FOOD TECHNOLOGY FOR THE VALORISATION OF GRAIN LEGUMES/PULSES

EMANUELE MARCONI
(UNIVERSITY OF MOLISE)
marconi@unimol.it

Società Italiana di Agronomia XLV Convegno Nazionale
La ricerca agronomica verso il 2030: gli obiettivi globali di sviluppo sostenibile
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Miglioramento genetico per la qualità del frumento tenero (*Triticum aestivum* L.) [1]

Mario Falcinelli, Fabio Veronesi, Giovanna Maria Briganti [2] e Emanuele Marconi [3]

Summary

BREEDING FOR QUALITY IN BREAD WHEAT (*TRITICUM AESTIVUM* L.)

With the aim of obtaining bread wheat lines characterized both by high level of quality for bread making properties as well as high productivity, a breeding program was carried out at Istituto di Miglioramento Genetico Vegetale, Università di Perugia (Italy).

Eight hexaploied breeder lines were obtained from crosses between the commercial varieties of bread wheat "Adria", "Orso" and "Marzotto", characterized by high yield, and the Sardinian landrace of durum wheat "Trigu Murru" and the breeder line of bread wheat "IGMV" , characterized by high flour quality. They were evaluated in 1983/84 both for yield and quality indexes.

Results of the research are summarized as follows:

— Zeleny index apapeared to be correlated with the G and W indexes of the Chopin Alveograph and the B, CD and E_{12} indexes of the Brabender Farinograph; the Zeleny test was confirmed as the most suitable method from a practical point of views in evaluating flour quality during breeding programs;

— W index of Alveograph was correlated with B, CD and E_{12} index of Farinograph.

— the independence of flour quality with respect to protein content;

— the absence of correlation between yield and flour quality.

Key words: Bread wheat, flour quality, breeding.

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"Cerealicoltura: coltivazione e produzione di cereali vernini"

Plant Foods for Human Nutrition **41**: 11–20, 1991.

Protein quality and antinutritional factors in wild and cultivated species of *Vigna* spp.

EMILIA CARNOVALE, ELENA LUGARO* &
EMANUELE MARCONI*
Istituto Nazionale della Nutrizione, Via Ardeatina 546, 00178 Rome, Italy

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Key words: cowpea, wild species, tannin, antitryptic factors, protein digestibility, amino acid

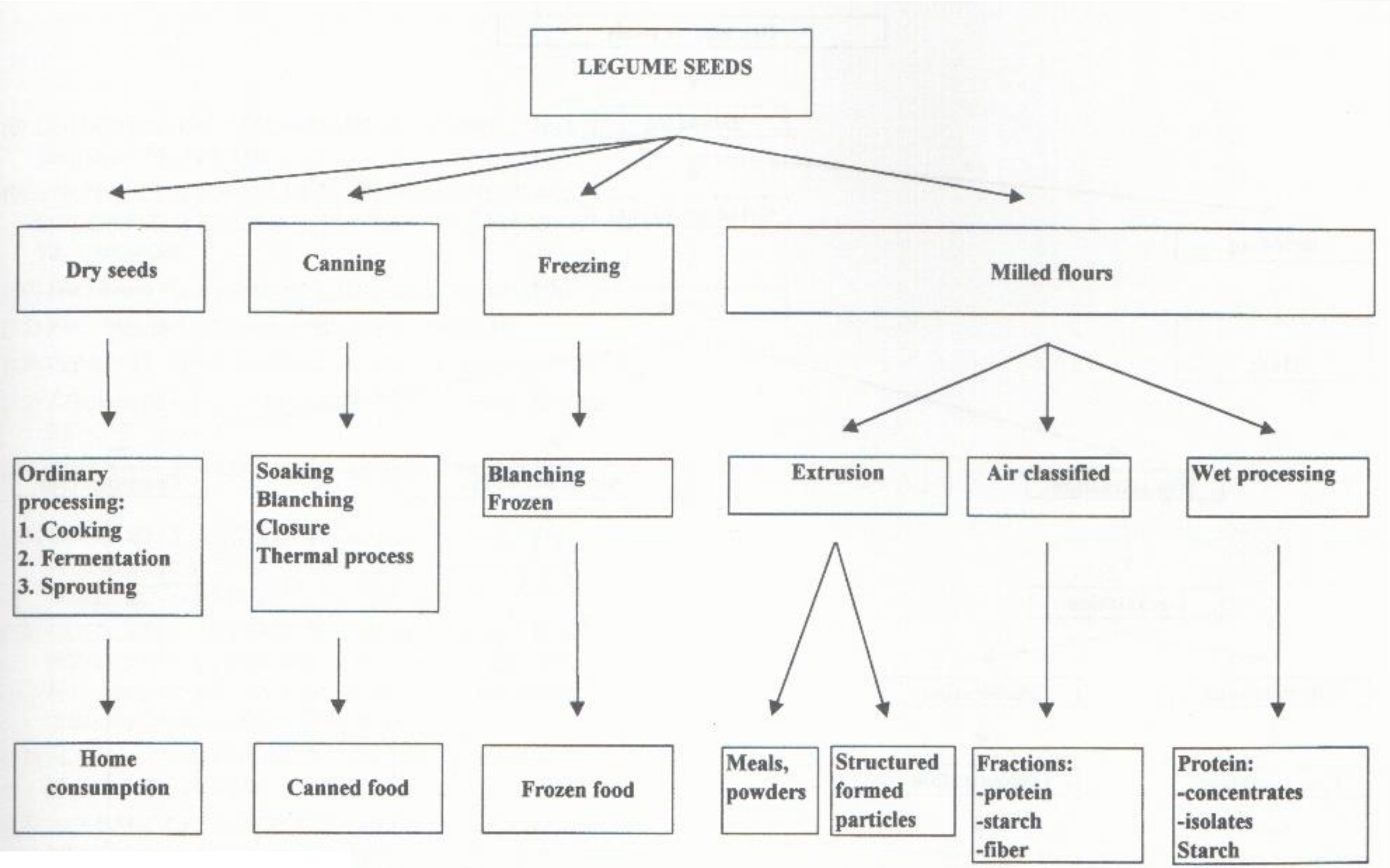
Abstract. The nutritional quality of wild and cultivated species of *Vigna* has been evaluated. Wild species showed significantly higher protein content ($P < 0.01$), antitryptic activity ($P < 0.005$) and tannin content ($P < 0.025$) and significantly lower protein digestibility ($P < 0.005$). No significant differences were found with regard to protein quality, measured as chemical score corrected by the digestibility; sulphur amino acids turned out to be limiting in both groups. In addition no correlations were found between sulphur amino acids and protein levels, or between sulphur amino acid and trypsin inhibitor levels.

Selected lines showed an improvement from the nutritional point of view linked to lower antitryptic factors and tannin content, which may give rise to a decreased resistance to pests. For all the properties considered, whether physical or biochemical, wild samples presented wider variations and the types considered most primitive were those that differed most from the cultivated ones, whose properties were altogether more consistent.

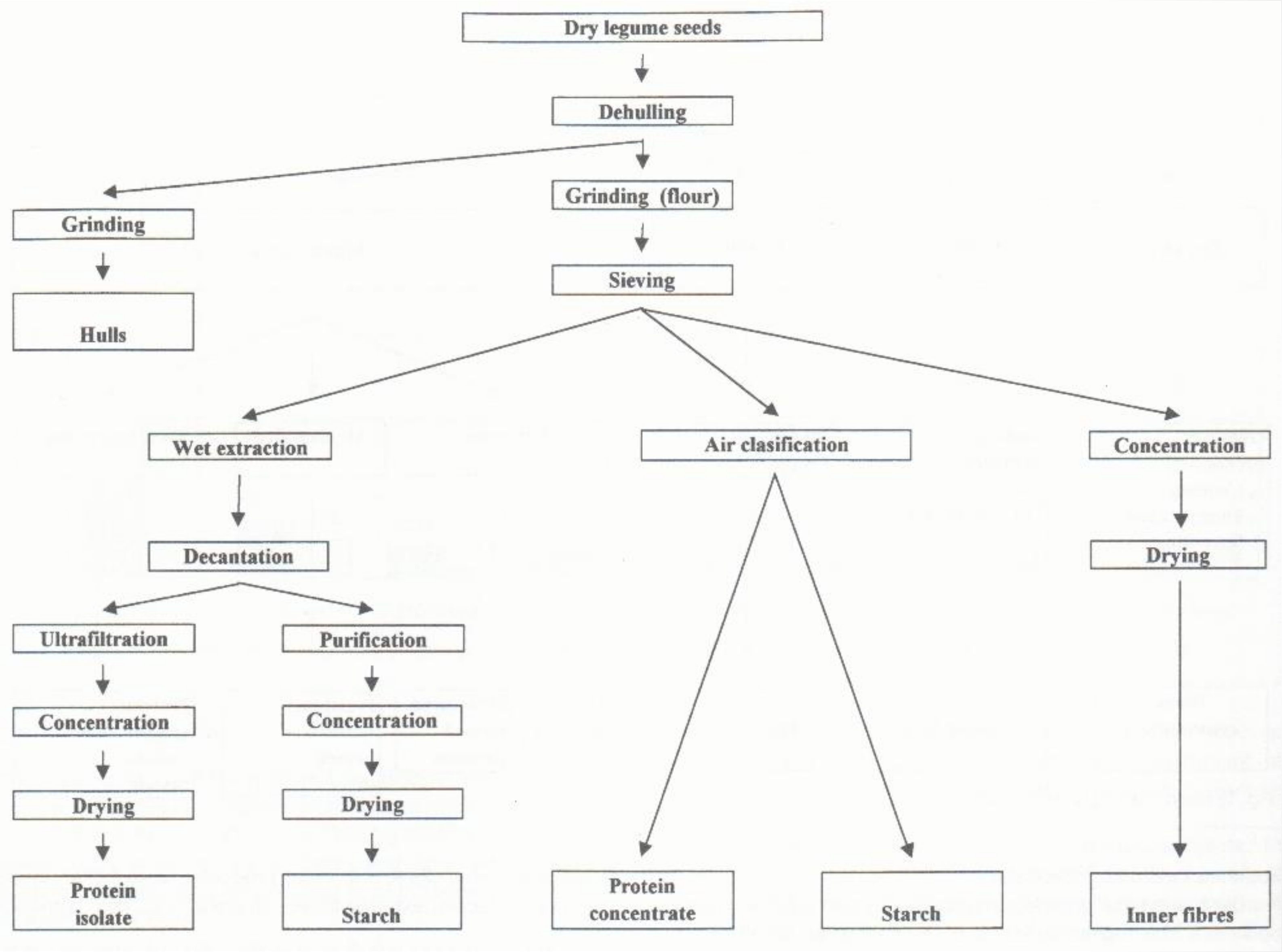
In vitro protein digestibility turned out to be a useful parameter in evaluating wild and improved samples.

* IITA (International Institute of Tropical Agriculture) fellowship recipients.

Food uses of legume seeds



Proteins, starch and fiber from legume seeds



FRACTIONATION AND RECOMBINATION TECHNOLOGIES

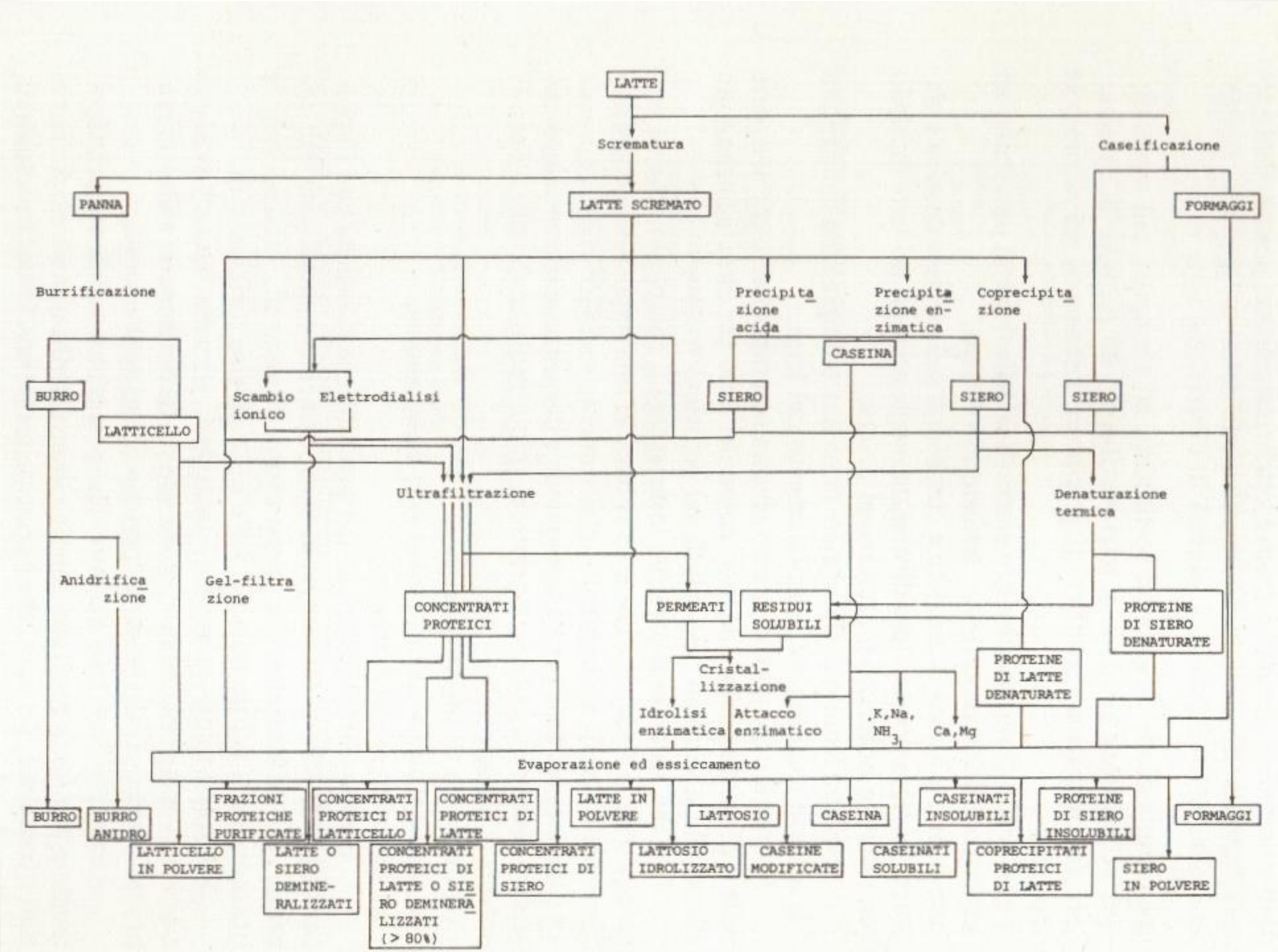
The fractionation and recombination technologies allow to enhance and valorize the use and the processing of cereals/ legumes.

The fractionation and recombination system consists in a first stage in which the kernel/seed is fractionated in different meal/flour fractions and in a second stage in which the ingredients are mixed (formulations) and structured to obtain different finished products (bakery products, snacks etc.).

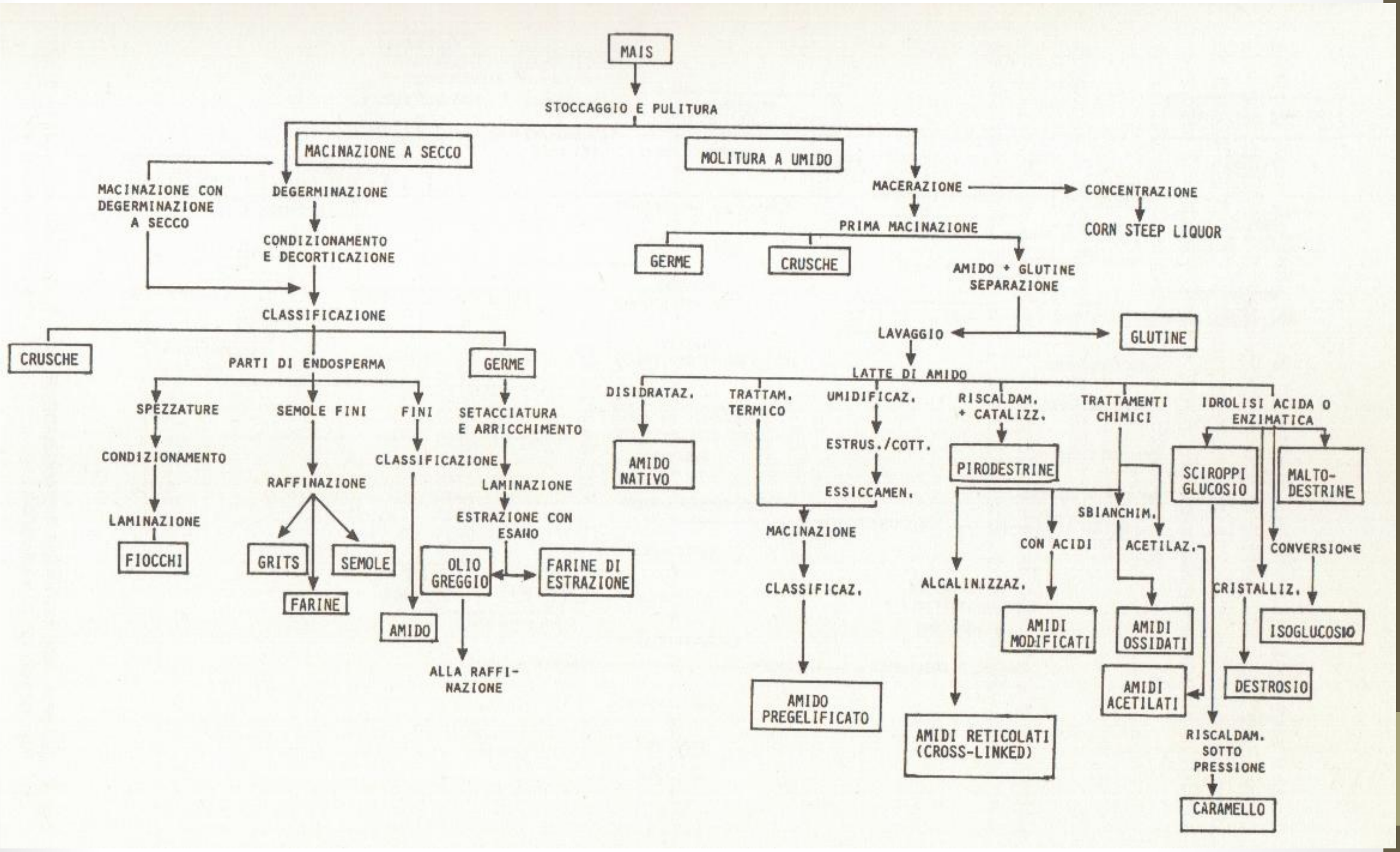
FRACTIONATION TECHNOLOGIES

- Air classification
- Alkaline extraction/Isoelectric precipitation
- Acid extraction
- Water extraction
- Salt extraction (micellization)
- Ultrafiltration

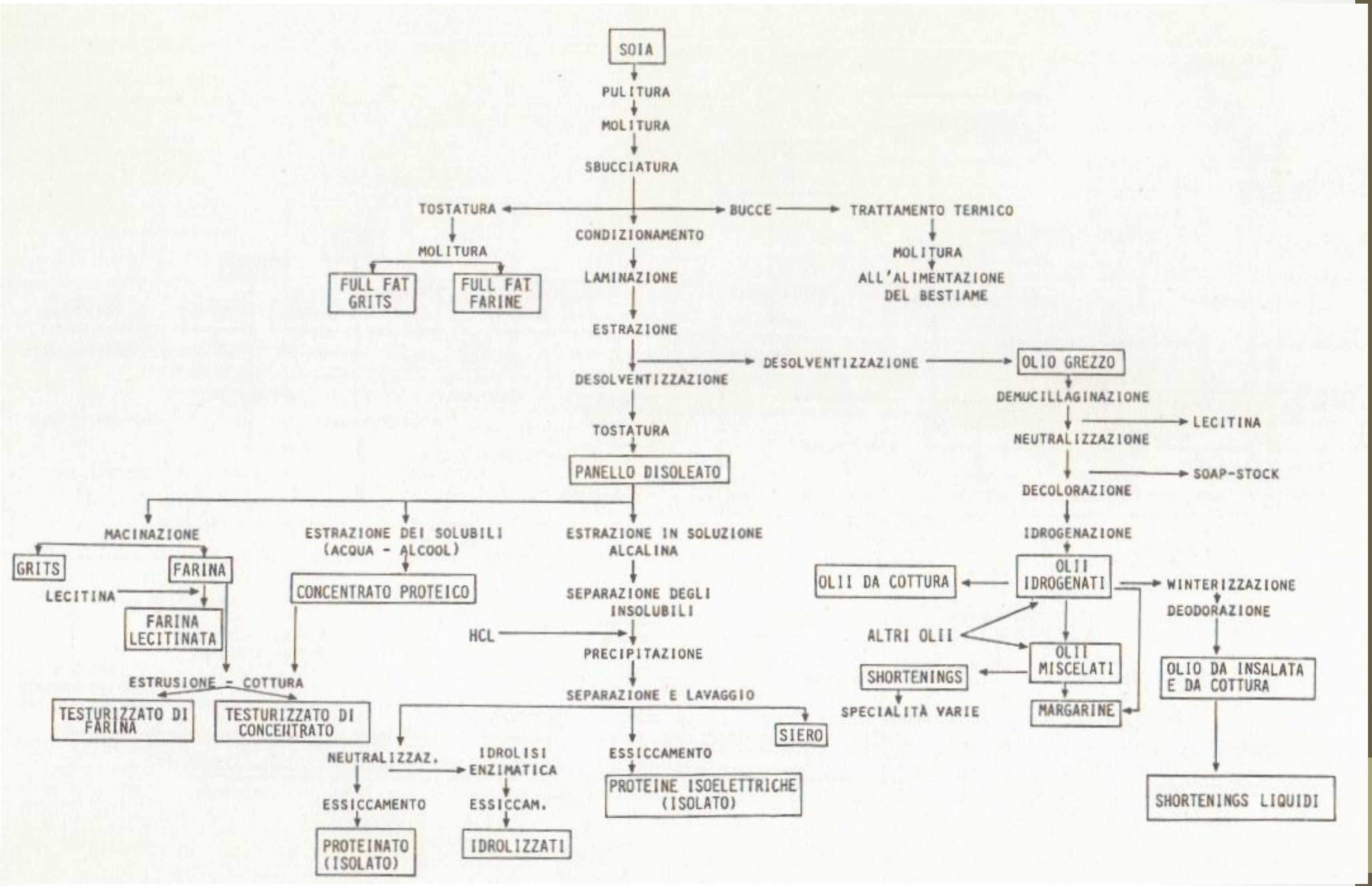
THE "CRACKING" OF MILK



THE "CRACKING" OF CORN



THE "CRACKING" OF SOYBEANS



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Trends in Food Science & Technology

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Dry fractionation for sustainable production of functional legume protein concentrates

M.A.I. Schutyser*, P.J.M. Pelgrom, A.J. van der Goot, R.M. Boom

Wageningen University, Food Process Engineering Group, Bornse Weilanden 9, 6708 WG, Wageningen, The Netherlands

A R T I C L E I N F O

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A B S T R A C T

Plant proteins gain increasing interest as part of a sustainable diet. Because plant materials not only contain protein, they are generally isolated via an energy intensive wet fractionation. This review discusses dry fractionation as an alternative and more sustainable route for producing functional legume protein-enriched fractions. Increasing protein purity of dry-enriched fractions is discussed by identification of relationships between legume morphology and ability for separation in the dry state. Finally, functionality and nutritional properties of legume protein fractions and their application in high protein beverage and meat like structures are reviewed.

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journal homepage: www.elsevier.com/locate/foodres

Review

Pulse proteins: Processing, characterization, functional properties and applications in food and feed

Joyce Boye [a,*], Fatemeh Zare [b], Alison Pletch [c]

[a] Food Research and Development Centre, Agriculture and Agri-Food Canada, 3600 Casavant Boul. West, St.-Hyacinthe, Quebec, Canada J2S 8E3
[b] Department of Bioresource Engineering, Macdonald Campus, McGill University, 21,111 Lakeshore Road, Ste Anne de Bellevue, Canada H9X 3V9
[c] Department of Nutrition, Macdonald Campus, McGill University, 21,111 Lakeshore Road, Ste Anne de Bellevue, Canada H9X 3V9

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ABSTRACT

Pulses (pea, chickpea, lentil, bean) are an important source of food proteins. They contain high amounts of lysine, leucine, aspartic acid, glutamic acid and arginine and provide well balanced essential amino acid profiles when consumed with cereals and other foods rich in sulphur-containing amino acids and tryptophan. The protein content of most pulse legumes fall within the range of 17–30% (d.w.b.). Apart from their nutritional properties, pulse proteins also possess functional properties that play an important role in food formulation and processing. Examples of such functional properties include solubility, water and fat binding capacity and foaming. Various research studies indicate that some functional properties of pulse proteins may be comparable to those of other frequently used proteins such as soy and whey. The functional properties of pulse proteins have been exploited in the preparation and development of products such as bakery products, soups, extruded products and ready to eat snacks. The growing body of research on the health benefits associated with the consumption of pulses has increased interest in developing innovative technologies to expand the use of pulses in food products. At the same time, there are growing global food security challenges and protein malnutrition continues to be a problem in many countries around the world. Pulses, especially when blended with cereal proteins, may offer a promising alternative source for nutritional and functional proteins. This review provides an overview of the characteristics of pulse proteins, current and emerging techniques for their fractionation, their major functional properties and opportunities for their use in various applications.

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Contents lists available at ScienceDirect

Food Research International

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Comparison of the functional properties of pea, chickpea and lentil protein concentrates processed using ultrafiltration and isoelectric precipitation techniques

J.I. Boye *, S. Aksay, S. Roufik, S. Ribéreau, M. Mondor, E. Farnworth, S.H. Rajamohamed

Agriculture and Agri-Food Canada, Food Research and Development Centre, 3600 Casavant Boulevard West, St. Hyacinthe Quebec, Canada J2S 8E3

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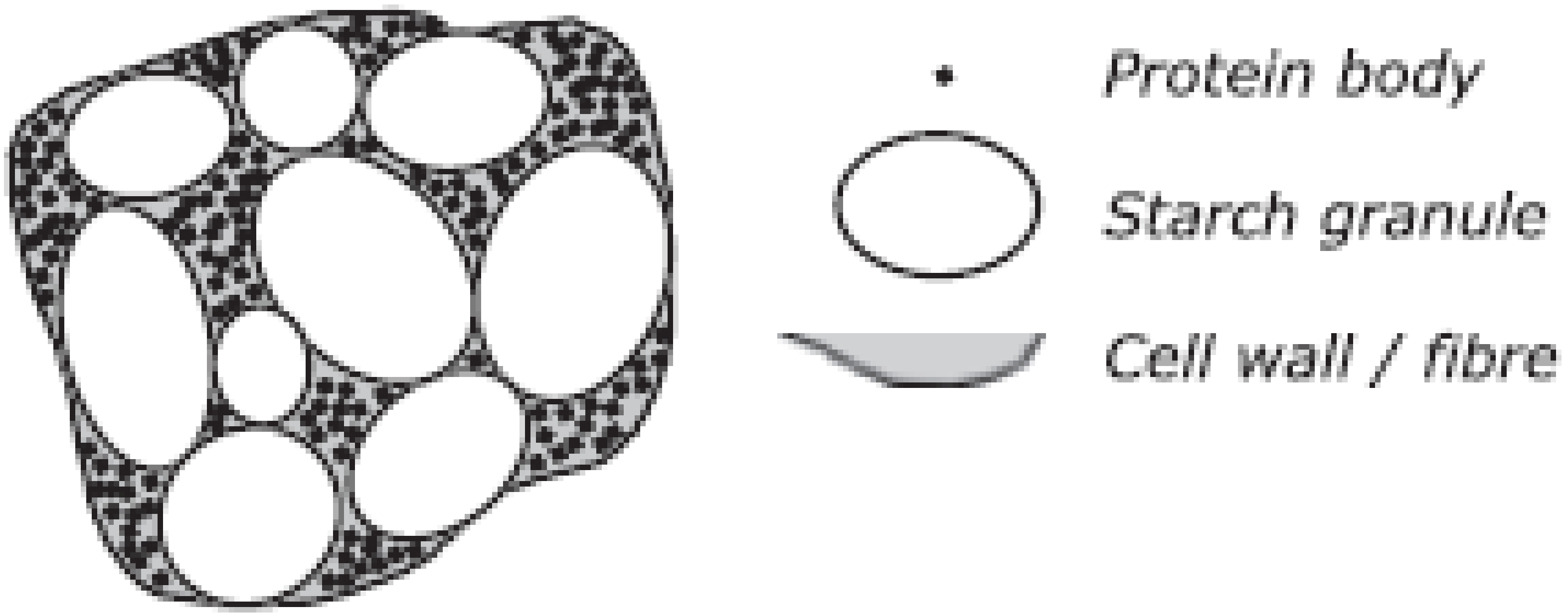
ABSTRACT

In this study, two methods, isoelectric precipitation (IEP) and ultrafiltration (UF) were optimised for the extraction of proteins from yellow pea, desi and kabuli chickpeas, red and green lentils. For IEP, the following optimal extraction conditions were used: pH 9.5, 1/15 solid/liquid ratio, 35 °C for yellow pea, desi and kabuli chickpeas, and pH 9.0, 1/10 solid/liquid ratio, 25 °C for red and green lentils. UF experiments were performed with a 50 kDa MWCO membrane with diafiltration (4X) at pH 6.0. The initial protein content of the pulses (16.7–24.8%, w/w) was concentrated nearly 4-fold. UF process generated concentrates with slightly higher protein contents (69.1–88.6%, w/w) compared to the IEP process (63.9–81.7%, w/w). Yields for both processes on a protein basis ranged from 50.3% to 69.1% (w/w). All concentrates exhibited good functional properties. However, functional properties varied to some extent as a function of the type of pulse and manufacturing process. For pH ranging from 1 to 3 and from 7 to 10, the red and green lentil concentrates were the most soluble (70–77%) and their UF concentrates were more soluble at all pH values studied compared to the IEP samples which was not the case for the pea and chickpea samples. Water holding capacity was highest for IEP-processed yellow pea and lowest for the UF-processed desi and kabuli chickpeas. Emulsifying properties and foam expansion were generally higher for the chickpea concentrates but they had less foam stability. Protein extracts from green lentils appeared to have the best gelling properties. The results highlight the technological potential of pulse protein extracts for food applications.

SCHEMATIC DRAWING OF CELLS OF PEA AND THE FRAGMENTS AFTER MILLING



SCHEMATIC ILLUSTRATION OF WET AND DRY FRACTIONATION PROCESS

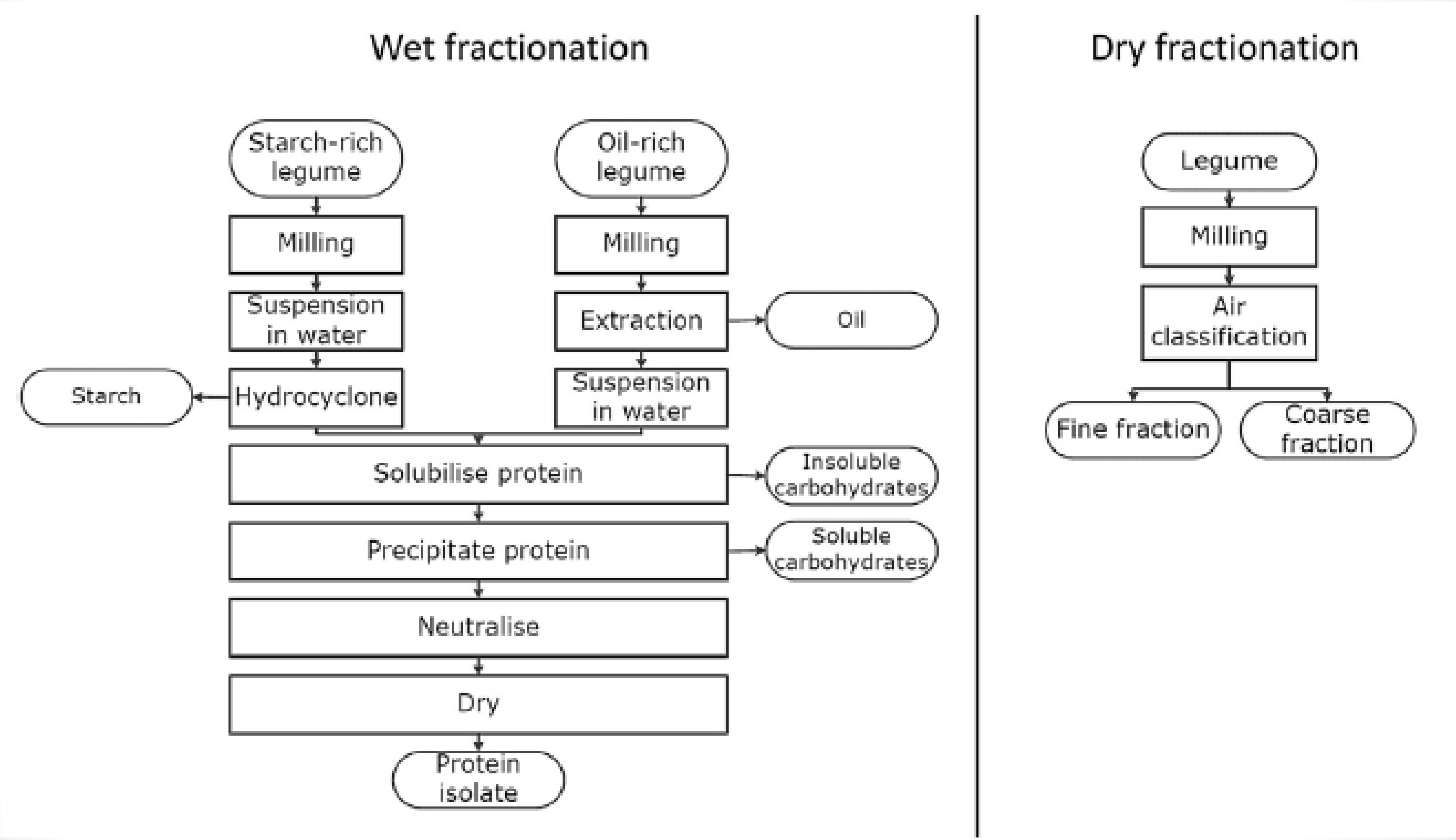


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Table 1
Protein enrichment by air classification of wheat and several legumes ± absolute deviation.

Legume/ grain	Initial protein content (g/100 g dry matter)	Protein content fine fraction (g/100 g dry matter)
Wheat	12.3 ± 1.8	28.3 ± 4.0
Lima bean	23.7 ± 0.4	48.9 ± 0.8
Cowpea	27.2 ± 0.0	50.9 ± 0.2
Common bean	26.3 ± 1.6	54.7 ± 2.2
Navy bean	27.2 ± 1.6	56.7 ± 6.8
Lentil	23.7 ± 2.1	57.6 ± 4.1
Pea	23.8 ± 1.2	58.5 ± 3.0
Mung bean	27.2 ± 0.4	62.3 ± 1.2
Faba bean	31.0 ± 0.8	69.9 ± 5.2
Lupine	40.4 ± 0.6	59.4 ± 0.6

(Aguilera, Lusas, Uebersax, & Zabik, 1982; Bergthaller, Dijkink, Langelaan, & Vereijken, 2001; Cloutt *et al.*, 1987; Elkowicz & Sosulski, 1982; Jones & Halton, 1959; Kent, 1965; Patel, Bedford, & Youngs, 1980; Pelgrom, Berghout, van der Goot, Boom, & Schutyser, 2014; Pelgrom, Boom, & Schutyser, 2015a; Poel van der, Aarts, & Stolp, 1989; Sosulski & Youngs, 1979; Stringfellow, Wall, Donaldson, & Anderson, 1976; Tyler *et al.*, 1981; Vose, Basterrechea, Gorin, Finlayson, & Youngs, 1976; Wright *et al.*, 1984; Wu & Nichols, 2005; Wu, Stringfellow, 1992).

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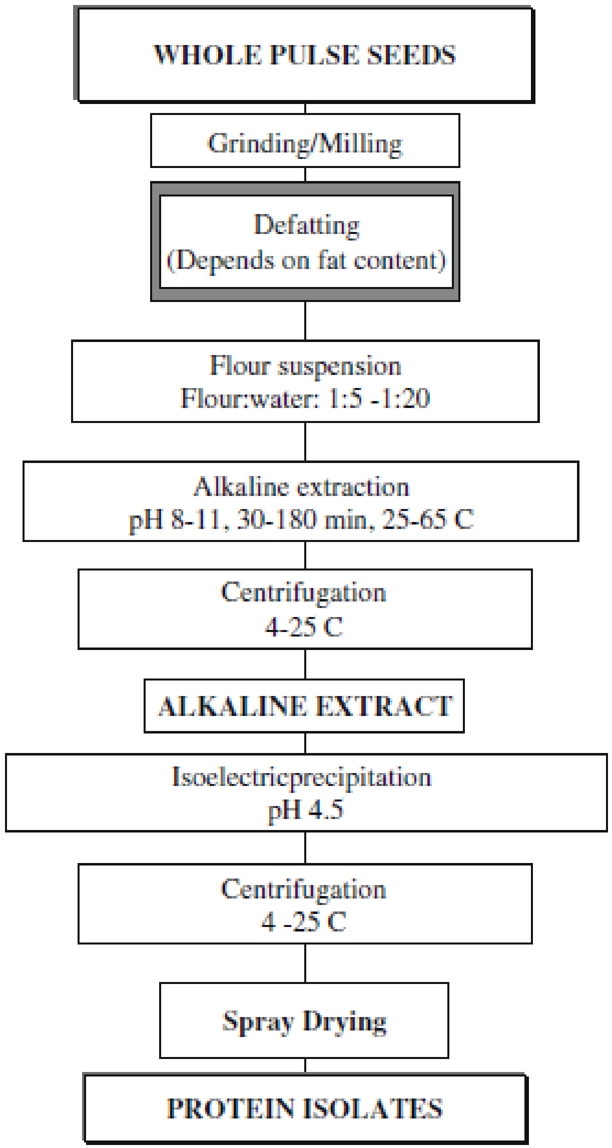
SCHEME FOR THE PREPARATION OF PROTEIN ISOLATES



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The technique takes advantage of the solubility of legume proteins which is high at alkaline pH and low at pH values close to their isoelectric point (pH 4–5).

Protein purity and yield are easily affected by processing conditions (e.g., temperature, time, flour/solvent ratio, condition and protein solubility of the starting material, type of equipment and process used, g forces used for centrifugation, laboratory vs. pilot- scale extraction, batch vs. continuous extraction, etc.).

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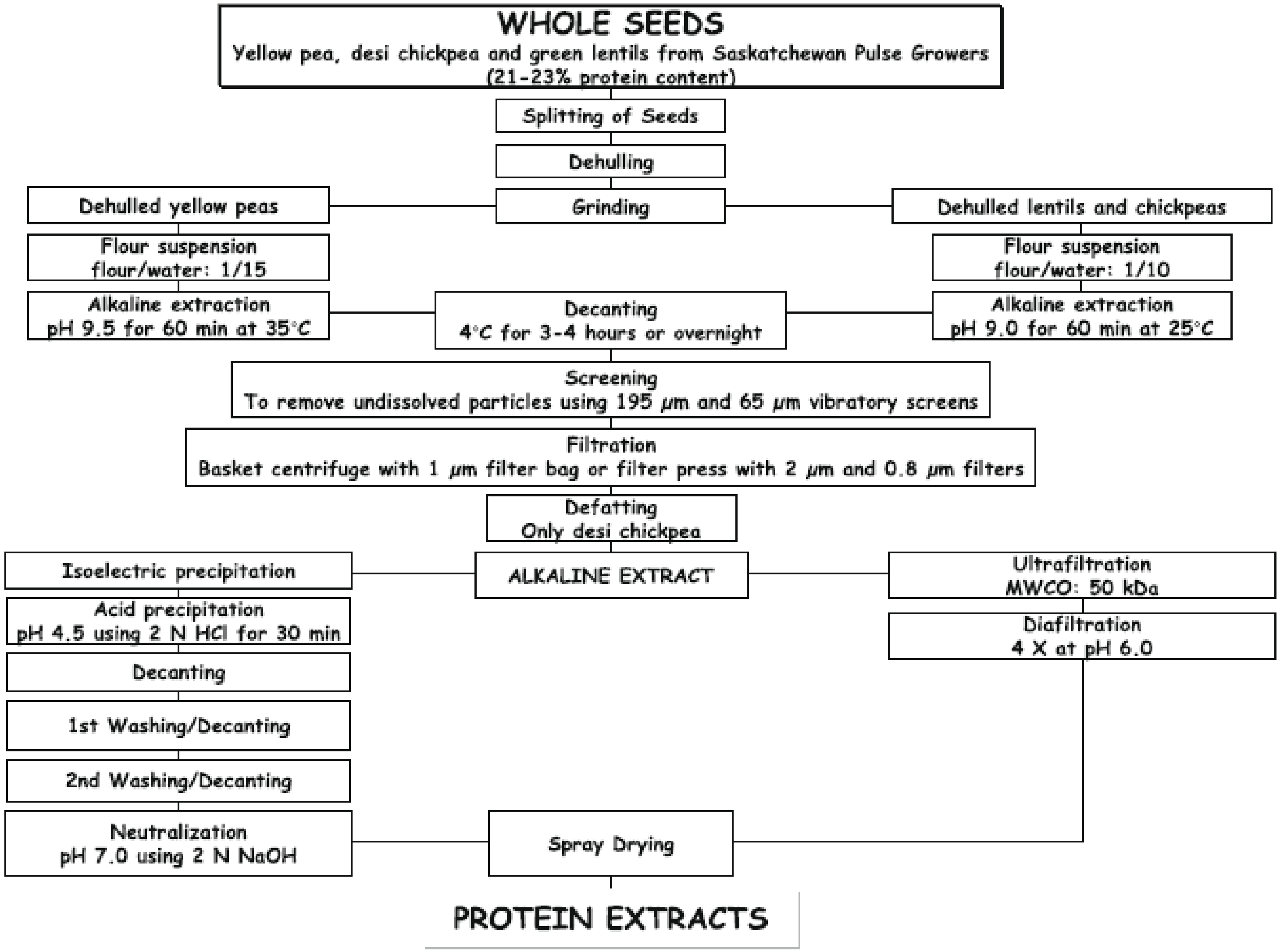

Fig. 1. Schematic of the process used for the pilot scale production of the pulse protein concentrates.

SUSTAINABILITY ASSESSMENT OF DRY AND WET FRACTIONATION

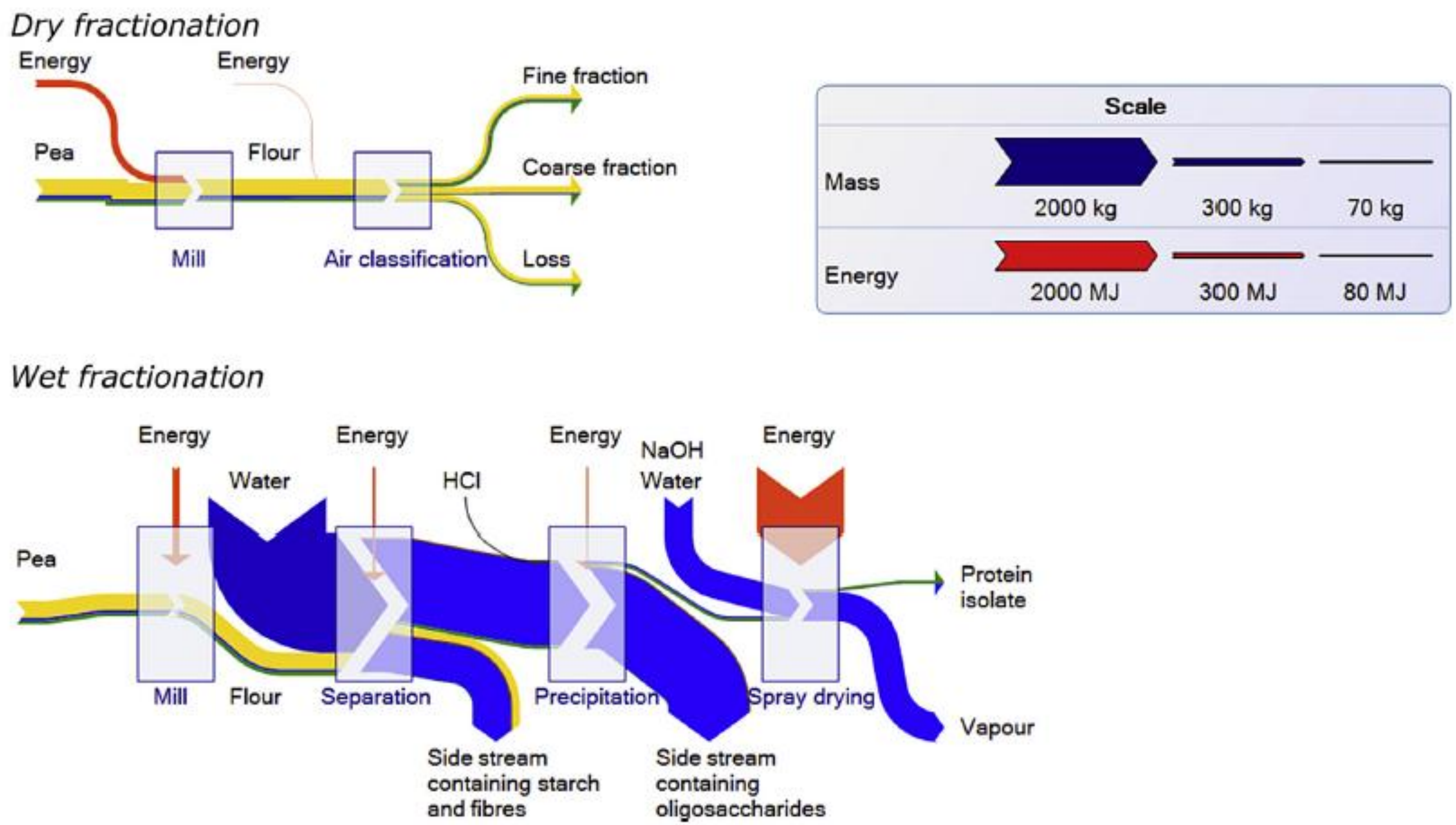

Fig. 5. Sankey diagrams of dry fractionation (left) based on (Pelgrom *et al.*, 2015a) and wet fractionation (right) based on (Passe *et al.*, 2008). Process streams containing water (blue), protein (green), starch, fibre, oil and ash (yellow) and energy (orange) are depicted. For simplicity reasons mass flows and energy are given in the same diagram.

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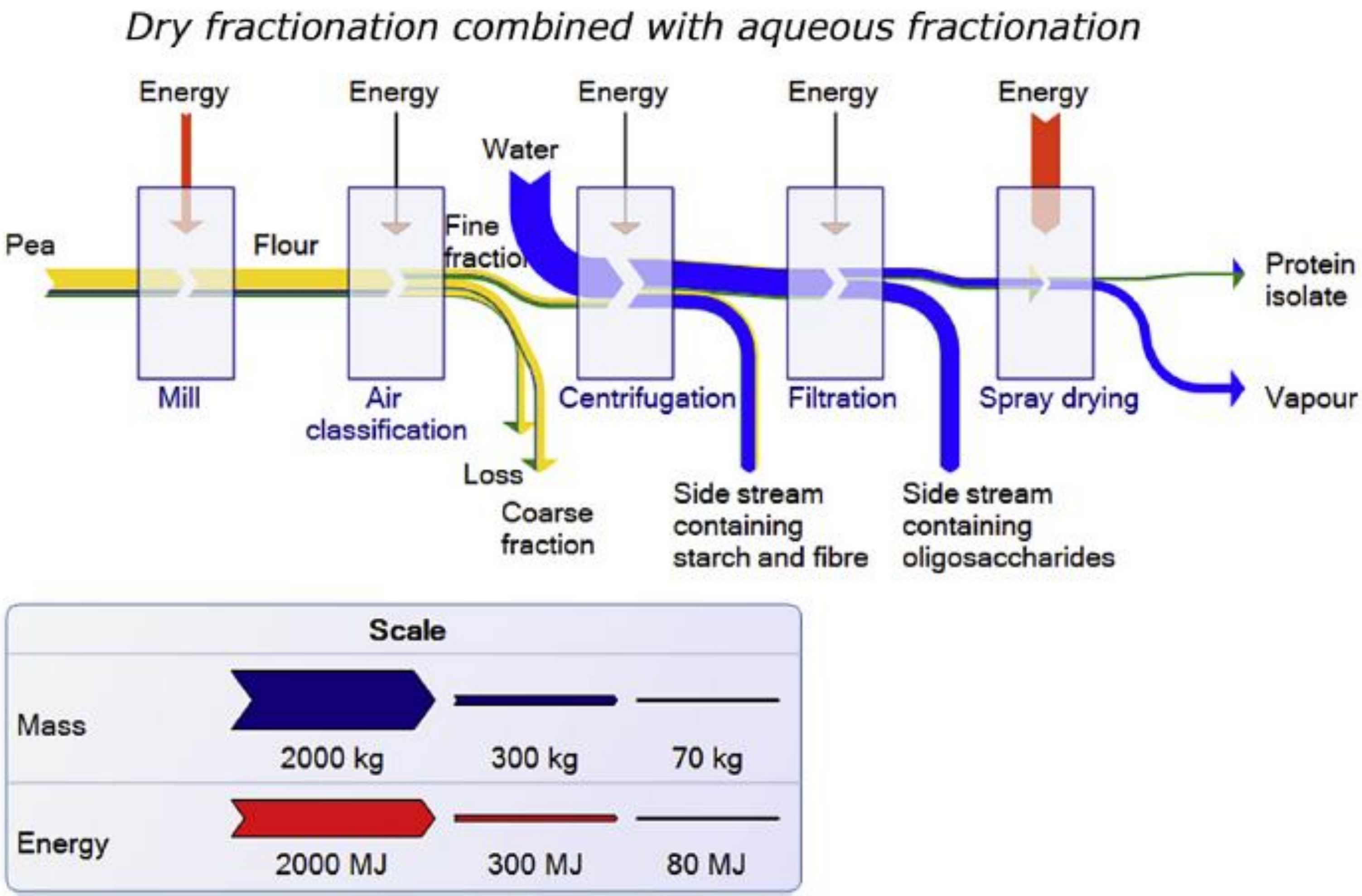

Fig. 6. Sankey diagrams of the combined dry and aqueous fractionation process based on (Pelgrom *et al.*, 2015b). Process streams containing water (blue), protein (green), starch, fibre, oil and ash (yellow) and energy (orange) are depicted. For simplicity reasons mass flows and energy are given in the same diagram.

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COMPOSITE FLOUR

"***Composite flours are a mixtures of flours from tubers rich in starch (e.g. cassava, yam, sweet potato) and /or protein-rich flours (e.g. soy, peanut, pulses) and/or cereals (e.g. maize, rice, millet, buckwheat), with or without wheat flour***".

COMPOSITE FLOUR

In 1964 the Food and Agriculture Organization (FAO) of the United Nations launched its ***Composite Flour Program*** to support the use of local raw materials in the production of high quality food products.

The principal aim of the composite flour program was to seek new possible uses for raw materials other than wheat in the production of breads, pastas, biscuits, and similar flour-based foods.
As part of the program, flour mixtures consisting mainly of indigenous raw material (cassava, tapioca, oilseeds, legumes, millet, sorghum, maize, rice, etc.) and having a composition that combines optimal nutritive value with good processing characteristics are formulated.

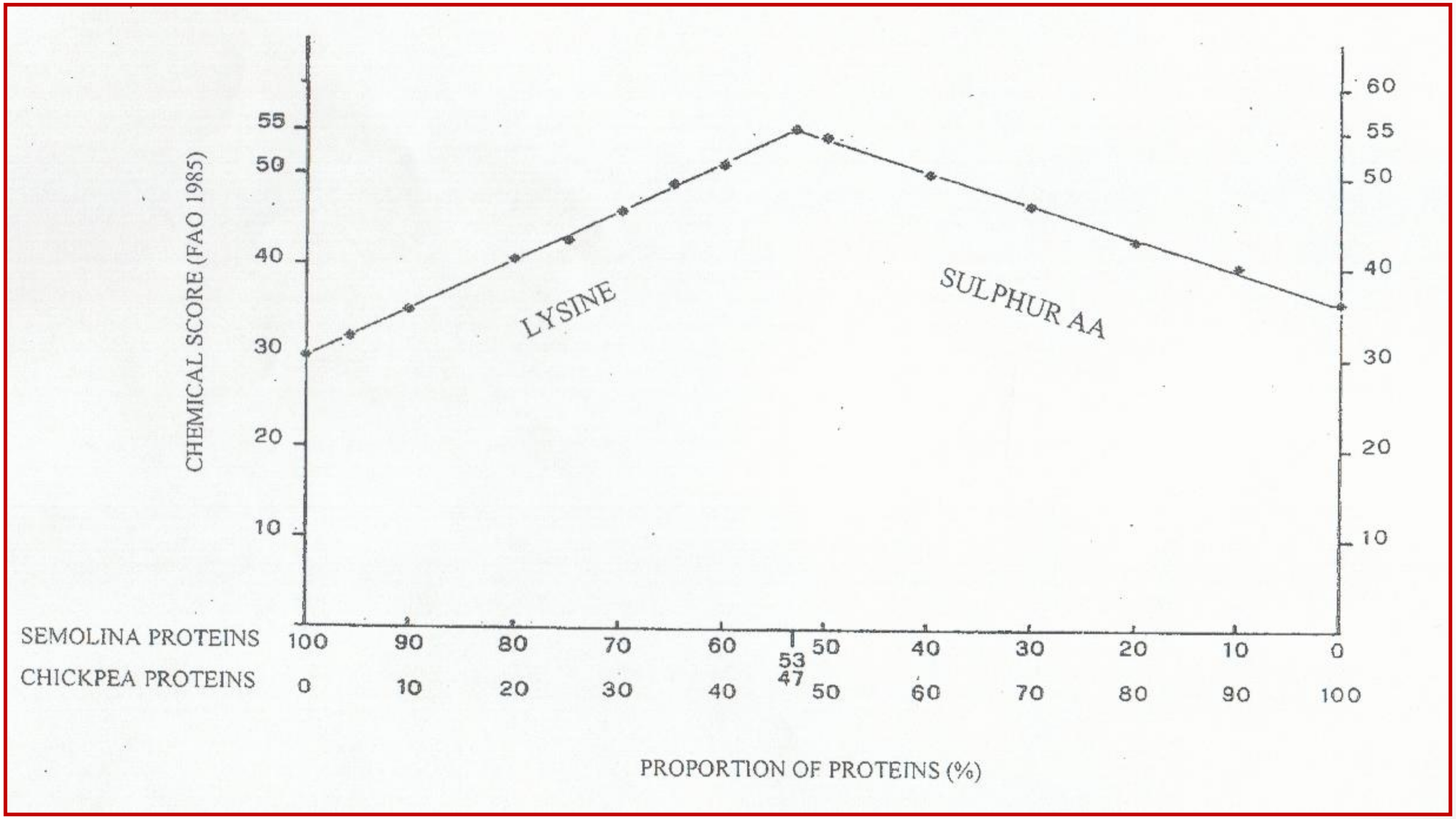
For these flour mixtures, the FAO coined the term **"*Composite Flour*"**.

FORMULATIONS AND NUTRITIONAL CHARACTERISTICS OF SOME COMPOSITE FLOUR CONTAINING WHEAT (WF), CHICKPEA (CF), AND MILK POWDER (MP)

Blend	% Ingredient in Blend			Protein Content (%)	Protein Quality	
	WF	CF	MP		Chemical Score[a]	LAA[b]
WF	100			13.0	0.43	Lysine
CF		100		22.0	1.00	SAA[c]
MP			100	34.0	>1.00	None
Blend 1	70	25	5	16.3	0.79	Lysine
Blend 2	60	30	10	17.8	0.90	Lysine
Blend 3	50	35	15	19.3	0.99	Lysine

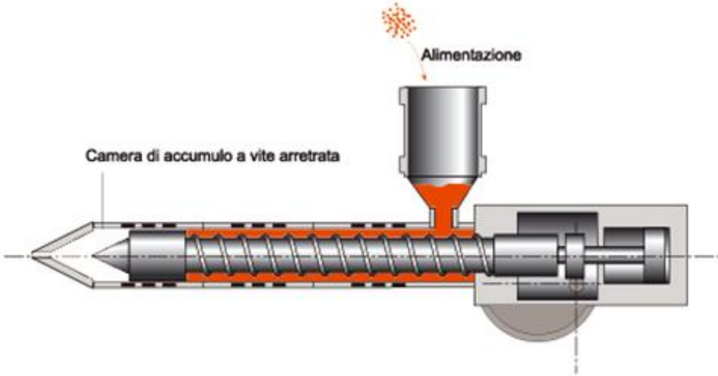
[a] Based on FAO/WHO/UNU (31,32) reference pattern.
[b] Limiting amino acids.
[c] Sulphur amino acids.

AA CHEMICAL SCORE WITH DIFFERENT PROPORTIONS OF CHICKPEA AND SEMOLINA PROTEINS

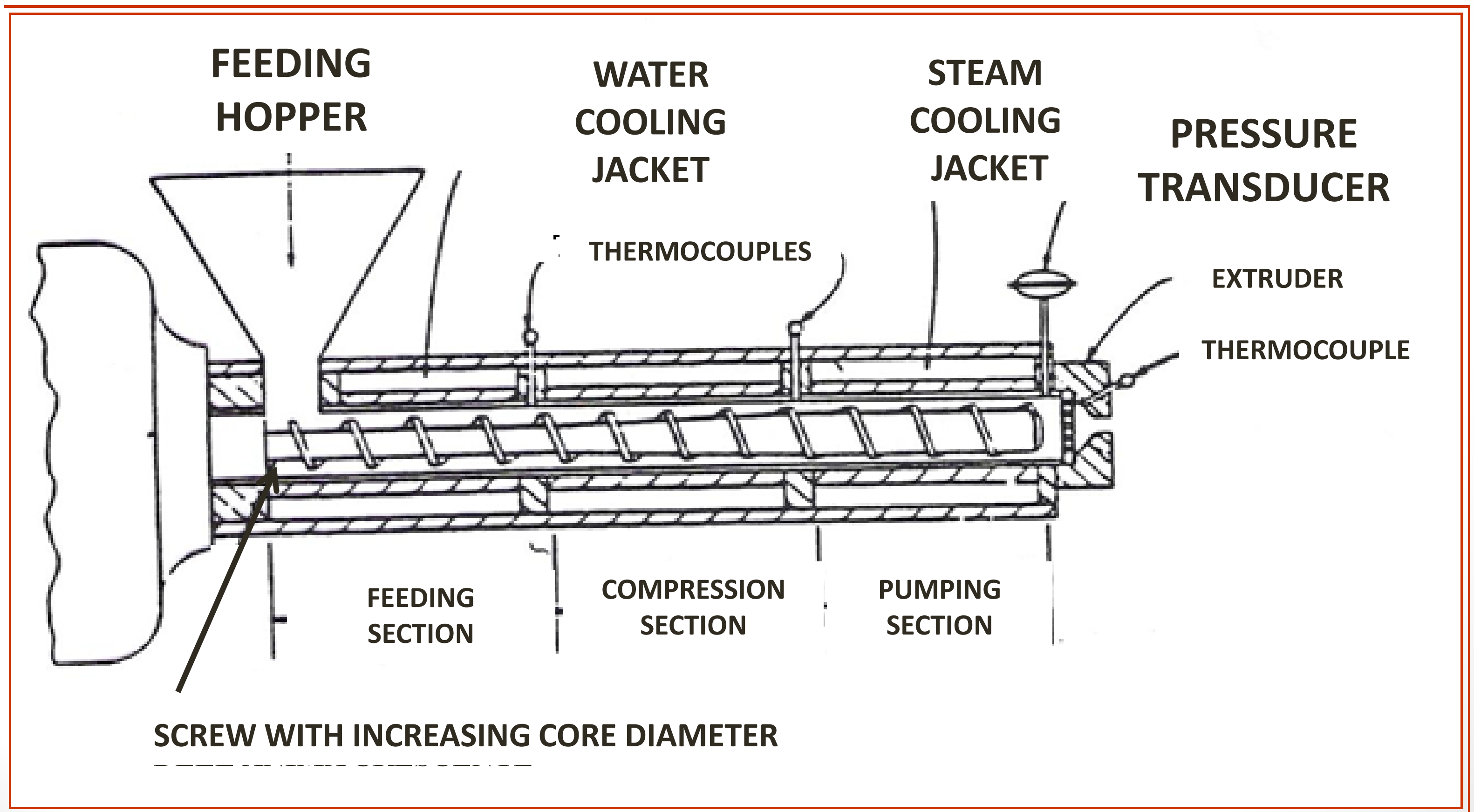


EXTRUSION COOKING

The Extrusion Cooking is the process by which ingredients are mixed, heat treated, cooked, and formed by a combination of moisture, pressure, temperature, and mechanical shear.
This technology allows in a rapid and continuous process to combine several unit operations such as mixing, hydration, kneading, cooking and drying.
As a result of cooking during the extrusion process, starch is gelatinized, proteins are denaturated, enzymes are inactivated, and antinutritional or toxic factors are destroyed. These phenomena allow the structuring of products even when raw materials with poor functional properties are used.
Extrusion technology is highly versatile and permits the use of a wide range of raw materials and mixtures of cereal and non cereal materials.



LONGITUDINAL SECTION OF A TYPICAL EXTRUDER-COOKER



MAIN APPLICATIONS OF EXTRUSION COOKING

PRODUCTS DERIVED FROM CEREALS, LEGUMES AND ROOTS

- Breakfast cereals
- Pre-cooking flours
- Pre-gelatinized starch
- Biscuits, crackers, wafers,
- Special breads (flat bread o crispbread)
- Unconventional pasta
- Puree istant
- Semifinished products

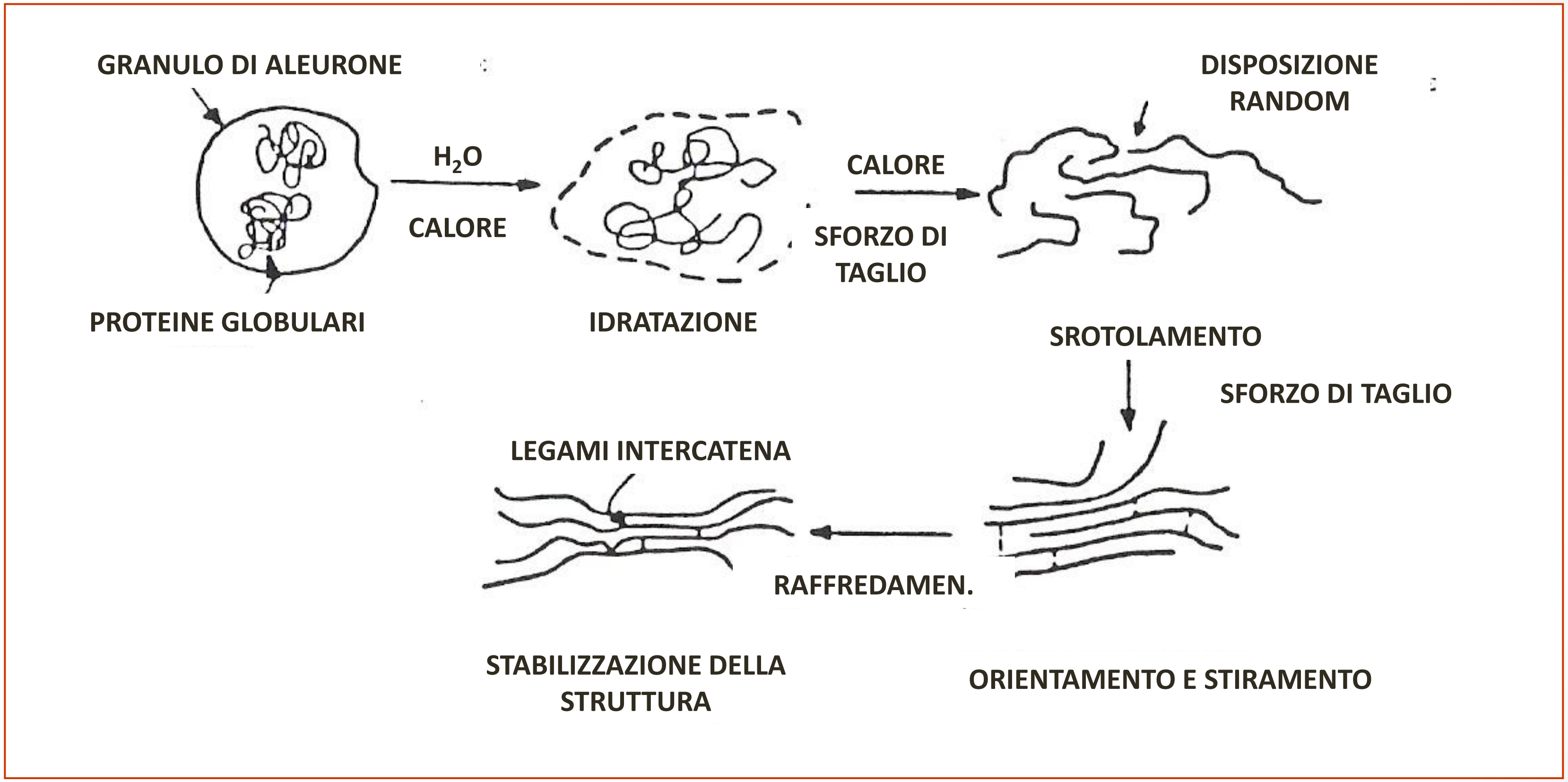
VEGETABLE TEXTURIZED PROTEIN

PRODUCT MIX

- Coextruded products (ravioli, filled snacks, egg rolls, etc.)
- Dried soups instant

BABY FOOD AND ENRICHED PRODUCTS

TEXTURIZED PROTEIN



CHANGES OCCURRING DURING THE EXTRUSION-COOKING PROCESS

- ✓ Enzymes inactivation
- ✓ Proteins denaturation (antinutritional factors)
- ✓ Maillard Reaction
- ✓ Starch gelatinization
- ✓ Reduction of microorganisms (HTST)

Pasta from Nontraditional Raw Materials

E. MARCONI
DISTAAM, University of Molise
Campobasso, Italy

M. CARCEA
National Institute for Food and Nutrition Research
Rome, Italy

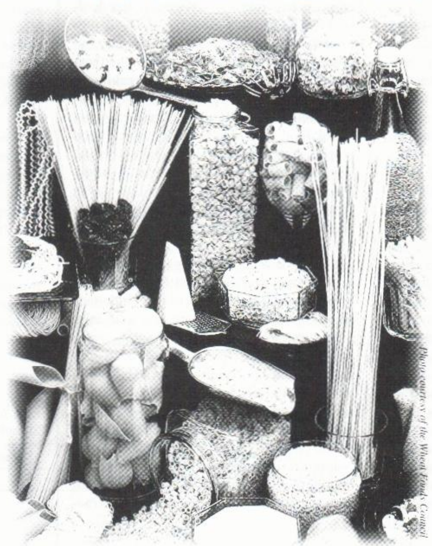


Photo courtesy of the Wheat Foods Council

Durum wheat semolina is the best raw material for pasta making because of the rheological properties of its proteins and its pigment content. Bread wheat or blends of bread and durum wheats can also be used but usually result in inferior pasta cooking quality and color.

Preparation of pasta containing gluten-free cereals, such as rice, maize, sorghum, etc., is difficult because of the lack of gluten, which contributes to the development of a strong protein network that prevents the dissolution of pasta during cooking.

The following types of ingredients can be used to substitute for all or part of the semolina: 1) other cereals (gluten or gluten-free); 2) raw materials other than cereals; 3) mixtures of cereals and other raw materials. Cereals and other raw materials that can be used to partially or totally replace semolina are listed in the sidebar.

Reasons for Using Nontraditional Ingredients

Nutritional Improvement. Nutritional improvement of pasta mainly involves increasing protein and dietary fiber and fortification with vitamins and minerals. The World Health Organization (WHO) and the U.S. Food and Drug Administration (FDA) consider pasta a good vehicle for added nutrients. Pasta was one of the first foods for which the FDA permitted vitamin and iron enrichment in the 1940s. High-protein flours can be added to increase the protein content of pasta from 10–12 to >15% and to improve the biological value of the protein and increase the chemical score of the amino acids from 35 to >70.

High-protein plant materials are derived mainly from soybean, pea, lupine, bean, chickpea used as flour, concentrates, and isolates. Defatted meals from cottonseed, wheat, and corn germ also are also high-protein materials that can be used in pasta.

Milk products such whey proteins, casein, and powdered milk, are the most frequently used materials from animal sources. Fish proteins, blood plasma proteins, and even proteins derived from microorganisms can also be used (65,67). However, the use of by-products from the meat industry is currently encountering severe criticism due to the recent outbreak of bovine spongiform encephalopathy (BSE) in Europe.

The amount of high-protein flour that can be added to or substituted for semolina represents a compromise between nutritional improvement of the pasta and achievement of satisfactory sensory and functional properties.

The addition of raw materials rich in proteins results in pasta products with higher protein contents and better nutritional values than conventional semolina pasta. Chickpea flour and milk powder (Table I) are examples of ingredients that can be used to improve the protein content of pasta. The chemical scores of pasta manufactured adding 10–15% powdered milk and 30–35% chickpea flour are significantly higher (0.90) than that of semolina pasta (0.43) and are comparable to those of animal proteins. Several studies have been done on the improvement of protein quantity and quality in pasta by the addition of raw plant (4–7,11,16,30,37,41,49,59–63,73) or animal (10,39,46,67,73–75) materials.

Similarly, the nutrient content of pasta can be improved by fortification or supplementation with vitamins, minerals, and dietary fiber (5,12,36,43,53,54).

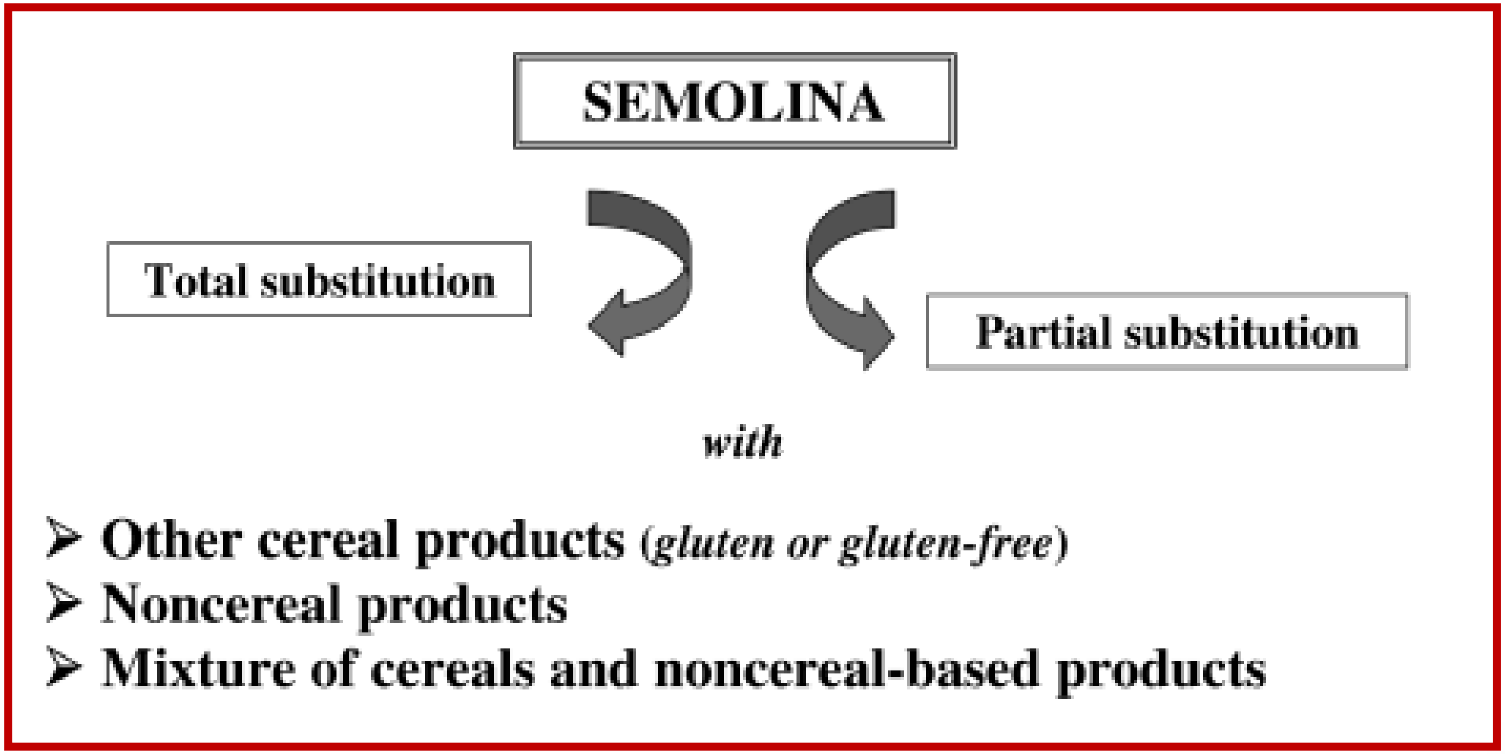
Use of Local Raw Materials. Local raw materials can be used when semolina is unavailable or the cost is too high, as can happen in developing countries. To aid developing countries, in 1964 the Food and Agriculture Organization (FAO) of the United Nations launched its Composite Flour Program to support the use of local raw materials in the production of high-quality food products (26).

The principal aim of the composite flour program was to seek new possible uses for raw materials other than wheat in the production of breads, pastas, biscuits, and similar flour-based foods. As part of the

[1] This paper was presented at the AACC short course "Pasta and Noodles: Raw Materials and Processing," INRAN, Rome, Italy, April 2–4, 2001.

Publication no. W-2001-1029-01F.

PASTA FROM NONTRADITIONAL RAW MATERIALS



REASONS FOR USING NONTRADITIONAL RAW MATERIALS IN PASTA MAKING

A) IMPROVEMENT OF NUTRITIONAL PROPERTIES
- *Protein contents (from 10-12% to 20%)*
- *Protein quality (lysine = limiting A.A.) (Chemical Score from 35 to > 70)*
- *Dietary fiber*
- *Vitamins and minerals*

B) USE OF LOCAL RAW MATERIALS
- *Limited availability and high cost of semolina*
- *Composite flours*
- *Environmental sustainability*

C) PRODUCTION OF GLUTEN-FREE PASTA
- *Celiac disease*
- *Gluten free diet*

D) VALORISATION OF CEREAL AND NON CEREAL BY-PRODUCTS
- Cereal by products
  - *milling (germ, aleurone, bran)*
  - *pearling (aleurone, germ, bran)*
  - *malting/brewing spent grain, roots, yeast crop etc.)*
  - *rice processing (broken rice flour, germ, bran)*
- Other by products (animal origin)
  - *cheese making (whey protein)*
  - *fish processing (fish meal)*
  - *meat processing (meat meal, bone meal etc)*

E) DEVELOPMENT OF TAILOR-MADE AND FUNCTIONAL FOODS
- Functional ingredients
  - *dietary fiber*
  - *β glucans*
  - *tococromanols (tocopherols and tocotrienols)*
  - *folic acid*
  - *ω3 fatty acids (DHA, EPA)*
  - *phytosterols*
- *Prebiotic ingredients*
  - *inulin*
  - *fructooligosaccharides (FOS)*

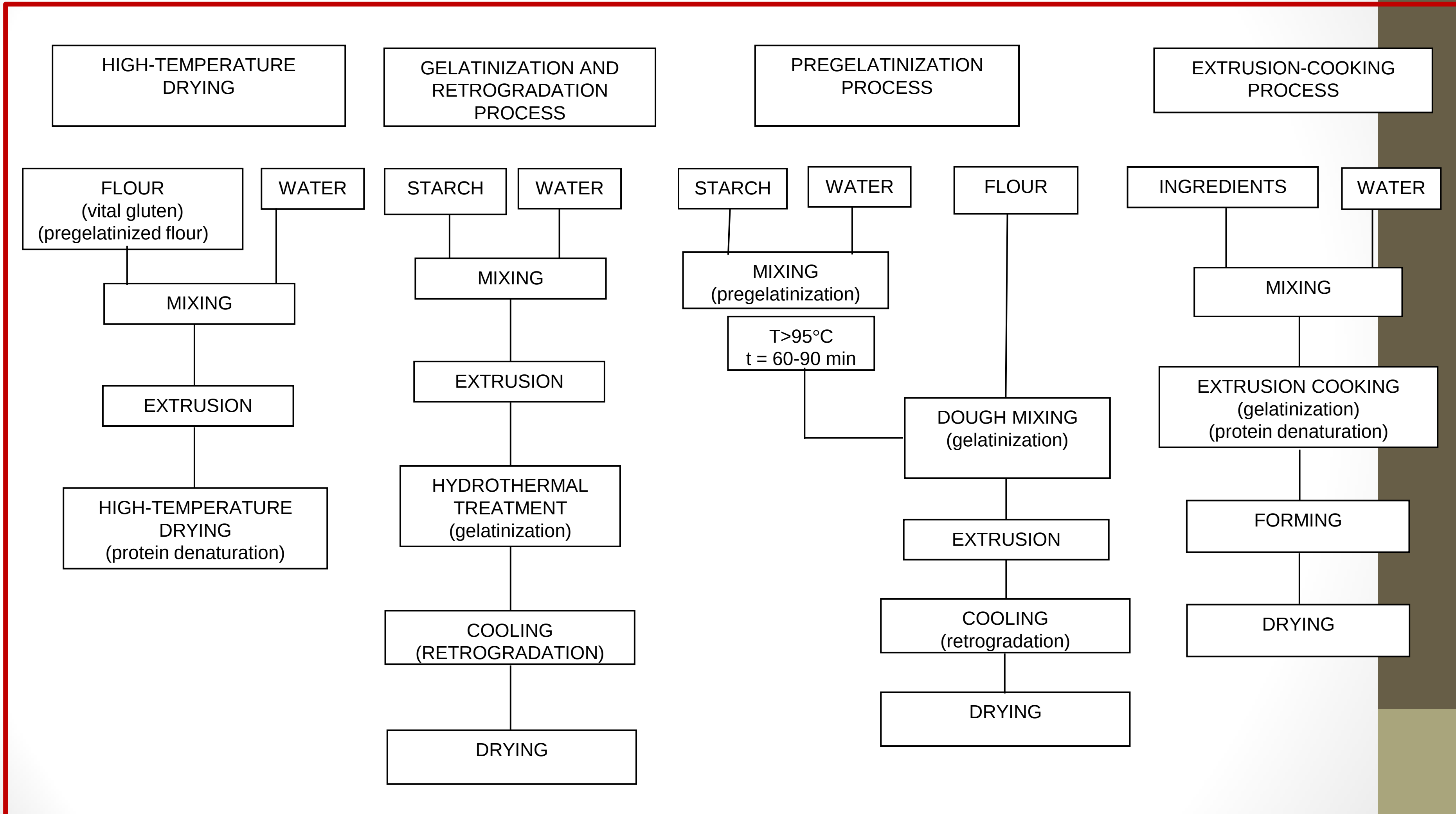
F) USE/RECOVERY/VALORISATION OF ANCIENT/UNDERUTILIZED/OBSOLETE WHEAT SPECIES, PSEUDOCEREALS AND LEGUMES
- *Hulled wheats (spelt, enkorn, emmer)*
- *Kamut*
- *Triticale*
- *Buckwheat*
- *Quinoa*
- *Amaranth*
- *Legumes*

TECHNOLOGIES, FORMULATIONS, AND ADDED INGREDIENTS FOR MANUFACTURING PASTA FROM NONTRADITIONAL RAW MATERIALS

Technology[a]	Formulation	Added Ingredient
High-temperature drying (P)	•Soft wheat, hulled wheat	•Vital wheat gluten or gluten-like proteins (caroubin and whey proteins) to support partial substitution of wheat flour
	•Add gluten-free cereals or fiber-enriched flour up to 30–40% •Pregelatinized flour/starch	•Ascorbic acid to improve gluten strength
Starch gelatinization and retrogradation (T)	•Starch (cereal and legume)	•Mono- or diglycerides, lecithin and polyphosphate salt to improve starch gelatinization and reduce cooking losses
	•Pregelatinized starch/flour •High-amylose starch susceptible to retrogradation	
Extrusion cooking (P, T)	•Composite flour, starch •Pregelatinized starch/flour •Fiber-enriched flour	•Emulsifiers, thickeners, stabilizers

[a] P = Partial replacement of semolina with gluten-free cereals; T = total replacement of semolina with gluten-free cereals.

SCHEMATIC DIAGRAMS FOR THE PRODUCTION OF PASTA FROM NON TRADITIONAL MATERIALS




Pasta con
Farro
Pasta integrata con
FARRO
Spaghetti
PST
MOLISEINNOVAZIONE

Pasta con
Quinoa
Pasta integrata con
QUINOA
Spaghetti
PST
MOLISEINNOVAZIONE

Pasta con
Ω3
Pasta integrata con
Ω3
Spaghetti
PST
MOLISEINNOVAZIONE

Pasta con
Legumi
PASTA AI 5
LEGUMI
pisello, fava,
fagiolo, cece
cowpea
Spaghetti
PST
MOLISEINNOVAZIONE

Food Research International 43 (2010) 634–641

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Fortification of pasta with split pea and faba bean flours: Pasta processing and quality evaluation

Maud Petitot [a,b], Laurence Boyer [b], Chantal Minier [b], Valérie Micard [a,*]

[a] Montpellier SupAgro, UMR IATE, 2, Place Pierre Viala, 34060 Montpellier Cedex 01, France
[b] PANZANI, CRECERPAL, 131 av. Corot, 13013 Marseille, France

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ABSTRACT

Nutritionally enhanced spaghetti was produced by adding high amounts (35% db) of legume flour (split pea or faba bean) to durum wheat semolina. The production of fortified pasta required an adaptation of the pasta making process (higher hydration level and mixing speed) to limit agglomeration of particles during mixing. Moreover, addition of legume flour induced a decrease in some pasta quality attributes (e.g. higher cooking loss, lower breaking energy). This could be attributed to the introduction of non-gluten proteins and insoluble fibres which weakened the overall structure of pasta. A modification of the sensorial properties including higher hardness and higher fracturability were also observed. Some quality attributes (e.g. lower cooking loss) of fortified pasta were improved by applying high and very high temperatures during the drying cycle, reflecting strengthening of the protein network. However, these treatments resulted in excessively firm and rubbery pasta according to the panelists.

Table 1
Chemical composition of durum wheat (DW) semolina, split pea (SP) flour, faba bean (FB) flour and blends of 65% DW semolina and 35% SP or FB flour used to produce pasta. Protein, starch, fibre, lipid and ash contents are expressed in g/100 g (db); vitamin and mineral contents are expressed in mg/100 g (db).

	Proteins	Starch	Lipids	Fibres		Ashes	Vitamins						Minerals		
				Total	Soluble		B1	B2	B3	B5	B6	B9	Fe	Mg	P
Durum wheat semolina	13.3 ± 0.2	77.6 ± 0.3	1.7 ± 0.04	2.4	0.7	1.1 ± 0.02	0.28	<0.05	3.7	0.5	0.15	0.022	1.9	63	233
Split pea flour	21.4 ± ± 0.4	47.9 ± 0.5	2.5 ± 0.09	13.4	1.1	2.9 ± 0.02	0.83	0.14	3.1	1.5	0.15	0.025	5.4	115	495
Faba bean flour	29.0 ± 0.8	44.4 ± 0.4	2.2 ± ± 0.09	7.3	1.0	3.4 ± 0.02	0.66	0.20	2.5	0.7	0.23	0.145	6.0	124	630
65% DW semolina + 35% SP flour[a]	16.1	67.0	1.9	6.2	0.8	1.7	0.47	0.05	3.5	0.8	0.15	0.023	3.1	81	324
65% DW semolina + 35% FB flour[a]	18.8	66.0	1.8	4.1	0.8	1.9	0.41	0.07	3.3	0.5	0.18	0.065	3.2	84	372

[a] Results obtained by calculation.

Table 3
Cooking quality of pasta made from durum wheat (DW) semolina (control) or a blend of 65% DW semolina and 35% split pea (SP) or faba bean (FB) flour, and dried at low (LT), high (HT), or very high temperature applied at low moisture content (VHT_LM).

Pasta made from	Drying profile	Optimal cooking time (min)	Water uptake (%, db)	Cooking loss (%, db)	Colour of pasta					
					L^*		a^*		b^*	
					Dried	Cooked	Dried	Cooked	Dried	Cooked
100% DW semolina (control)	LT	9.3 ± 0.3^{a}	192 ± 7^{a}	5.6 ± 0.4^{b}	67.9 ± 1.1^{a}	69.9 ± 0.4^{a}	5.0 ± 0.2^{f}	1.0 ± 0.8^{d}	42.7 ± 6.2^{ab}	21.0 ± 3.2^{ab}
65% DW semolina + 35% SP flour	LT	8.7 ± 0.1^{b}	166 ± 6^{b}	7.0 ± 0.6^{a}	57.1 ± 1.4^{b}	62.4 ± 1.9^{b}	5.4 ± 1.9^{f}	1.8 ± 0.6^{d}	37.4 ± 6.1^{b}	18.4 ± 1.1^{b}
	HT	8.7 ± 0.2^{b}	168 ± 7^{b}	5.6 ± 0.3^{b}	54.9 ± 1.1^{d}	57.5 ± 0.9^{d}	9.3 ± 0.7^{d}	3.6 ± 0.5^{bc}	42.0 ± 1.9^{ab}	21.4 ± 1.1^{ab}
	VHT_LM	8.7 ± 0.1^{b}	150 ± 3^{c}	6.1 ± 0.5^{b}	41.2 ± 1.9^{e}	45.9 ± 0.8^{e}	19.7 ± 1.4^{b}	10.5 ± 1.7^{a}	24.8 ± 3.4^{c}	22.1 ± 1.2^{a}
65% DW semolina + 35% FB flour	LT	8.5 ± 0.1^{b}	166 ± 6^{b}	6.8 ± 0.8^{a}	60.7 ± 2.2^{bc}	61.0 ± ± 1.3^{bc}	7.3 ± 0.2^{e}	2.2 ± 0.8^{cd}	40.7 ± 2.6^{ab}	18.3 ± 0.5^{b}
	HT	8.5 ± 0.2^{b}	169 ± 6^{b}	5.8 ± 0.4^{b}	58.7 ± 1.7^{cd}	59.2 ± 0.6^{cd}	11.0 ± 0.4^{c}	4.1 ± 0.3^{b}	46.8 ± 2.7^{a}	19.6 ± 2.9^{ab}
	VHT_LM	8.5 ± 0.2^{b}	139 ± 7^{d}	5.9 ± 0.6^{b}	41.1 ± 0.2^{e}	45.0 ± 1.0^{e}	21.5 ± 0.3^{a}	10.2 ± 0.4^{a}	28.0 ± 0.2^{c}	22.4 ± 1.1^{a}

Means with the same superscript within a column are not significantly different ($P > 0.05$).
* Means ± SD of three repetitions on pasta produced at three different occasions.

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Nutritional, Health, and Technological Functionality of Lupin Flour Addition to Bread and Other Baked Products: Benefits and Challenges

C. B. J. VILLARINO,[1] V. JAYASENA,[1] R. COOREY,[1] S. CHAKRABARTI-BELL[2,3] and S. K. JOHNSON[1]

[1]Food Science and Technology Program, School of Public Health, Curtin University, Bentley, WA Australia
[2]Centre for Grain Food Innovation, Kensington, WA Australia
[3]CSIRO Food Futures National Research Flagship, CSIRO, Kensington, WA Australia

Lupin is an undervalued legume despite its high protein and dietary fiber content and potential health benefits. This review focuses on the nutritional value, health benefits, and technological effects of incorporating lupin flour into wheat-based bread. Results of clinical studies suggest that consuming lupin compared to wheat bread and other baked products reduce chronic disease risk markers; possibly due to increased protein and dietary fiber and bioactive compounds. However, lupin protein allergy has also been recorded. Bread quality has been improved when 10% lupin flour is substituted for refined wheat flour; possibly due to lupin-wheat protein cross-linking assisting bread volume and the high water-binding capacity (WBC) of lupin fiber delaying staling. Above 10% substitution appears to reduce bread quality due to lupin proteins low elasticity and the high WBC of its dietary fiber interrupting gluten network development. Gaps in understanding of the role of lupin flour in bread quality include the optimal formulation and processing conditions to maximize lupin incorporation, role of protein cross-linking, antistaling functionality, and bioactivity of its γ-conglutin protein.

Keywords Lupin, wheat flour, bread, proteins, dietary fiber, γ-conglutin, disulphide and dityrosine cross-linking, bread staling, legume, health

Table 6 Studies investigating the effects on dough and loaf quality of lupin incorporation into bread *(Continued)*

Lupin species/variety	Lupin fraction	Product	Lupin incorporation rate (% replacement of wheat flour)	Water incorporation rate (% of product)	Bread making process	Positive effects	Negative effects	Reference
L. albus	Flour Protein concentrate Protein isolate	Pan bread	3, 6, 9, 12	Based on Farinograph value	Straight dough	Flour and protein concentrate can be added up to 6% while protein isolate can be added up to 9% without detrimental effects on sensory properties	Increased dough development time and dough weakening Decreased dough stability and loaf volume	Mubarak (2001)
Lupinus albus ssp. Graecus	Flour (full-fat, concentrated, defatted, and concentrated)	Pan bread	5, 10, 15	Based on Farinograph value of 500 BU	Straight dough	Increased stability and tolerance of dough at 5%	Decreased dough strength at 15% Lowered volume as % lupin flour increased	Dervas et al. (1999)
L. albus cv. Multolupa	Full-fat flour	Rolled bread	0, 3, 6, 9, 12	Not cited	Straight dough	Increased loaf volume for all substituted bread		Ballester et al. (1988)

CONSIGLIO NAZIONALE DELLE RICERCHE

PROGETTI FINALIZZATI

RICERCA DI NUOVE FONTI PROTEICHE E DI NUOVE FORMULAZIONI ALIMENTARI

MIGLIORAMENTO DELLE PRODUZIONI VEGETALI PER FINI ALIMENTARI ED INDUSTRIALI MEDIANTE INTERVENTI GENETICI

PROSPETTIVE DELLE PROTEAGINOSE IN ITALIA

ASPETTI NUTRIZIONALI, AGRONOMICI, ECONOMICI DELLA UTILIZZAZIONE DELLE LEGUMINOSE DA GRANELLA

ATTI DEL CONVEGNO DI PERUGIA
30 Maggio/2 Giugno 1979

A cura di CARLO POMPEI

PROSPECTS OF "PROTEAGINOUS" IN ITALY

Nutritional, agronomic, technological and economic aspects of the use of grain legumes

The neologism "proteagineous" was coined for the title of a meeting in which the production and processing of vegetable proteins from grain was examined, expecially as a source of food proteins and its value as an essential source to meet protein demand was reconsidered.

These sources of vegetable protein have always played an important role in our alimentation, particularly in Italy. We have, however, witnessed two contradictory factors which have seriously affected our economy and the actual structure of agricolture, especially in the south: a) a great expansion in the consumption of protein foods; b) a considerable decrease in the cultivation of protein plants such grain legumes.

We therefore considered it necessary to try to verify the potential availability of these plants and the extent to which they can be utilized by examining their nutritional value. This in order to define the genetic intervention, agrotechniques and processing methods necessary to ensure the biological quality of these foods also to promote revival of the type of crops considered valid and to innovate the processing industry, compatibly with the economy of this sector.

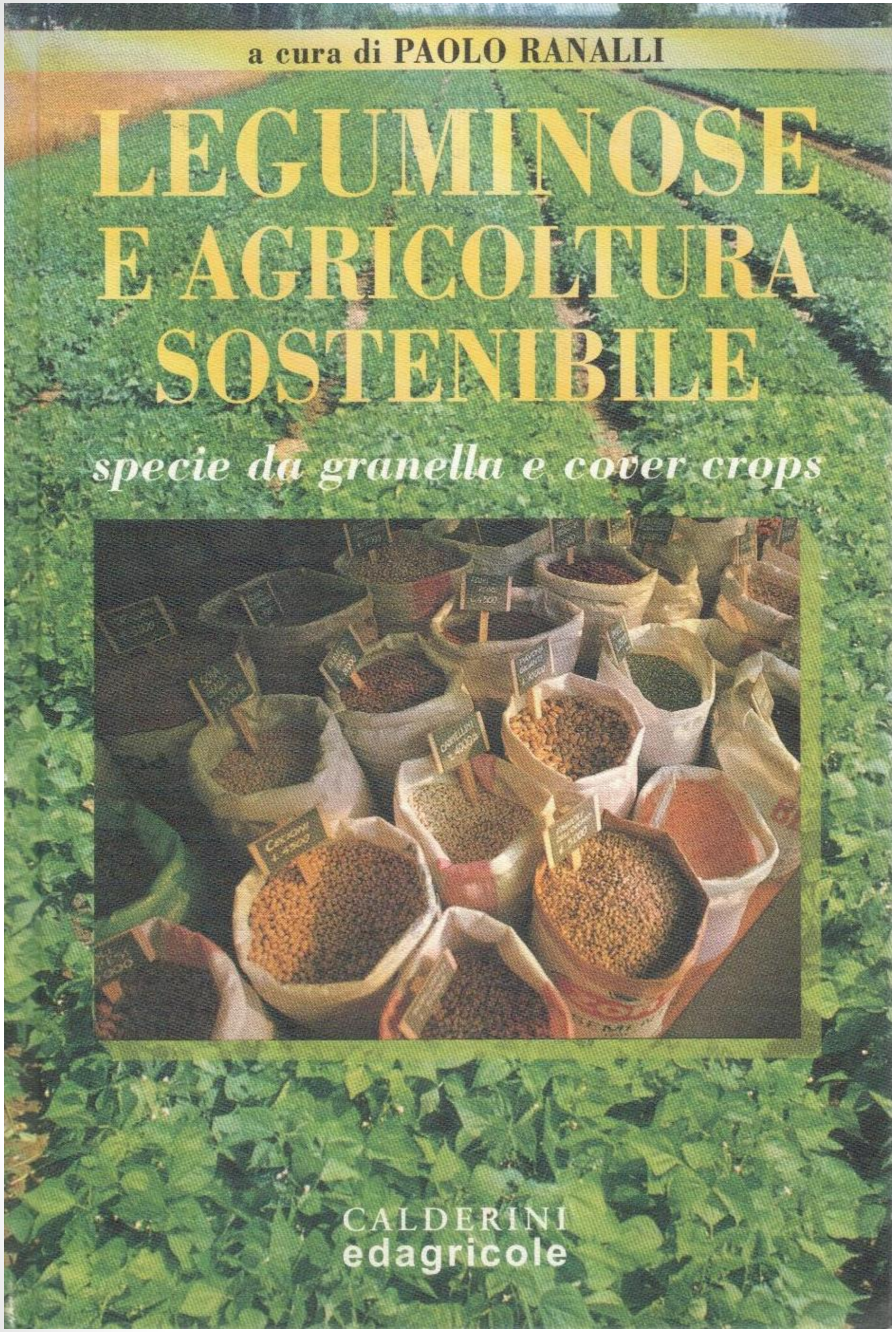
It must be remembered that, compared with a drastic fall in production, a gradual increase in consumption has made it necessary to resort to imports which are unthinkable 20 years ago. On the other hand, the image of "Proteaginus" plants as "substantial" food is very deep in our cultural habitus. This justifies promotion, along the lines already followed in countries with different food traditions, within the framework of a policy for re–evaluating nutritions and low cost vegetable protein foods.

Merit for organizing the meeting goes to Prof. Flaminio Fidanza, director of the Institute of Food Science of the University of Perugia, where the meeting was held. Our warm thanks to the speakers and organizers of working groups. Prof. Carlo Pompei is responsible for the collection, pubblication and version of the textes.

Enrico Porceddu
Progetto finalizzato C.N.R. per il miglioramento delle produzioni vegetali per fini alimentari ed industriali mediante interventi genetici.

Corrado Cantarelli
Progetto finalizzato C.N.R. per la ricerca di nuove fonti proteiche e di nuove formulazioni alimentari.

INDICE



Presentazione

A partire dagli anni '50, le leguminose da granella hanno avuto nel nostro Paese una regressione continua delle superfici coltivate (valga qualche esempio: la fava è passata da ha 517.567 nel 1959 ad ha 49.263 nel 1996; nello stesso periodo, la superficie investita a fagiolo si è ridotta da ha 488.115 ad ha 13.031).

La contrazione della superficie è dipesa principalmente dal minore utilizzo della granella nell'alimentazione dell'uomo (sostituita da alimenti più nobili) e degli animali (per la consistente riduzione del patrimonio zootecnico) e dal ridotto reddito assicurato agli agricoltori.

La minore competitività di queste specie negli ordinamenti colturali si è andata accentuando poiché: da un lato sono state relegate in aree sempre più marginali, povere, ed hanno fruito di ridotti interventi colturali; da un altro lato, hanno potuto disporre di ridotti o nulli interventi genetici e di insufficienti miglioramenti agrotecnici per adattare la tipologia di pianta alle mutate esigenze dei nostri sistemi colturali (meccanizzazione integrale delle colture, più opportuno collocamento del ciclo colturale per valorizzare l'umidità del suolo, resistenza alle avversità ambientali ed alle fitopatie).

Come è noto, gli scenari agricoli nell'Unione Europea e nel nostro Paese stanno cambiando e gli elementi base della politica agricola comunitaria poggiano sul riorientamento verso colture a destinazione non alimentare, a ridotto input di materie prime non rinnovabili e praticate con sistemi colturali il più possibile conservativi delle caratteristiche del suolo.

In questi scenari, alcune leguminose da granella sono suscettibili di fornire un contributo essenziale all'affermarsi di una agricoltura sostenibile e rispettosa dell'ambiente, in virtù di alcune importanti prerogative di cui sono depositarie: alternativa colturale in sistemi agricoli basati su monosuccessione di cereali, arricchimento del suolo con azoto atmosferico, preparazione dei terreni per la conversione a produzioni biologiche, copertura del suolo a fini protettivi, fonte di proteine ad alto valore biologico per il razionamento degli animali da reddito e per l'uomo (quest'ultimo, sempre più orientato a riscoprire le tradizioni della dieta mediterranea).

Realisticamente, il successo di queste colture dipende dall'attivazione delle relative filiere (che devono integrare tutte le fasi, dalla produzione alla utilizzazione) e dalla loro competitività in termini di reddito. In pratica, l'agricoltore deve essere incentivato alla coltivazione di queste piante e il mangimista deve trarre convenienza dall'utilizzo della granella prodotta "in loco", anziché da quella importata.

Nell'ottica di un rilancio del comparto, questo volume tratta le principali leguminose (da granella e da cover crops) che hanno maggiori tradizioni colturali nel nostro Paese, descrivendone per ognuna, in modo approfondito ed aggiornato, lo

Indice generale

AGRICOLTURA RICERCA

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A cura dell'Ismea
La rivista Agricoltura Ricerca viene pubblicata nel quadro dei programmi svolti dall'Ismea, con il contributo del Miraaf, per l'informazione sistematica sui risultati della ricerca e della sperimentazione

direttore editoriale
Ezio Castiglione

direttore responsabile
Antonio Falconio

redazione e amministrazione
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Ricerche e interventi per il miglioramento quantitativo e qualitativo delle leguminose da granella

Presentazione del Sottoprogetto: fava, cece, lupino

coordinatore **S. Foti**

L'Autore, nella qualità di coordinatore del sottoprogetto fava, cece, lupino, nell'introdurre l'organizzazione dei lavori del Convegno, premette alcune notizie essenziali sulla progressiva e marcata riduzione della superficie destinata a queste colture in Italia e sulle relative cause. Delinea quindi il ruolo che queste colture potrebbero svolgere nel quadro attuale dell'agricoltura italiana sia per il valore biologico del loro prodotto, sia per la funzione agronomica della loro coltivazione.
Riassume, quindi, gli obiettivi perseguiti dal sottoprogetto attraverso una rassegna dei settori e delle linee di ricerca posti allo studio, mettendo in evidenza le numerose Unità Operative coinvolte, la loro distribuzione territoriale e le linee di ricerca a ciascuna di esse affidate.
Precisato che il Convegno è stato articolato in una serie di relazioni di sintesi su ciascun settore di ricerca e per ciascuna coltura, il coordinatore conclude rilevando che, al di là dei risultati scientifici ed applicativi delle ricerche attuate, il progetto ha avuto certamente il merito di avere attivato le energie latenti nella ricerca italiana del settore e di aver mobilitato molteplici interessi attorno a colture per tanto tempo neglette.

In his introduction on the organization of the work of the meeting, the Author as coordinator of the "subproject Faba bean, chickpea, lupin" (Special project of the Miraaf: "Research and interventions for the qualitative and quantitative improvement of grain legume production") presents some essential information on the marked and progressive reduction of the area destinated to the above mentioned crops in Italy and on the causes of this.
Then he outlines the role that these crops may actually play in Italian agriculture considering the biological value of their production and the agronomic role of their cultivation.
He summarises the objectives of the subproject with a review of the sections and research lines studied, introducing the research groups involved, their territorial distribution and the research lines carried out by each group.
After specifying that the meeting had been organized in a series of synthetic reports on every research section and crop, the coordinator concludes by noting that, besides the scientific and practical relevance of the research carried out, the project had undoubtely the merit of putting into action some hidden energies of the Italian research on this subject, and of focussing several interests on these long neglected crops.

Introduzione

Il progetto di cui trattasi, i cui obiettivi sono esplicitamente espressi nel titolo, per ragioni operative è stato articolato in due sottoprogetti, facenti riferimento a colture caratteristicamente diverse per esigenze ambientali e tecniche:

I - fagiolo e pisello a ciclo primaverile-estivo, soprattutto il primo, con più o meno spiccate esigenze irrigue;

II - fava, cece e lupino a ciclo autunno-vernino-primaverile, pertanto non richiedenti, di norma, l'intervento dell'irrigazione.

Sul primo sottoprogetto, già nel febbraio 1992 è stato tenuto ad Ancona un Convegno conclusivo in seno al quale B. Casarini, responsabile del Progetto, ha riassunto le linee generali dello stesso e ha definito un bilancio dei risultati conseguiti nel quinquennio relativamente a fagiolo e pisello.

Questo secondo Convegno,

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STRENGTHS

TECHNOLOGICAL ASPECTS

- GREEN AND SUSTAINABLE TECHNOLOGIES
- FRACTIONATION AND RECOMBINATION
- EXTRUSION COOKING
- CONSOLIDATED TECHNOLOGY

NUTRITIONAL ASPECTS

- FUNCTIONAL FOODS (BIOACTIVE COMPOUNDS)
- TAILOR MADE FOODS
- FOOD MODELS (MEDITERRANEAN DIET, VEGETARIAN AND VEGAN DIET)
- INTOLERANCE /SENSITIVITY (LACTOSE, GLUTEN, MILK PROTEIN)
- PSEUDOCEREALS AND OTHER EXOTIC SPECIES
- GLUTEN-PHOBIA

WEAKNESSES

- LACK OF INDUSTRIAL CHAIN (ITALY)

  (STOCK APPROPRIATE FOR QUANTITY AND QUALITY)
- NICHE PRODUCTS (PDO, PGI, TRADITIONAL)
- COMPETITION WITH CEREALS (WHEAT)
- ANTINUTRITIONAL FACTORS
- BEANY FLAVOUR

CONCLUSION/PROPOSAL

- ***STRATEGIC PROJECTS***

  (MIPAAF, MIUR, MISE)

- ***INFORMATION AND COMMUNICATION***

  (appropriate and correct)

- ***INDUSTRIAL PULSE CHAIN***

Mister **Kamut**: «La mia America? L'ho trovata da voi in Italia»

Parla Bob Quinn, creatore del marchio: «Qui consumate il 75% della produzione mondiale del nostro grano»

Chi è

● Bob Quinn, statunitense del Montana, è il fondatore del marchio Kamut che mette in commercio prodotti come pasta, cracker o grissini a base di khorasan, un grano antico dall'elevato contenuto di proteine e sali minerali

L'inizio della storia sta in 36 chicchi giganti di un grano antico spediti in dono dall'Egitto a un pilota americano. Il quale, a sua volta, li spedì al padre perché li piantasse nel proprio terreno. Il grano germogliò e fu presentato un po' in giro. Ma non ebbe successo.

Trent'anni dopo Bob Quinn sta leggendo la composizione di una confezione di Corn Nuts e si ricorda del grano gigante visto tanto tempo prima alla fiera della contea. Parte così la scommessa: il khorasan Kamut, un cereale antico biologico di alta qualità che piace soprattutto in Italia. Anzi, si potrebbe dire che Quinn, americano del Montana, la sua America l'abbia trovata da noi. «L'Italia — racconta, infatti, l'imprenditore — assorbe circa il 75% della produzione mondiale di khorasan Kamut». Siamo stati noi, per esempio, i primi a produrre la pizza Kamut e gli unici a produrre la birra Kamut. Pioniere dell'agricoltura biologica e sostenibile, cresciuto in una fattoria del Montana, un Phd in biochimica vegetale, Quinn è riuscito non solo ad affermare questa particolarità di grano, ma soprattutto ad affermarla come marchio. Kamut, infatti, non è il nome del cereale (che invece è khorasan), ma il brand scelto da Quinn e da suo padre. «Pensai che avevamo bisogno di un nome che fosse unico e che rimandasse all'egiziano antico — ricorda —. Nella biblioteca di Great Falls, una città vicina alla nostra azienda agricola, trovammo che nell'antico Egitto grano si diceva kamut. Molti anni dopo scoprimmo che questo antico cereale non aveva origine in Egitto, ma ormai il nome era stato registrato».

Chi è
Bob Quinn, americano, esperto di biologico, è l'inventore del marchio Kamut

Fa davvero bene il Kamut? Escluso chi soffre di celiachia, per i quali non è adatto, ha un elevato contenuto di proteine e sali minerali come zinco e magnesio e soprattutto il selenio dalle proprietà antiossidanti. Ma c'è chi dice che sia solo un'operazione di marketing. «La maggior parte delle persone che non possono mangiare grano moderno — risponde — non ha problemi con il Kamut, stiamo riscontrando risultati molto positivi, sono stati pubblicati 16 articoli su alcune delle più importanti riviste scientifiche su questo argomento. Che è anche il tema che mi appassiona di più. Quanto alle critiche, succede per qualunque progetto, c'è chi lo ama e chi no».

Per usare il marchio occorre un accordo di licenza: «Non ha costi. Chiediamo però all'utilizzatore di comunicare in modo trasparente le informazioni sul grano, usarlo in modo corretto, mantenerne la qualità e consentire ovviamente le verifiche tese ad accertare che non venga miscelato con altri grani».

Maria Silvia Sacchi

CORRIERE DELLA SERA 10 giugno 2016 – pag. 35

FOOD TECHNOLOGY FOR THE VALORISATION OF GRAIN LEGUMES/PULSES

EMANUELE MARCONI

(UNIVERSITY OF MOLISE)

marconi@unimol.it

Società Italiana di Agronomia XLV Convegno Nazionale

La ricerca agronomica verso il 2030: gli obiettivi globali di sviluppo sostenibile

Università degli Studi di Sassari 20-22 settembre 2016