Formulating with Protein Factsheet

This factsheet is intended to give SMEs an introductory overview of the various considerations when formulating products that have protein claims on them.

High protein foods are more popular than ever which is reflected by sales across protein drink, bars, and yogurts[1]. For a product to carry a source of protein or a high protein claim, 12% or 20% respectively of the energy value of the product must come from the protein[2]. As a small business, formulating for high-protein claims goes beyond just adding in one or more protein-rich ingredients. There are important factors to consider which are outlined below.

This overview covers how to decide which protein you could consider in your formulation depending on functionality, nutritional profile (quantity and quality of protein), bioavailability, cost, and nutritional implications.

A good introduction to proteins can also be found on the IFST website.

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The impact of processing on protein quantity

How much protein is present in 100g of the product?

The quantity of protein in an ingredient varies depending on how it has been processed. Flours generally refer to milled grains or legumes. Flours can also be further processed through heat treatment (dry heat, steam, extrusion); dry fractionation or air classification to yield starch-rich, protein-rich, and fibre-rich fractions or wet extraction to yield isolates and concentrates[3]. The same ingredient whose structure has changed on account of processing, even if just by physical means (e.g. milling) can have an increased/decreased protein content (Table 1). With each level of processing, there is an added cost, so while isolates and concentrates have a far higher protein content, they are also more expensive. Protein quantity is sometimes expressed as a % dry weight. This is useful when dealing with dehydrated proteins, uncooked beans, or for some flours where 12-14% moisture will change the protein content when it is used.

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Table 1: Protein content and relative price of the same raw material processed in different ways

	Protein (g/100g) on a dry weight basis unless indicated otherwise	Source	Relative Price Indication
Fava bean, whole, raw	26.1	McCance & Widdowson	£
Fava bean, whole, raw, split	28.9	Holland & Barrett back of pack labelling (Feb 2025)	£
Fava bean, whole, boiled	9 (wet weight basis so protein content is lower)	McCance & Widdowson	££
Fava bean, milled into flour	30	Ingredion technical data sheet	££
Fava bean, concentrate	61.3	Ingredion technical data sheet	££££
Fava bean, isolate	88	Pulsin, back of pack labelling (Feb 2025)	£££££
Chickpea flour, native	19.3	Bakerite technical data sheet	££
Chickpea flour, steam treated	21	Bakerite technical data sheet	£££

Understanding protein functionality in formulations

For further reading, read our case study.

Proteins serve many functional purposes such as gelling, stabilizing, emulsifying, foaming, and are also involved in Maillard browning reactions that enhance the flavour and visual appeal of roasted and baked meats and bread[4]. Protein functionality is dependent on its structure. Proteins consist of building blocks called amino acids, which link up in a particular sequence. This sequence is generally referred to as the proteins primary structure.

A protein sequence rarely exists as a straight chain and will usually fold up on itself to form helices or sheets. These are referred to as its “secondary structure” which is stabilized by hydrogen bonds or other molecular forces. These amino acid sections of alpha helices or beta sheets sometimes have side chains. Each amino acid and side chain carries a positive or negative charge and depending on this charge, they may interact, giving rise to the tertiary structure of the protein. The final protein shape may be globular (as is the case for most proteins we use in food) or fibrous (e.g. gelatine to form a gel that can be reversed on heating).

The overall protein itself also carries an electrical charge and this charge affects its functional properties like solubility, emulsion stability, and water holding capacity. This charge, and consequently, the protein’s stability, is affected by acidity (pH) of the surrounding environment. The curdling of milk is one such example. The caseins in milk coagulate and precipitate out of solution when conditions turn acidic. This is because at a particular pH (known as the isoelectric point), the net charge on the protein molecule is neutral causing it to drop out of solution. In cheesemaking, this is desirable but when developing milkshakes, it is not![4]

Controlling these conditions allows us to successfully use proteins in emulsions, beverages, and food products. These charges also mean that protein binds with water. A good example is gluten formation in bread where the proteins glutenin and gliadin from gluten in the presence of moisture when kneaded. These water-binding properties have other effects too. As an example, when troubleshooting moisture migration and short shelf-life in a high-protein cookie format, in addition to the packaging, the sugar and type and quantity of protein are important factors to account for, as the protein and starch fractions in the formulation will both fight for the water and it might require adding in more moisture to balance it out.

Considerations for optimising protein bioavailability

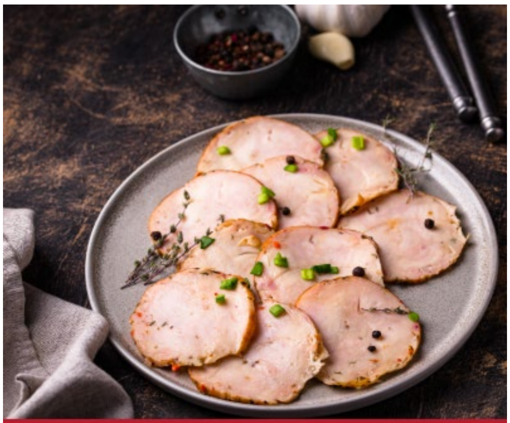
There is yet another factor to consider that is often overlooked which is that of digestibility and bioavailability. A lot of this is to do with the food's structure and how the raw materials and the final product have been processed. The choice of raw material depends on the final objective. For example, when considering whether to use native or heat-treated flour, it is necessary to understand the implication of the applied heat treatment.

Heat treatment of flours induces some gelatinization in the starches, as well as some denaturation in the native protein structures. While this can be useful for some applications, denaturation of the protein also means some of its functionality (its behaviour on account of its structure) might be lost.[5,6,7] At the same time because this structure opens up, as heat has been applied to break the bonds holding the chains down, it is more accessible to our bodies for digestion (bioaccessible) and this in turn might mean that our digestive enzymes are able to break these apart more easily making them more available to us (bioavailable). Consequently, we end up absorbing more of these amino acids from the food we eat (digestible). However, heat treatment alone does not guarantee an improvement in bioavailability. In one study, there was no difference in protein digestibility in cooked, baked or extruded chickpea[8]. There are interactions with other ingredients in a formulation or the presence of compounds within the ingredient themselves that may improve or impair this bioavailability ("matrix effect"). For example, the presence of phytates, tannins, and fibre in plant-based sources of protein can reduce protein digestibility, but this can be overcome through appropriate processing techniques that reduce the presence of these inhibitory factors (called anti-nutritional factors). Examples of such techniques are extrusion, compression popping, fermentation, or through using ingredients with lower fibre for example (a concentrate instead of a whole flour)[9,10].

Thus, it is not just the amount of protein going into a product, but the profile of that protein and its availability for our bodies to use.

These distinctions are most useful when deciding whether to use animal sourced proteins or vegan proteins or when formulating foods for specific uses such as muscle gain. Some vegan proteins contain all the essential amino acids we need (soy, pea, algal proteins) but in lower amounts than would be present in something like beef or milk (compared in mg per g of protein). The amino acid present in the lowest quantity is referred to as the 'limiting amino acid'. In such cases, using complimentary sources of amino acids is a useful strategy to improve the amino acid profile of the resulting mix. Many cultures around the world follow this approach. E.g. beans and toast, beans and rice.

A commonly used methodology to assess the adequacy of a protein source is a Protein Digestible Corrected Amino Acid Score (PDCAAS) where the individual amino acid contents are compared to a standard reference protein and adjusted by the protein's true faecal digestibility factor.[11] A more robust and newer approach is to use the Digestible Indispensable Amino Acid Score (DIAAS) utilises ileal digestibility of each individual essential amino acid and thus gives a better and more accurate representation of protein digestibility in humans. UoN's Nutritional Composition and Digestibility Lab (NCDL) use a validated in vitro protocol based on the INFOGEST digestion model to estimate protein quality of a diverse range of protein sources such as chicken and chicken analogues, as well as different maize varieties [12,13]. In addition, they are involved in the generation of tools and resources to enable formulation of high-quality protein products such as this database of the protein, amino acid composition, ileal digestibility, and DIAAS values of more than 100 world food products.



More on in-vitro digestion and protein quality.

Awareness of supply chains, source geography and the impact on carbon footprint

Plant sources of protein have lower carbon footprints than animal proteins and it is possible today to source proteins that have been produced or processed all over the world. There are many businesses in the UK that grow legumes locally and process them into value-added ingredients for the manufacturing supply chain. If sourcing is a key part of your business, look into the country of origin on your supplier's specification sheet. Sometimes, like with oats, crops are grown in the UK, but then processed elsewhere and re-imported so awareness of your supply chain is key to communicate your story to your end consumer.

Potential unintended implications of working with different protein sources

In the UK, there is a list of 14 allergens that need to be declared on food labels[14]. In most cases, since an allergy is an immune reaction, it is the proteins that usually trigger the response. While some legumes like pea, fava, and chickpea are not on this list, take care when sourcing as they may be produced in a factory that handles other allergens. Refer to your supplier's specification sheet and to any precautionary allergen labelling on pack if you are buying from a supermarket. Some legumes are also shown to exhibit cross-reactivity and trigger allergic responses[15]. Keep referring to updated guidance from the FSA.

More on iodine deficiency using shopping data.

If you are trying to substitute animal-based protein sources with their plant-based equivalent counterpart, (e.g. swapping out dairy milk for plant-based drinks) it is important to also be aware of nutritional drawbacks like the absence of certain bioaccessible minerals in these products. An example is iodine, the impact of which the UoN has explored in multiple papers and a recently published position addressing the implications that such substitutions could have on food policy .[16, 17, 18] Another example is that of calcium, which although added to most plant-based beverages except organic versions, may not necessarily be bioavailable depending on the chemical form used and the plant matrix as demonstrated in a recent UoN study.[19] Awareness of these deficiencies can then be tackled using strategies to ensure that they are being supplemented through other means in the diet or in product development.

Summary

In summary, when formulating a product with protein consider the functionality, nutritional profile (quantity and quality of protein), bioavailability, environmental footprint, and cost.

For more information on our research and how we can help you develop products with protein claims and improved protein quality, reach out to the FIC on **foodinnovationcentre@nottingham.ac.uk.**

To understand the work done at the UoN Nutritional Composition and Digestibility Lab, visit their website **here.**

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