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OPPORTUNITIES FOR EMPLOYING FIELD BEAN PROTEIN ISOLATE IN FOODS

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Key words: field bean protein isolate, functional properties, gelation, emulsifying properties, meat substitution.

Review on possibilities for using field bean protein isolate as a functional component in foods (coffee whitener, fish sauce, meat emulsion, chopped meat products) — to save raw materials for whose rearing or production a high expenditure of energy is necessary (e.g. meat, fish, milk protein).

Field beans (*Vicia faba var. minor*) are predominantly cultivated in Asia and Africa (Table 1). While in these regions field beans principally serve human nourishment, in Europa they are an important source of protein for animal

Table 1. Field Beans Production and Yield 1983 [1]

Continent	Production kt	Yield dt/ha
World	4222	12
Asia	2390	12
Africa	1149	14
Europe	466	14
South America	123	5

fodder. The chief producers are China, Ethiopia and Italy (Table 2). The highest yields from field bean cultivation are attained in Europe. The Netherlands takes pride of place with 60 dt/ha (Table 3). Field bean flour contains an average of 28% protein, 43% starch, 1.8% lipids and 7% oligosaccharides (Table 4). Field beans are distinguished from soya beans most particularly by their essentially higher starch content and lower proportion of fat. These differences are also the reason

Table 2. Field Beans Production and Yield 1983 [1]

Countries	Production kt	Yield dt/ha
China	2300	12
Ethiopia	600	15
Egypt	295	23
Italy	175	12
France	150	30
FRG	17	29
GDR	14	23

Table 3. Field Beans (*Vicia faba*) Yield 1981 (2)

Region	Yield dt/ha
Germany (FRG)	32.7
France (North)	40.0
France (South)	30.0
Netherlands	60.0 (particularly to 80.0)

Table 4. Field Beans (*Vicia faba L. var. minor*) Composition

	Whole beans %	Bean flour %
Protein (N × 5,9)	23.8	28.0
Fat	1.5	1.8
Starch	36.6	43.0
Oligosaccharides	6.0	7.0
Ash	3.4	4.0
Crude fibre	1.5	1.8
Water	12.2	14.4

why, in contrast to soya beans, no field bean protein concentrate can be produced from field bean flour by aqueous extraction. Such concentrates are only obtained by dry fractionating the starch and protein constituents (by means of air classification).

In the following explanations Field Bean Protein Isolate (ABPI) is brought forward as new raw material for the manufacture of foodstuffs.

The isolation of protein proceeds from field bean flour dispersions at pH 7.5. After separating out starch, the precipitation of protein from this solution results from a lowering of the pH value to 4.2 (Chart 1) [8]. The precipitated and centrifuged protein is washed, neutralised and spray-dried. A field bean starch rich in amylose appears as a by-product of the isolation process [7]. ABPI obtained in this way is not optimal in its functional properties. To improve these

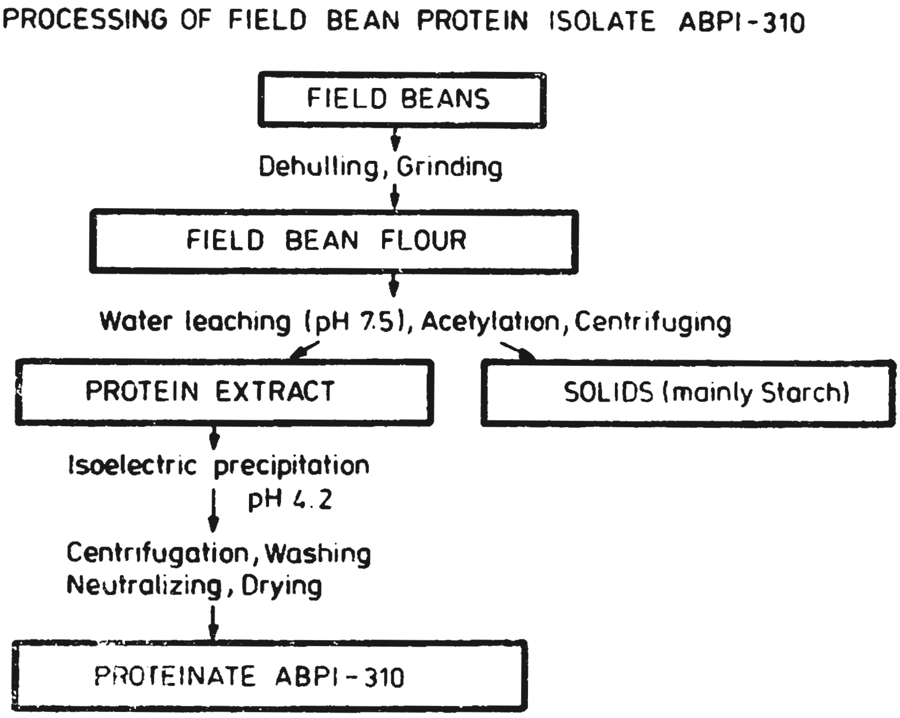

Chart 1. Processing of acetylated field bean protein isolate

acetic anhydride is injected into the flour dispersion, thus acetylating the protein. Acetylation causes unfolding of the protein molecule and leads through blocking the ε-amino groups of lysine to an increase in the net negative charge of the protein molecule. It also effects an increased viscosity of the protein dispersions (Fig. 1) [3]. With a rise in the acetylation degree the protein concentration

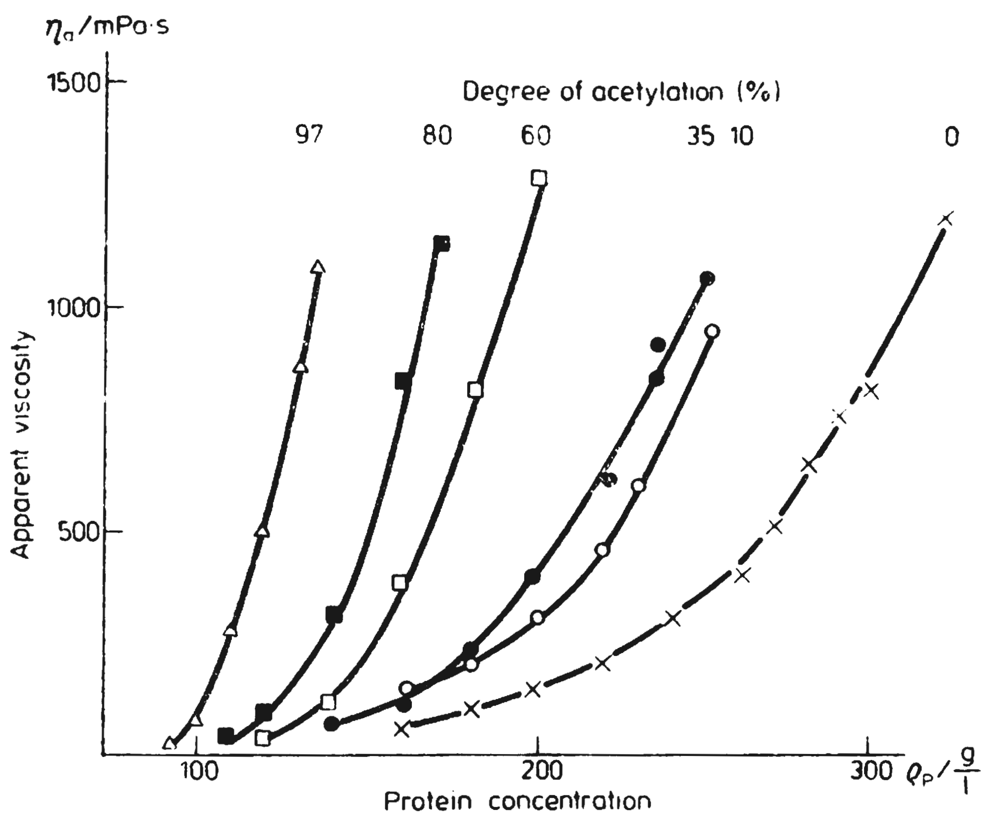

Fig. 1 Apparrent viscosity of different acetylated field bean protein isolates dependent on the protein concentration

necessary for achieving the same viscosity value can be substantially reduced. Acetylation also operates in a similar way on viscosity increase with heating protein dispersion (equal initial viscosity at 20°C) (Fig. 2) [3].

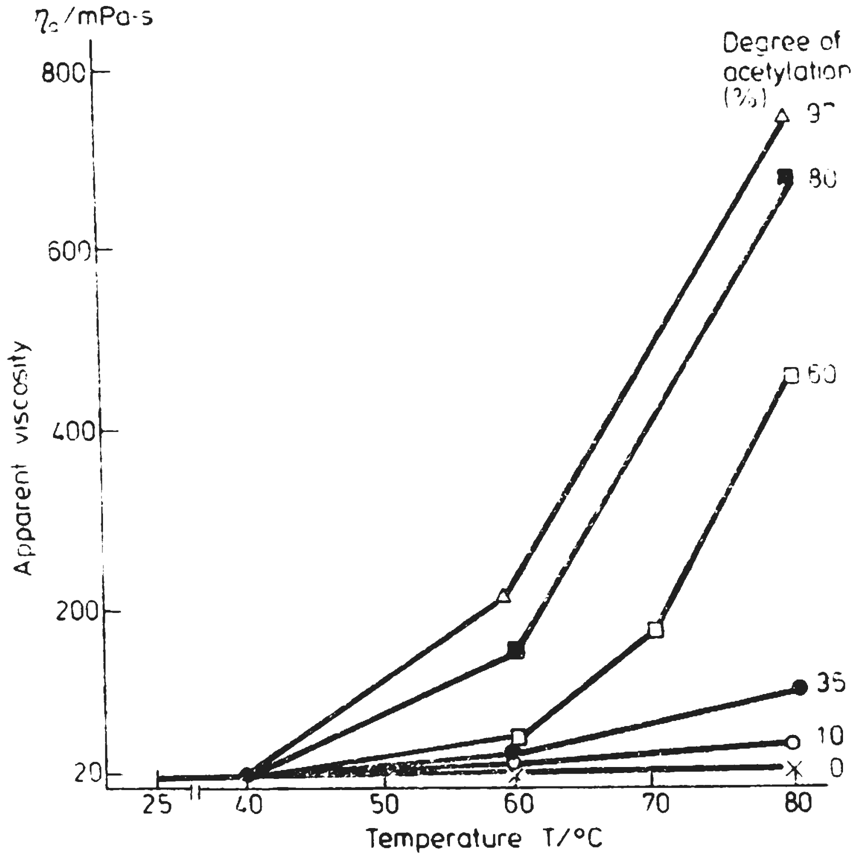

Fig. 2 Apparent viscosity of different acetylated field bean protein isolates dependent on the heating temperature

The acetylation of Field Bean Protein Isolate likewise promotes the formation of gels with the heating of protein solutions. In Table 5 the influence of protein modification on gel-formation from Field Bean Protein Isolate is set out. If 14% protein dispersions are heated at 95°C, unmodified field bean protein does not form a gel. For this at least 17% protein content in the dispersion is necessary.

Table 5. Gelation of Field Bean Protein Isolates

Isolate	Gel-Firmness**) kPa	Gel-Properties*)
ABPI-301 (from non-treated flour)	0.9	no gelation, mashy
ABPI-303 (from defatted flour)	1.7	low gelation, very soft
ABPI-302 (from steamed beans)	6.1	good gelation, softy
ABPI-310-80 (acetylation degree 80%)	21.3	good gelation, firm
ABPI-310-97 (acetylation degree 97%)	25.2	good gelation, firm

*) Protein dispersion (14% w/w) heated at 95°C, 45 min
**) circular-slot-method, slot breadth 0.5 mm

While an isolate from defatted flour remains a poor basis for gels, steaming the beans before producing the flour brings about an improvement in this property. Acetylation is an essential step in altering the gel-forming property. For manufacturing gels from acetylated protein isolate, the protein concentration needed for forming gels in the dispersion can be lowered compared to non-acetylated protein isolates.

Regarding the emulsifying property of the protein isolate, acetylation raises the oil-binding of aqueous protein dispersions, especially in the concentration range below 2% (Fig. 3) [4]. With over 1.5% protein in the aqueous phase, however, this difference is no longer so marked. If a comparison is made with whey protein, then a higher oil-binding is achieved using acetylated field bean protein in the range below 1% protein. In Fig. 3 the stated emulsifying functions for different proteins were established by means of conductivity measurement (determination of the breakdown of the emulsion).

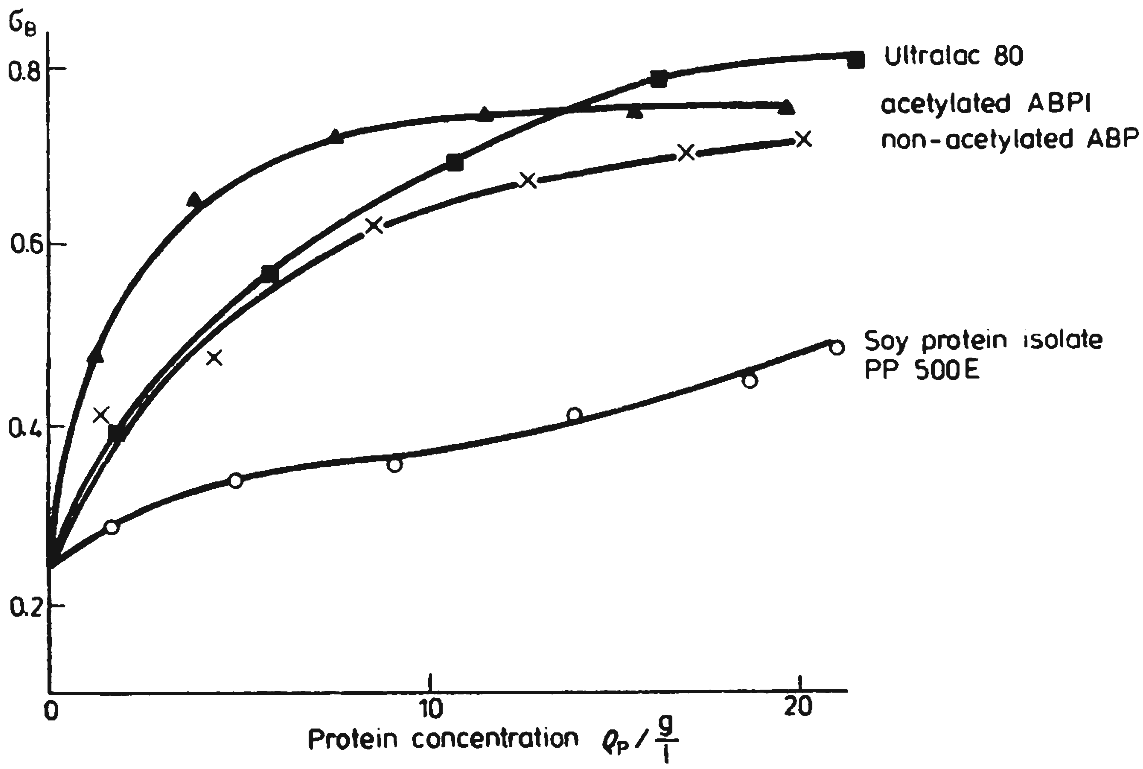

Fig. 3 Influence of acetylation of field bean protein isolate on emulsifying property as volume concentration σ_B of the emulsified oil as a function of protein concentration (■ whey protein, ▲ field bean protein isolate, acetylation degree 97%, x unmodified field bean protein isolate)

In determining emulsifying activity and emulsion stability (oil 50%) the influence of acetylation on these properties becomes perceptible only after heating the emulsion (emulsion stability) (Table 6). In doing so the stabilizing effect of the acetylated isolate is made clear as a result of viscosity increase under heating.

The following examples underline that ABPI is a good functional component in foods.

Table 7 gives the basic composition for a sauce (20% oil content) containing 1% to 4% ABPI (highly acetylated). To assist thickening it contains 1.5% wheat flour and 1.5% wheat starch [3].

Table 6. Emulsifying Properties of Field Bean Protein Isolates (2.5 g isolate, 50 ml aqua dest., 50 ml sunflower oil) at pH 6.0

Isolate	Emulsifying activity*) %	Emulsion stability**) %
ABPI-301 (from non-treated flour)	64	69
ABPI-310-26 (acetylation degree 26%)	61	73
ABPI-310-75 (acetylation degree 75%)	63	83
ABPI-310-97 (acetylation degree 97%)	74	91

*) Centrifugated at 1000 g, 10 min
**) Centrifugated after heating (80°C, 10 min)

Table 7. Ingredients of Sauce for Canned Fish

Constituents	% (by wt.)
Rapeseed oil	20.0
Field bean protein isolate 310-97	1.0 to 4.0
Sucrose	8.0
NaCl	2.0
Wheat starch	1.5
Wheat flour	1.5
Acetic acid	0.7
Water	completed to 100

The emulsion is manufactured with protein isolate dispersed in water and homogenised under addition of vegetable oil (Chart 2). Finally the other raw materials are stirred into the emulsion and acetic acid is added after another

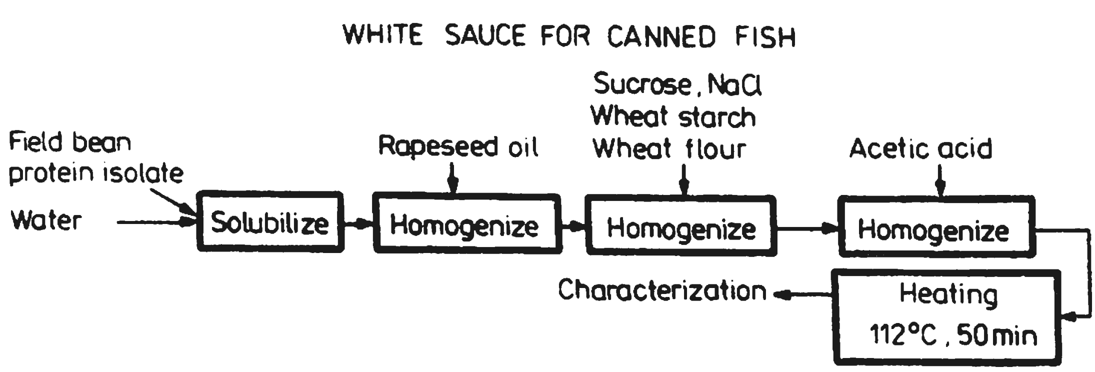

Chart 2. Processing of white sauce for canned fish

emulsification. After homogenisation the acidified emulsion is sterilised. The properties of fish sauce in dependence on the content of protein isolate are evident in Table 8. Together with the improvement of emulsion formation a protein content of 1-4% substantially influences emulsion stability, viscosity and

Table 8. Influence of Acetylated Field Bean Protein Isolate on the Properties of Sauce for Canned Fish

Protein isolate %	Emulsion stability (%)*)	Apparent viscosity (mPa·s)**)	Liquid state
1	50	75	thinly
2	70	110	thinly
3	90	191	thickly
4	100	325	creamy

*) at 1000 × g
**) Shear rate $\dot{\gamma}$ = 145.8 s⁻¹

appearence. Addition of protein reveals an emulsifiying and emulsion-stablilising effect at the same time.

As a further example, Table 9 gives the composition of a coffee whitener with 11% vegetable oil, containing 2-5% ABPI (highly acetylated).

Table 9. Ingredients of Coffee Whitener with Acetylated Field Bean Protein Isolate ABPI-310-97

Constituents	% (by wt.)
Sunflower oil	11.0
Field bean protein isolate	2.0 to 5.0
$Na_2HPO_4 \times 2H_2O$	0.3 to 0.5
Potato starch syrup	5.0
Sucrose	3.0
Water	completed to 100

pH value 6.5-7.0

For manufacturing the coffee whitener the protein isolate is dispersed in water under addition of sucrose and buffer salt, and emulsified under addition of vegetable oil (Chart 3). After the addition of potato starch syrup, calcium salt, and pre-heating, there is further homogenization [5].

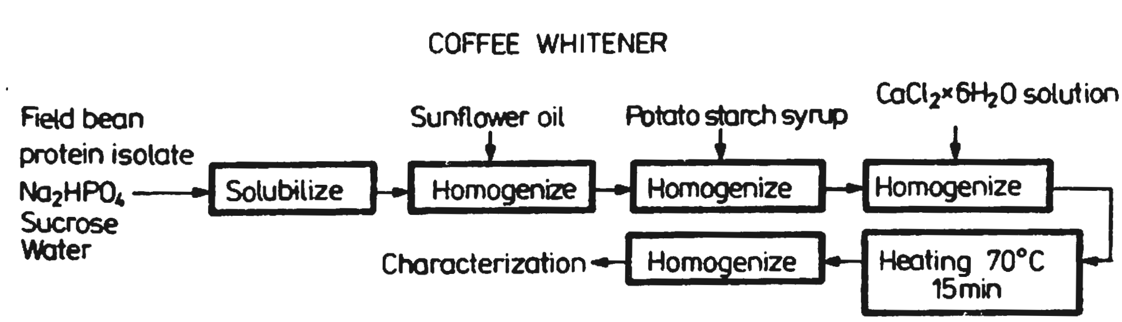

Chart 3. Processing of coffee whitener

It follows from Table 10 that the stability of the coffee whitener is positively influenced by raising the acetylated ABPI content [3]. Emulsion stability and

Table 10. Influence of heating and calcium ions on the emulsion stability and viscosity of coffee whitener with 5% acetylated field bean protein isolate ABPI-310-97

Ca^{++} (mg/g protein)	Heating[1]	Emulsion stability[3] %	Apparent viscosity mPa·s)[2]	Flow property (liquid state)
–	–	87	8	thinly
–	+	89	8	thinly
14	–	100	17	thickly
14	+	100	183	thickly, creamy

[1] 70°C, 15 min
[2] Shear rate $\dot{\gamma}$ = 145.8 s^{-1}
[3] Centrifugation at 1000 × g, 10 min

viscosity are likewise raised if the emulsion contains additional calcium salt. By adding the stated salt the coffee whitener becomes creamy [5]. As acetylated ABPI simultaneously promotes the formation of emulsions and gels, its influence on the properties of heated meat emulsions was also tested. In this 2% meat protein was substituted by 2% vegetable protein isolate (Table 11). Compared to the control sample, the addition of Field Bean Protein Isolate leads to a reduction of fat loss. With non-acetylated ABPI the firmness of the heated emulsion is less. If acetylated ABPI is used, the loss of firmness is not so striking. With increasing acetylation degree the amount of drained water is reduced.

Table 11. Influence of Field Bean Protein Isolates on Meat Emulsion

Isolate	Firmness[4] kPa	Meat emulsion cooking loss[3]	
		at %	water %
Control[1]	347	12.4	14.2
ABPI-301[2] (non-modified)	208	3.5	16.0
ABPI-310-80[2] (acetylation degree 80%)	312	3.4	13.7
ABPI-310-97[2] (acetylation degree 97%)	312	2.2	10.6

[1] 8.7% meat protein, 30% meat fat
[2] 6.7% meat protein, 29,5% meat fat, 2% protein isolate
[3] after heating (80°C, 15 min), centrifugated at 3200 g, 10 min
[4] after heating (80°C, 15 min), circular-slot-method, slot breadth 0.5 mm

As well as the direct use of various modifications of ABPI in food production it is also possible to apply them in an intermediate structuring process. Such structuring includes gel-formation, extrusion or spinning. Subsequently the production of extrudates as substitutes for minced meat and the structuring of fibres to give texture to minced fish flesh products will be more exactly described as examples. Field bean flour and ABPI are equally suitable for extrusion. In order to obtain extrudate with an optimal water absorption and pleasant consistency (rehydrated) for the replacement of meat in minced meat products, the regulation of a definite protein-carbohydrate ratio is necessary. This ratio was regulated by mixing field bean flour and ABPI (Chart 4). For producing minced

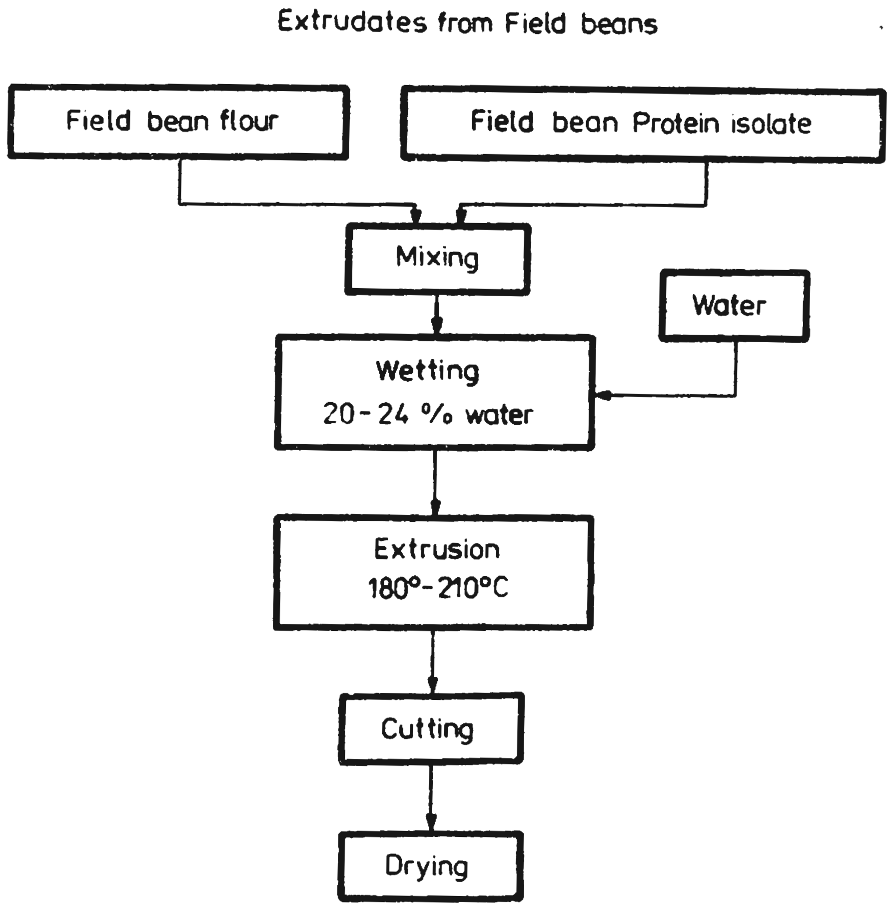

Chart 4. Processing of extrudates from field beans

meat the ratio 1:1 was found to be the optimal variant. The extender thus produced, at a substitution of 25% minced meat, brought about an improvement in consistency as well as a reduction of cooking loss (Table 12) [6].

Table 12. Influence of Extrudates on Frying Loss of 'Hamburger' (25% meat substituted by 8% extrudate and 17% water)

Extrudate	Extrudate water absorption %	Hamburger frying loss %
Field bean flour (ABM)	491	29.0
Field bean protein isolate (ABPI)	392	34.5
ABM-ABPI-Mixture (1:1)	387	23.3
Soybean concentrate (TVP-ACH-Mince 240; ADM)	210	25.5
Control	—	34.0

For producing fibrous extenders, protein dispersions from mixtures of field bean protein and casein were "spun out" in a hot calcium chloride bath (Chart 5)

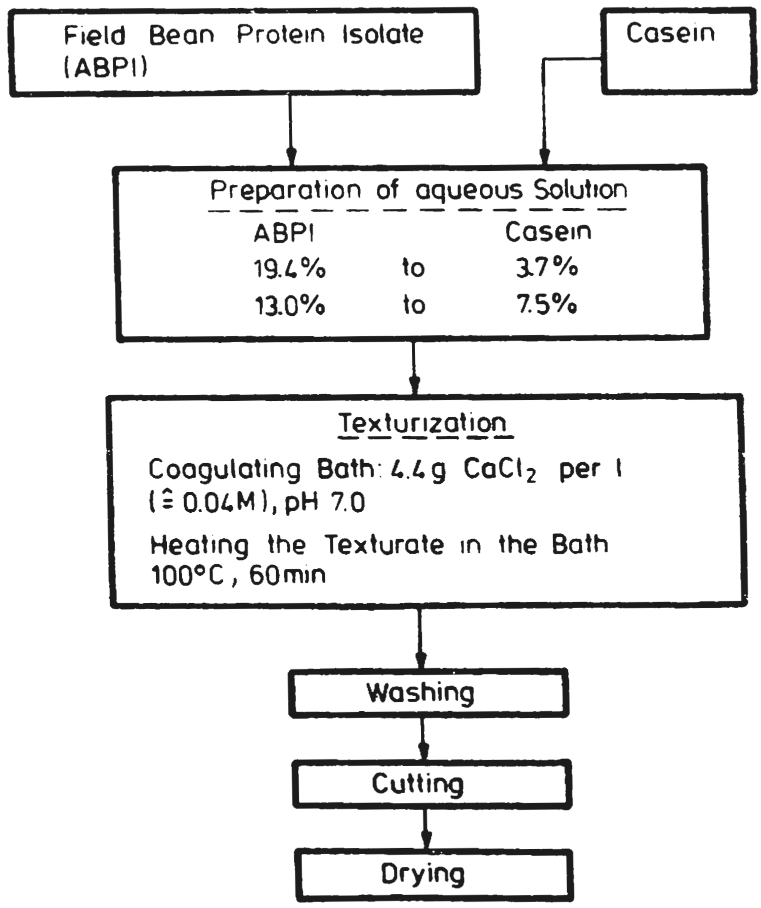

Chart 5. Processing of fibrous texturates

[9]. On the contrary to the classical spinning of protein solutions in acid baths, neutral structures were thus obtained.

When using these fibrous extenders in minced fish flesh products (Table 13) an improvement in water retention and texture was achieved alongside the substitution of 20% minced fish.

Table 13. Substitution of minced fish flesh by fibrous extenders[1] in fish fingers

Rehydrated texturate		Fish flesh %	Mass loss at heating[2] %	Texture	Taste	Acceptability
Texturate %	Water %					
Control		87	1.57	—	—	—
4.25	12.75	70	0.45	improved	same	improved

[1] Field bean protein isolate 84.0%, casein 16.0% in dry matter
[2] 90°C, 5 min, Air-O-Steam-Oven

Summarising, it can be stated that, like the soya been, the protein isolate of the field bean are capable of utilisation in a wide extent of foodstuffs and display a high functional efficiency.

Previous results in the application of field bean protein isolate make it clear that the isolate also leads to the saving of raw materials for whose rearing or production a high expenditure of energy is necessary.

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MOŻLIWOŚCI WYKORZYSTANIA IZOLATU BIAŁKOWEGO Z BOBIKU W TECHNOLOGII ŻYWNOŚCI

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S t r e s z c z e n i e

Bobik (*Vicia faba L. var. minor*) jest uprawiany w Europie głównie na cele paszowe. Jednakże jego główne składniki — skrobia i białko — są przedmiotem zainteresowania w technologii żywności.

Izolację białek z mąki bobiku prowadzi się po jej zdyspergowaniu przy pH 7,5. Po oddzieleniu skrobi precypitacja białka zachodzi w wyniku obniżenia pH do 4,2. W celu poprawy właściwości funkcjonalnych białka bobiku wprowadza się bezwodnik kwasu octowego do zdyspergowanej mąki podczas procesu ekstrakcji. Ze wzrostem stopnia acetylowania podwyższa się lepkość roztworu białka bobiku. Korzystnie zmienia się również zdolność tworzenia żelu i emulsji tłuszczu. Dzięki temu rysuje się możliwość wykorzystania izolatów białkowych bobiku w technologii i stabilizacji emulsji spożywczych. Podane są przykłady takich zastosowań (zabielacz do kawy, sos rybny).

Dodatek izolatu białek do emulsji kiełbasianej obniża spożycie mięsa. Izolat daje się łatwo ekstrudować w mieszaninie z mąką z bobiku. Zastąpienie 25% mięsa ekstrudatem tego rodzaju w produkcji wyrobów z mięsa mielonego pozwala na obniżenie strat w czasie obróbki termicznej i jednoczesną poprawę tekstury.

Włókniste ekstendery otrzymane z mieszaniny izolatu białka bobiku i kazeiny pozwalają na zastąpienie 20% mięsa w mielonych farszach rybnych stosowanych do wyrobu np. paluszków rybnych, polepszając także strukturę tych produktów. Zastosowanie izolatu białka bobiku prowadzi do oszczędności surowców, których produkcja wymaga dużych nakładów energetycznych.