FOOD PERSPECTIVES OF SUNFLOWER PROTEIN PRODUCTS

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INTRODUCTION

New protein sources for human consumption are regarded as valid protein supplements to the traditional animal and vegetable proteins. Among those which may be considered high-protein commodities, particularly important are the vegetable sources namely legumes and oilseeds.

Currently the major part of novel vegetable proteins are produced from soybeans, and are generally used as a protein base in animal feedstuff. However, the development of vegetable proteins for human consumption has the advantage of avoiding the high cost of the intermediary livestock step in the nutrition chain. Because of their low cost with respect to animal proteins, vegetable proteins are expected to favor a more equal distribution of protein consumption among the different social groups.

The novel food proteins issue in these last few years received considerable attention also in Italy and large effort has been devoted to the development of suitable technologies for the production of edible vegetable proteins from existing agricultural products on those which could easily be cropped in Italy (Bonni and Sodini, 1981).

In this framework sunflower seed has been considered a very attractive raw material.

The utilization of sunflower seed as a good quality edible oil source is well established.

By now the industrial production of sunflower oil has reached five million tons/year worldwide, and it is second only to that of soybean oil. This production is supported by a substantial development of the genetics and agronomy of sunflower (Carter, 1978).

In 1979—1980 in Italy, 50—60 thousand hectares of sunflowers were grown, with an average yield of 17—20 quintals/hectare and a production estimated at 100,000 tons of seeds (Sediari, 1980).

Sunflower seed is also a very good source of protein, but up to now it has not yet been at best exploited for this purpose, because of the low quality of the flake obtained by the food oil industry, which can be used only as animal feedstuff.

With respect to other oleaginous products, such as soybeans, sunflower seed is characterized by the absence of antinutritional factors (e.g. trypsin inhibitors and the fermentescible sugar stachiose) and specific off-flavors and the presence of proteins with a rather ballanced aminoacid profile and particularly a good percentage of sulphur aminoacids (Clandinin, 1958; Sosulski and Fleming, 1977; Roy and Bhat, 1974; Sabir et. al., 1975; Tranchino et al., 1981).

The industrial research laboratories ASSORENI have recently deviced and developed a novel process, where mild operating conditions are applied, capable of producing high protein products suitable for human consumption by using high oil type sunflower seed as raw material (Tranchino et al., 1981; Costantino et al., 1981).

A thorough study is under way in our laboratories aiming to :

— assess whether the good qualities of sunflower seed are retained in the final products;

— find out specific food applications depending on the biological-functional characteristics of the products themselves.

This report describes the main results obtained until now.

RESULTS AND DISCUSSION

Defatted sunflower flour and sunflower protein concentrate represent the main products of the ASSORENI process, whose block scheme is shown in figures 1—2.

On these protein materials we have carried out a detailed characterization and an evaluation of their applicative performance both in model and real food systems.

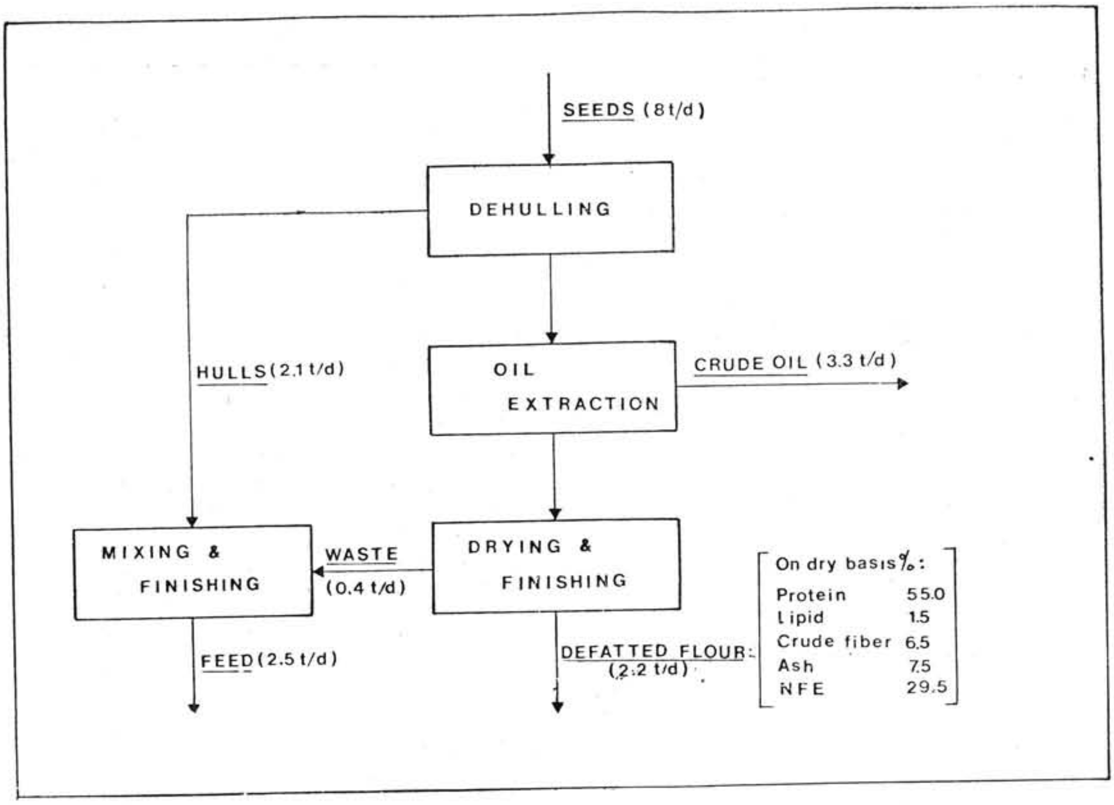

Fig. 1 — Diagram of process producing defatted sunflower flour.

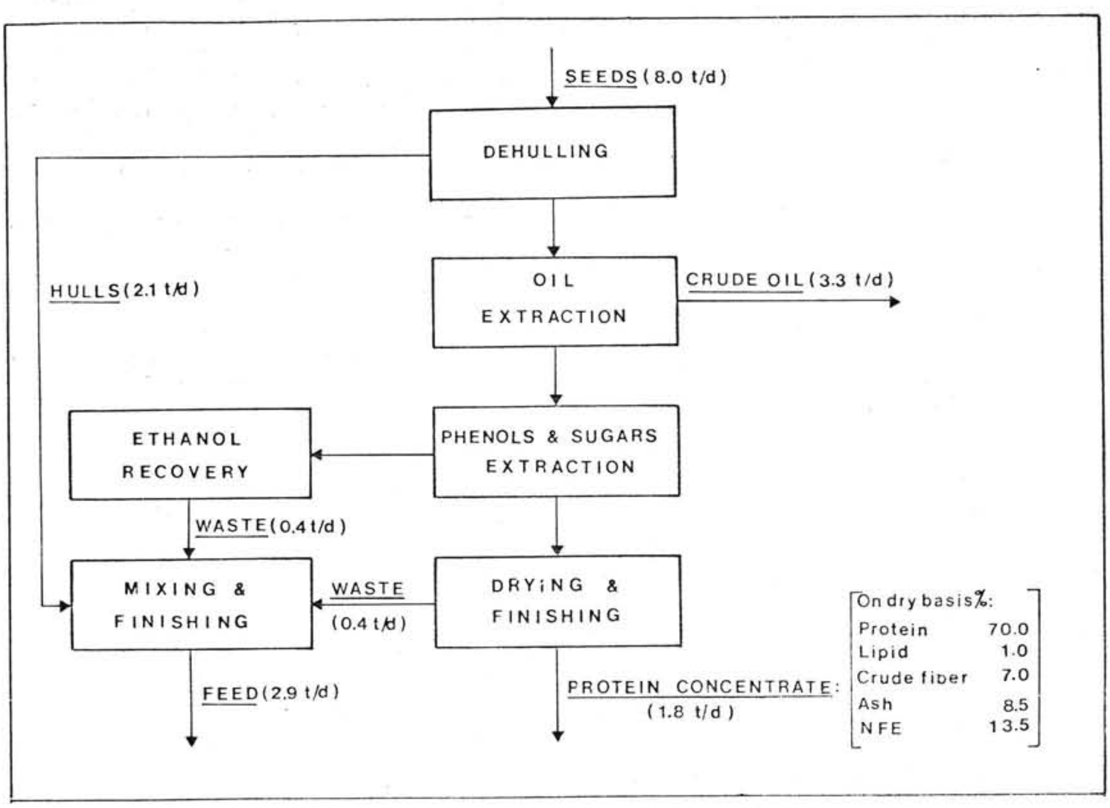

Fig. 2 — Diagram of process producing sunflower protein concentrate.

PRODUCT CHARACTERIZATION

1. CHEMICAL COMPOSITION

The proximate chemical composition of sunflower protein products is shown in table 1.

Both materials are characterized by a high protein content and a low residual value of lipid and crude fiber.

Table 1

Chemical composition (%, dry basis)

Components	Defatted sunflower flour	Sunflower concentrate
Protein	55.0	70.0
Lipid	1.5	1.0
Crude fiber	6.5	7.0
Ash	7.5	8.5
N.F.E.	29.5	13.5

Particularly defatted flour contains complex polysaccharides namely cellulose (7.0%), hemicellulose (6.0%) and pectins (2.0%), which are not metabolized by the human body and may be considered dietetic fiber, and oligosaccharides, such as saccharose (6.0%), raffinose (3.5%) and glucose (1.0%).

Chlorogenic acid (3.5%), a phenolic compound, comprising a molecule of quinic acid and a molecule of caffeic acid, which is a darkening agent under neutral and alkaline conditions, is also present.

As regards sunflower concentrate this refined product is characterized by a very low content of residual chlorogenic acid (0.2%) and soluble sugars (0.3%).

2. AMINOACID PROFILE

Table 2 illustrates the aminoacid profile of sunflower protein products in comparison with F.A.O. indications.

Except for lysine, all other essential aminoacids are contained in an amount comparable with that recommended by F.A.O.

The lower lysine content makes this aminoacid the first limiting aminoacid for sunflower proteins, which, on the other hand, show an interesting high content of methionine and cysteine.

However we have assessed that the lysine content of the seed remained practically unchanged in the processed materials and lysine availability, measured by using the Carpenter method (1960) was nearly total in the final products.

3. MICRONUTRIENTS

Sunflower protein products and especially defatted flour are characterized by a good content in minerals of nutritional interest such as calcium, iron and phosphorus and may be considered a good source of hydrosoluble complex B vitamins (thiamin, riboflavin, and panthotenic acid).

Table 3 shows the content in micronutrients of sunflower defatted flour compared with that of a commercial soybean defatted flour.

Table 2

Aminoacid composition (g/16 g N)

Essential	Sunflower flour	Sunflower concentrate	F.A.O. pattern
Isoleucine	3.7	4.6	4.0
Leucine	6.5	6.8	7.0
Lysine	3.4	3.4	5.5
Methionine	2.1	1.8	3.5*
Cystine (1/2)	2.0	1.7	
Tryptophan	1.5	1.4	1.0
Phenylalanine	5.5	5.5	
Tyrosine	2.7	3.2	6.0**
Valine	4.9	4.6	5.0
Threonine	3.3	3.4	4.0
Non essential			
Arginine	7.8	9.1	
Histidine	2.3	2.5	
Alanine	4.4	3.9	
Aspartic acid	9.5	9.0	
Glutamic acid	22.0	22.5	
Glycine	5.9	5.5	
Proline	5.0	4.0	
Serine	3.7	3.9	

* Methionine + Cystein
** Phenylalanine + Tyrosine

4. FLAVOR PROPERTIES

No off-flavors are present in sunflower seed, as is evidenced by the direct use of the kernel as snack food or nut substitute.

Table 3

Micronutrient content of defatted sunflower and soybean flours

Micronutrients	Products	
	sunflower flour	soybean flour
Minerals (%)		
Calcium	0.60	0.25
Iron	0.035	0.007
Phosphorus	1.3	0.70
Vitamins (mg/kg)		
Thiamine (B_1)	38.0	8.5
Riboflavin (B_2)	4.2	2.4
Panthotenic a. (B_5)	45.0	25.0
Nicotinic a.	318.0	27.0

To check whether the process conditions alter the good flavor of the seed, an organoleptic analysis was carried out by a 15 member trained taste panel on the sunflower protein products *.

The panelists rated each sample (presented as 2% dispersion in water) on a scale of 10 to 1 with 10 as bland and 1 as strong and described the predominant flavors which they detected, rating it on a scale of 0 to 3 with 3 as strong.

Sunflower flour received a flavor score (7.9) and descriptions (cereal 1.0 and bitter 0.3) typical of wheat flour analyzed for comparison, which was rated as 8.0 by the panel.

The predominant flavors detected in sunflower concentrate were cereal, grassy/beany and bitter rated 0.5, 0.5 and 0.4.

For this product the importance of removing the residual ethanol (used during the process to extract phenols and sugars) to maintain the taste neutrality and the high flavor score of sunflower flour was also remarked.

5. SOLUBILITY CHARACTERISTICS

Figure 3 shows the nitrogen solubility data in water and in 5% sodium chloride at different pHs of sunflower defatted flour and concentrate.

The curve in water for both products is characterized by a minimum at acid pHs and presents a drastic increase going towards alkaline pHs. In sodium chloride, at neutral pH, where the globulin fraction, which is the main component of sunflower seed proteins (Sosulski and Bakal, 1969), is naturally soluble, the flour and protein concentrate show solubility values of protein nitrogen close to 80% and 60% respectively.

The data, showing a poor water solubility of sunflower proteins at acid-neutral pHs and a high solubility in sodium chloride solutions at neutral pH, suggest good applicative possibilities for the products in many foods, including ground meat and milk type products, whose salts like sodium and calcium chloride are common constituents (Sosulski and Fleming, 1977).

To increase the solubility in water at acid-neutral pHs of sunflower protein products and render it suitable to be introduced in beverage, confectionary and some other specialized products sunflower proteins have been successfully hydrolized by proteases (Russomanno et al., 1982; Kabirullah et Wills, 1981).

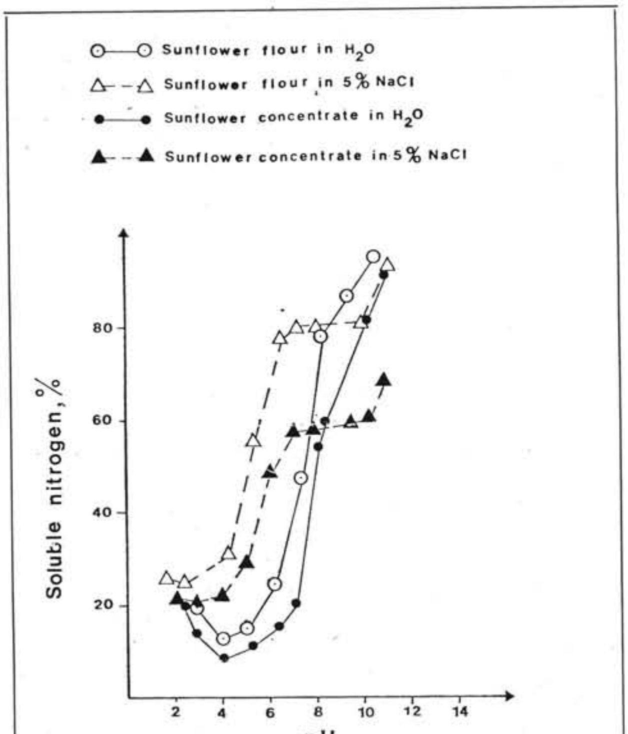

Fig. 3 — Nitrogen solubility profiles in H_2O and 5% NaCl of sunflower protein products.

* Rachis J. J. and Warner K., personal communication.

EVALUATION OF APPLICATIVE PERFORMANCE

Taking into account the low percentage of albumins ($\sim 20\%$), water soluble proteins, and the high content of globulins ($\sim 55\%$), quite soluble proteins in salt solutions, which characterize sunflower proteins, the solubility curves, seen above, suggest for the plant-produced sunflower protein products, particularly for defatted flour, a very limited degree of denaturation.

This is generally an important property in determining good food performance.

1. FUNCTIONAL PROPERTIES

In order to have information about the functionality of our products and consequently their behaviour in food we have measured by proper laboratory tests (14—16) some chemical-physical properties of the powdered materials in very simple model systems. Some commercial soybean products have been examined for comparison.

The results are shown in Table 4. Sunflower protein products, and in particular the flour, have a fat absorption capacity which, in general, is higher than that of the respective soybean products ; water absorption, on the other hand, shows an opposite trend. Whipping properties, either in terms of percentage of volume increase or foam stability, and emulsifying properties (emulsifying activity and emulsion stability) are remarkable, especially again for sunflower flour.

Table 4

Functional properties of sunflower and soybean protein products

Functional properties	Sunflower flour	Soybean flour	Sunflower concentrate	Soybean concentrate
pH, 10% dispersion	6.4	6.5	5.6	6.9
Water absorption (ml/100 g)	95	153	145	245
Oil absorption (ml/100 g)	213	115	125	110
Volume increase on whipping (%)	121	67	50	42
Foam decrease at 30′ (%)	19	44	24	91
Emulsifying activity (%)	58	58	53	51
Emulsion stability at 80°C, 30′ (%)	56	56	50	27

2. TEXTURIZING FEASIBILITY

If used as main food constituents, the novel food proteins must be texturized in order to have suitable chewability.

We have studied the feasibility of texturizing defatted sunflower flour and protein concentrate and evaluated the applicability of the successfully texturized products in selected food systems. Various texturization methods have been examined and applied to sunflower proteins : extrusion cooking, gelation, stretch-cross-folding and freeze texturization (Boni et al., 1981).

Extrusion cooking. This technology has been applied to our products to prepare meat extenders and analogs, and in mixture with starch, snack foods, biscuits and highly nutritive beverages and puddings.

Extruded sunflower defatted flour and protein concentrate, with a definite fibrous structure, resembling the meat texture, have been produced by using single or double screw pilot plant extruders. The extruded materials obtained both in chunk and mince form maintain their structural integrity during the hydration, showing a good rehydration ratio (2.5—3.0 g H_2O/g).

Owing to these physical properties, a natural color close to cooked meat color and above all a bland taste, extruded sunflower protein products can be advantageously used as meat analogs and meat extenders.

For example hamburgers, with an increasing extension degree from 0 to 100, have been successfully prepared by using rehydrated extruded flour in mince form.

Unlike extruded soybean flour, extruded sunflower proteins are well suited to be introduced in canned products because their texture is not affected by the sterilization conditions.

Using a Brabender extruder at 135°C—140°C, a slurry containing up to 20% sunflower concentrate has been extruded, shaped, dryed and then expanded in 170°C—175°C oil.

The resulting product is a high protein snack product, corn chip type, which has been obtained with different flavors (salty or sweet type).

On a cooking extruder Grondona-Nimet (Torino, Italy) two differently composed mixture containing principally sunflower defatted flour and starchy materials have been prepared. They may be the basis of highly nutritive foods particularly suitable for developing countries.

High protein instant beverages, variously flavored, can be easily obtained by adding water to the proper mixture resulting in a 15% milk-type emulsion.

By adding 3 part of warm water to 1 part of the other mixture puddings are obtained in a form of a paste.

The composition of the formulas (protein, lipid, carbohydrates and minerals) has been carefully studied in order to have a final food products properly balanced from nutritional point of view.

Gelation. The gelation process has been tried for both sunflower flour and concentrate.

Different conditions of concentration, pH and heat were exploited.

A 30% water dispersion of flour and concentrate forms firm gels at pH close to neutrality when heated for 30 minutes at 120°C. Flavorings have been incorporated into the gelling system by adding them to an emulsion, properly prepared, and mixing the emulsion with the sunflower dispersion. The aroma was evident in the finished product. These trials show that gelling can be utilized as a good method of texturization and flavor incorporation.

Luncheon meats, dietetic and specialty foods can be successfully developed using the gelling technique. These formulations represent a good prototype especially for 10% sunflower flour utilization.

Stretch-cross-folding. In stretch-cross-folding, texturization method developed at Institute Battelle-Genève a proteinaceous dough is passed through rotating rolls, where it is at first stretched into a thin film. At the end of the third roll a blade is used to scrape and gather the stretched film forming small longitudinal folds, which resemble the fibrous structure of meat. These small folds are gathered in larger folds similar to the matrix of connective tissue. This texture is set with heat. This method is widely applicable to sunflower concentrate alone or in connection with meat. Up to 15% (dry basis) sunflower concentrate in meat, the flavor and color of the unheated textured material are not significantly different from those of meat and the product can be frozen, sliced and marketed as a frozen extended steak or roast.

It can also be sterilized right after texturization and used in institutional applications.

One can also utilize high concentrations of sunflower proteins in combination with low quality meat at high fat content and obtain stretch-cross-folded samples that can be used very successfully in canned stew, ragù or pasta filling type products. This possibility should be very interesting to the meat industry in a context of meat reforming. In this application sunflower protein is superior to soybean protein, because at this high percentage the utilization of soybean would impart a very distinct taste.

Freeze texturization. The other novel method of texturization, also developed at Battelle-Genève mainly for animal proteins, is freeze texturization (Giddey and Güney).

It is a mechanical process where a mixture of proteins and water (containing up to 80% water) is spread in 3 mm thick sheets and let to freeze. After imprinting of grooves to form points of better adhesion, a second and then a third layer are applied.

The texture created is fixed after heat treatment in the frozen state.

Sunflower flour and concentrate can be most successfully used to extend meat mixture using this method.

15% concentrate and 10% flour in meat seem to give the best results. By introducing sunflower proteins no significant changes were in the color and flavor of meat. The texturized product can be used as a frozen steak or in stew type canned products.

It is interesting to note that the samples were better than similar runs made with soybean proteins, in which the soybean flavor came through.

CONCLUSIONS

The high protein and low crude fiber content of sunflower protein materials produced by ASSORENI technology, as well as their good biological, flavor and functional properties let foresee a vast range of food applications.

We can distinguish two categories of applications, namely those ones not requiring texturization process and those for which this technology is a necessary step.

Within the first category sunflower proteins, because of their biological properties, may be profitably introduced in protein fortified foods, for instance in some bakery products and baby foods or in low-cholesterol diets.

Moreover these proteins, having a remarkable functionality, may be used as technological aids in confectionary products (e.g. creams, puddings and other desserts) and emulsified meats (e.g. sausages, würstels).

As concerns the second category, the feasibility of sunflower proteins to give structured materials characterized by a good texture and a bland taste has been widely assessed.

Properly texturized sunflower flour and concentrate may be successfully introduced as main components in food systems covering important market sectors such as processed cooked and raw meats, (e.g. hamburger, reformed meat), ready foods (e.g. stew, luncheon, ragù), special pasta (e.g. ravioli and tortellini filling) and high protein specialized foods (e.g. snack, instant beverage and instant pudding).

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PERSPECTIVES ALIMENTAIRES DES PRODUITS PROTÉINIQUES DU TOURNESOL

Résumé

La graine de tournesol constitue une excellente source d'huile végétale et de protéines pour la consommation. Les laboratoires d'études industrielles ASSORENI ont mis au point un nouveau procédé pour obtenir du tournesol des produits comestibles ayant un taux élevé de protéines : la farine dégraissée de tournesol et un concentré de protéine.

Les propriétés biologiques, fonctionnelles et gustatives de ces produits ainsi que les possibilités de texturer ont été étudiées sur modèle et dans des essais d'alimentaion réelle. Les excellentes qualités de ces produits de tournesol riches en protéines ouvrent un vaste champ d'applications dans le secteur alimentaire, pour la farine et les formes texturées. Ainsi, on entrevoit l'utilisation des protéines texturées de tournesol pour des produits de viande (hamburger, etc.) préparés à partir du produit haché, malaxé et façonné ou à partir du produit texturé congelé. Différentes recettes furent formulées pour des mets tels que ragout, les hamburger, les bouchées, entièrement à base végétale, protéines du tournesol texturées par gélatinisation, malaxage et façonnage au hachage. Pour d'autres types de produits alimentaires : produits expandés, boissons et patisserie à préparation rapide, les protéines de tournesol ont été mélangées à des matières riches en amidon. Tous ces produits alimentaires ont une haute valeur nutritive.

PERSPECTIVAS ALIMENTICIAS DE LOS PRODUCTOS CON PROTEÍNA DE GIRASOL

Resúmen

La semilla de girasol ha probado ser una excelente fuente no sólo de aceite vegetal, sino también de proteina para el consumo humano. Los laboratorios de investigación industrial ASSORENI han desarrollado recientemente un nuevo proceso para fabricar productos de girasol comestibles, con un porcentaje elevado de proteína, a saber : harina de girasol degresada y concentrado de proteína.

Se han estudiado en sistemas modelo y de alimento real las propriedades biológicas, funcionales y gustativas de estas materiales, así como sus posibilidades de texturización. Las buenas calidades de los productos con proteína de girasol dejan entreverse un amplio campo de aplicación en el dominio alimenticio, tanto utilizando la harina, como también formas texturizadas. Se han puesto en evidencia las interesantes aplicaciones de las proteinas texturizadas de girasol en diferentes sectores de consumó.

Productos de carne en mezcla (hamburger y carne reformada) se han preferado empleando pruebas picadas, amasadas y reformadas, o bien pruebas texturizadas y heladas. Se han formulado platos enteramente vegetales (carne para aperitivos, ragu, hamburger) basadas en proteína de girasol, texturizada por gelatinización, amasamiento y recomposición, o picado. Se han preparado mezclas de proteínas de girasol y materiales amidonosas para obtener alimentos como : aperitivos expandatos, bebidas y pasteles preparadas instantáneamente, caracterizadas por un valor nutritivo elevado.