribute to reducing these negative factors. However, in many applications, such as milk substitute products, native protein and starch concentrates undergo little or only brief heating. Thermal treatment of legumes allows for effective elimination of microbial contaminants, thereby enhancing food safety. The processes can be adjusted to maintain the sensory properties of the product, achieving an optimal balance between safety and quality.

The advantage of debittering and deodorization was determined in a sensory testing procedure with trained individuals (see adjacent table). The debittered, deodorized protein and starch concentrates are primarily used in:

- vegan milk substitutes (similar to yogurt or milk drinks),
- baked goods,
- vegan products (similar to sausages),
- powders for sports or diet drinks,
- protein bars,
- vegan egg substitutes (liquid and dry),
- vegan spreads,
- protein-rich noodles,
- pet food.

The use of thermally treated protein or starch concentrates appears particularly beneficial, especially when the product will not be reheated in further processing. Even in textured vegetable proteins (TVPs), adding 30 percent of the debittered semi-finished products can be advantageous, helping to create a milder taste, as the heating process is shorter compared to high-moisture meat analogues (HMMA).

The development of flavor-neutral preparations from plant-based proteins is being pursued intensively. There are already some promising production-scale processes. Enhancing the much larger sidestream—actually the main stream in dynamic air classification, namely the starch concentrate—is also of great importance.

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Product and process developer Robert H. Spiegel is deeply engaged in creating flavor-neutral preparations from plant-based proteins. He sees a wide range of advantageous applications for these products in the food industry.