PROSPECTS FOR COMPOSITE FLOURS AND NOVEL PROTEIN SOURCES

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Introduction

The events in food availability and market prices which have taken place during the last 3-5 years have made governments realize to some extent, the tremendous importance agriculture has in supplying the basic food needed to, at least, keep hunger away from their own populations, and in a way become self-sufficient in the production of these foods. But basic foods alone, which vary according to regions and dietary habits, are good to fill stomachs but not good enough to provide adequate nutrition in spite of the fact that the correct mixture of cereal and legume grains is better than just cereals whether for young or adult human subjects. The situation is far worse if instead of cereals, tubers are consumed, since there is some difference in protein content between the two.

Self sufficiency in terms of food availability must be based on sound and efficient agricultural programmes which must include, when possible, the production of foods in an integrated manner. The concept of self-sufficiency carries within it a very strong economic component which should not override the nutritional aspects of food, otherwise, very little would be gained in terms of the well-being of the population.

However, increased and planned agricultural production together with food science and technology may make it possible yet, to produce highly acceptable and nutritionally good foods, and make countries and regions less dependent on other nations for their food supply. Furthermore, independence can also be attained by developing their own type of foods following dietary habits and customs of their own populations.

The present paper will discuss the possibilities that composite flours have to supply good nutrition and help attain self-sufficiency. It will also discuss the potential of new protein sources and analyse the problem of improved quality of basic food crops, and efficiency of land utilization in agricultural production.

Composite Flours

The term composite flours was coined in 1964 by FAO when it was recognised that non-wheat producing countries had to find ways by which wheat imports could be maintained constant, be reduced or even disappear. Wheat consumption is constantly increasing in most countries due to a normal rate of population growth, improved socio-economic conditions of the people, increased availability of wheat products and because these are well accepted by people. Therefore, much attention has been given to the problem in recent years.

The term *composite flours* is utilized according to the concept first expressed by FAO to define mixtures designed to produce foods commonly manufactured from wheat, such as bread, pasta, cookies and others. The various possibilities are shown in Table 1. Composite flours can be made from cereals other than wheat and from other vegetable sources and may or may not contain wheat flour. On this basis, there are two general kinds of flours. One is known as diluted wheat flours in which wheat flour has been extended with other flours up to a level of about 40 per cent. They may contain other components and the addition of supplementary protein is optional. The general conditions of processing and the type of final product obtained are comparable to those products made exclusively from wheat.

Table 1. Composite flours

1. *Wheat flour + other flours* (cereal, starchy roots and tubers)

   Wheat flour + other flours + supplementary protein

   Wheat flour + supplementary protein

2. *Starchy roots or tubers* + supplementary protein

3. *Legume grain flours, oilseed flours* and *other*

The second type is represented by flours without wheat and are made of tuber flours and protein, usually from soya beans in the proportion of 4 to 1. These products are different in rheological characteristics from those made of wheat gluten. Work carried out during recent years has resulted in technologies capable of producing flours with increasing acceptability by the consumer.

The concept composite flour may, however, be expanded to cover those not necessarily made of cereals or tubers, as is the case of legume grain flours, high protein foods containing oil seed flours and others.

The examples to be given in this paper are, therefore, used in this broad concept of composite flours. These examples are applicable to most countries; however, some are specific for Central America and may not be applied to other regions. Similar situations, however, may be developed in other regions depending on dietary habits and availability of raw materials.

Nutritional Considerations

The concept of composite flours includes an economic component which should not prevail over the nutritional component, otherwise, nothing is really accomplished. Since cereal grains are in most places the basic staple and in many of them wheat is involved, the nutritional considerations will be based on the nutritional changes which could occur when the wheat flour is extended or replaced by other flours. Various possibilities will be discussed.

Extension by Means of Other Cereal Grain Flours

Cereal grain proteins are basically nutritionally very similar, with one or two exceptions [1]. Furthermore, the protein make-up is also quite similar. The total protein and lysine content of different cereal grains and the quality of the protein is shown in Table 2. The main amino acid deficiency in all of them is lysine, and protein concentration is below 10-12 per cent. Wheat flour has the same quality as corn or sorghum flour with oats, Opaque-2 corn and rice being superior, in this respect. Therefore, any replacement of wheat flour by the flour from other cereal grain with the exception indicated, will result in a production of equal nutritional characteristics as wheat flour or slightly above.

Table 2. Protein content and quality of various cereal grains

Cereal grain	Protein Content (%)	Protein Quality PER	Lysine Content mg/g N
Corn (common)	8.5	1.32	180
Opaque-2 Corn	10.2	2.74	281
Rice	7.8	1.98	235
Whole Wheat	14.1	1.62	160
Wheat Flour	10.2	0.86	130
Oats	13.3	2.04	214
Sorghum	10.2		170

Extension by Means of Root Crop Flour

Various countries, particularly those in the tropics produce significant amounts of root crops. These are chemically characterized as being excellent sources of carbohydrate energy, but have the disadvantage of containing relatively low amounts of protein as shown in Table 3. Furthermore, this protein is poorly identified with the exception of that in potato and cassava. Since potatoes are not a crop from tropical areas they will not be discussed. On the other hand, there are reports indicating that the nitrogen in cassava is not only present in small amounts, but is only 50 per cent protein in nature and this, deficient in sulphur-containing amino acids. It is not appropriate to generalize on this basis about other root crops, therefore, if root crops are to make a contribution, attention should be given to a better identification of the protein.

The Table also includes values for common wheat flour. It may be seen that all root crop flours have a lower crude protein content than wheat flour. Therefore, if wheat flour is replaced by root flour, it is obvious that total crude protein content will decrease. This also implies that protein quality will decrease as shown in Table 4. In this example weight gain highly correlated with protein quality, decreased from 33g to a value of -5g when the protein in the cereal was diluted with corn starch from 9.5 to 5.7 per cent. The latter value is comparable to the protein content of a mixture of 50 per cent wheat flour and 50 per cent cassava flour. In this case, therefore, protein supplementation is required if the final objective is not one of economic savings alone but one of nutritional quality as well. An additional factor which should be taken into consideration is the extent of biological utilisation of the

Table 3. Major tropical root crops and their protein content

Root Crop	Protein Content	
	Fresh (%)	Flour (%)
Manioc *Manihot esculenta*	1.0	1.7
Yams *Dioscorea* spp.	2.0	6.4
Aroids *Colocasiu esculenta*	1.6	5.5
Xanthosoma anfittifolium	1.7	4.3
Chayote *Sechium edule*	2.0	8.2
Sweet Potato *Ipomonea batata*	1.3	3.5
Potato *Solanum tuberosum*	2.8	6.4
Wheat Flour	-	10.2

Table 4. Effect of dilution of cereal grain protein with cornstarch on weight gain of rats

Protein (%)	Average Weight Gain (g)
9.50	33
7.69	5
5.69	-5

the carbohydrate fraction of the root crops, in comparison with the utilization of the carbohydrate fraction in wheat flour and other cereal grains. This point is under investigation in our laboratories since studies are being conducted on the use of root flour in composite flour. Some preliminary results in which cornstarch from the basal diet was replaced by the flour produced from an edible aroid, *Xanthusome sigittifolium*, showed that weight gain decreased as the root flour increased in the diet, although food intake was higher. The dry weight of faeces collected from animals consuming such diets, also increased as root flour increased in the diet. These results thus inducate that the animal had to consume more food in order to satisfy its energy needs, suggesting that the digestible energy of the carbohydrate fraction in the root flour, is low. This aspect, however, requires further investigation since all root flours may not behave the same.

Novel Protein Sources

Much has been written on the subject particularly during the last ten years, but the use of the new proteins has been rather limited particularly in developing countries. The traditional sources are the residues of the oil-containing seeds, with soyabean playing a significant role [1,2]. The importance of these products is related to both, the protein contribution they can make, as well as the functional properties they have and can transfer to the food being produced. In this respect the soyabean has also a privileged position. Although there is a great deal of interest in introducing soyabeans, in the tropical areas of the world which thus far, looks encouraging, there are already in the tropics, seeds which could play a role similar to that of the soyabean. These are the legume grains, which have a protein make up similar to that of the soyabean, although at a lower concentration. A comparison in selected nutrient content between soyabeans and other legume grains, is shown in Table 5.

The difference between soyabeans and other legume grains is that the soyabean contains around 20 per cent of oil which when removed causes an increase in protein concentration to almost 50 per cent. On the other hand, other legume grains contain higher amounts of carbohydrates instead of oil and about half the amount of protein. The extraction of this portion, however, as is also the case of soyabeans, can yield a protein isolate with as much as 90 per cent protein. Lysine and methionine content is, in general, quite similar. The functional properties of both are very similar; in this presentation therefore, rather than discussing the prospects of the traditional new protein sources emphasis will be given to the proteins of legume grains, many of which are already grown in many countries in the tropics.

Before discussing their use, some information will be presented on the process of making protein isolates from legume grains. One example is given in Figure 1 for the extraction of the protein from cowpea *(Vigna sinensis)*. By a very simple process involving water extraction of the meal at an alkaline pH, about 87 per cent of the protein is recovered. The protein isolate prepared from this extract has a protein content of 60-70 per cent and a protein quality as good as that of the original source. The isolated protein can be dehydrated or used as obtained depending on the application to be given to them. A similar type of process has been applied to *Cajanus* and *Canavalia* with the same kind of results.

Applications

1. *The Use of Other Cereal Grains to Extend Wheat Flour*

It was already indicated that one variation of composite flour is that in which part of the wheat flour is substituted partially by the flour of a cereal grain. In Central America for obvious reasons, the combination studied so far, was that of wheat flour and degerminated corn flour. The mixture was tested in various types of food products; bread, pasta and cookies.

Figure 1. Process for the preparation of pre-cooked bean flour

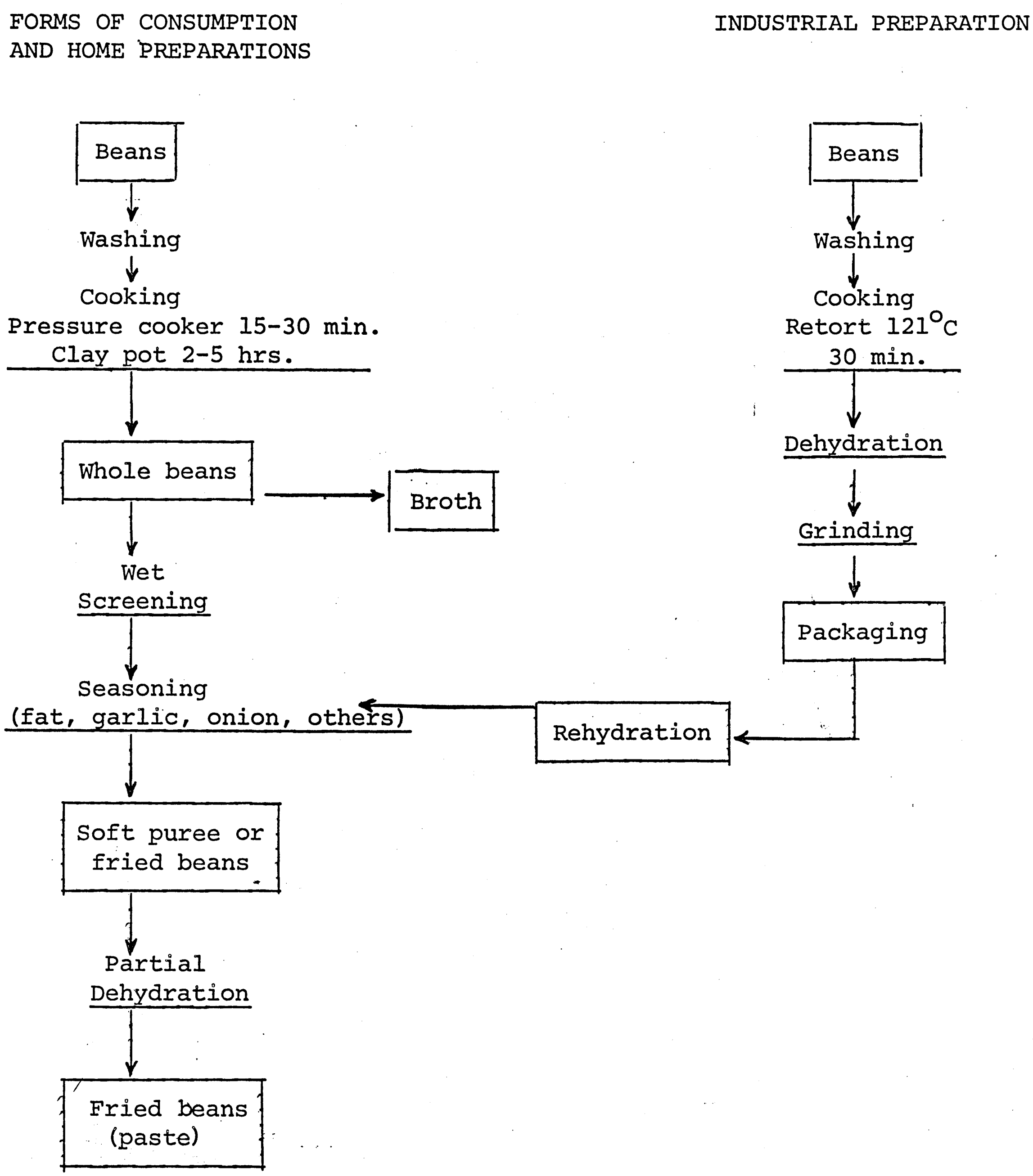

Table 5. Content of selected nutrients in soyabeans and other legume grains (moisture-free basis)

(%)

Nutrients	Soyabean *Glycine max*	Caupi *V. sinensis*	Pigeon pea *Cajanus cajan*	Common bean *P. valgaris*
Protein	42.0	27.0	22	26
Fat	20.0	2.1	1.7	1.8
Carbohydrates	35.5	58.5	64.0	61.4
Lysine (mg/g N)	395	486	546	500
Methionine (mg/g N)	84	79	111	67

Table 6. Effect of replacing wheat flour by corn flour and other modifications on the physical and organoleptic characteristics of bread for Central America

Treatment	French type		Treatment	Sweet type
	Volume (ml)	Organoleptic Score		Volume (ml)
Standard	330	5.2	Standard	223
70% Wheat flour 30% Corn flour (1)	155	3.9	60% soft Wheat flour 40% Corn flour (2)	150
(1) + CMC	258	4.5	(2) + CMC	163
(1) + SSL	288	5.1	(2) + SSL	170
(1) + CMC + SSL	303	5.3		
Mechanical action	320	5.3	60% soft Wheat flour + 28% Cowpea flour + 12% Corn flour	200

Maximum possible organoleptic score: 6.0
INCAP unpublished data.

The studies concerning the development of bread were carried out using degerminated corn flour for the preparation of two types of bread consumed in Central America. One is a french type and the second a sweet roll type of bread, the latter of high consumption among the population of low economic resources. The studies carried out, involving standard measurements in bakery shown in Table 6, indicated that for the french type of bread substitutions as high as 30 per cent of the wheat flour by corn flour did not interfere with baking characteristics and was highly acceptable. The bread produced is no different from a 100 per cent wheat flour bread particularly if emulsifiers, such as SSL or CMC are added in amounts of 0.5 and 2 per cent, respectively. Better results were obtained when both were added together, however, mechanical treatment of the dough was as suitable, with economic advantages. Biological tests also indicated the wheat flour-corn bread was slightly but constantly higher in protein quality than 100 per cent wheat flour bread.

In the case of sweet bread, containing more sugar and fat than the french type, levels of corn flour as high as 40 per cent gave good results in terms of having good characteristics and organoleptic properties. This bread is now being produced daily, without problems, in one of the largest hospitals in Guatemala city.

Studies were also carried out to increase protein content and quality by the addition of 8 per cent soyabean flour. No problems were encountered, however, the cost increased because soyabean flour is an imported product in Central America. In more recent studies, however, use is being made of dehulled cowpea flour with very good results in terms of flavour, baking characteristics, protein content and quality [3].

Similar results have been obtained in the preparation of pasta type of food products, in which semolina is replaced by partially gelatinized corn flour, the two cereal foods making up 70 per cent of the blend, and cowpea or pigeon pea the other 30 per cent. An example on blends of semolina, semolina/corn flour, and semolina/corn flour/soy flour is shown in Table 7. This food behaves as regular pasta in cooking characteristics as shown by the figures on solids in cooking water which are not statistically significant. Because of the presence of soyabean flour in the three component mixture, this has a higher protein content and quality [3]. It is of interest to point out that the pasta made from the 40/60 mixture semolina/corn flour has the same quality as 100 per cent semolina.

Obviously, if bread and pasta can be made with very acceptable properties other bakery products, such as cookies, can also be made. In the Central American area much interest is developing in the milling and baking industry in this aspect, a good sign that the products being made can play a significant role in the area coupling economical gains with nutritional advantages.

2. *Wheat and Starchy Roots*

Although it is not possible to discuss in this presentation all the technological aspects of bread-making, it is of interest to mention that several studies [4,5] have demonstrated the possibilities of obtaining breads of pure starch, water and an appropriate surfactant which create a system that permits the retention of a sufficient amount

Table 7. Percent of solids in the cooking water, organoleptic evaluation and protein quality of pasta products prepared from semolina and from semolina - corn flour and semolina - corn - soy mixtures.

Mixture Semolina-corn-soyabean flour	Solids, % in cooking water	Organoleptic evaluation score	PER
100	2.10 ± 0.14	7.0 ± 0.5	0.73 ± 0.14
40:60	4.90 ± 0.10	5.2 ± 0.4	0.74 ± 0.14
32:60:8	4.49 ± 0.13	5.6 ± 0.5	1.31 ± 0.24

Taken from Molina *et al*, *Cereal Chem*, 1974.

Table 8. Comparison between a bread made from a composite flour (70 parts wheat flour plus 30 parts cassava flour) and a bread made from pure wheat flour.*

Wheat/cassava ratio	100/0	70/30	70/30	100/0
Calcium-stearyl lactate (%)	0	0	0.75	0.75
Loaf volume (ml/kg flour)	7,100	4,200	6,100	7,500
Specific volume (ml/g bread)	5.0	2.9	4.1	5.3
Final score (average)**	6.75	2.75	5.9	7.9

*Taken from reference 6.

** Final score includes: browning, shape and appearance, crumb texture and crumbs colour. Maximum score from each of these loaf characteristics is 10 points.

of the gas produced during fermentation, which can also be retained during the baking step. In addition, it has been also possible to maintain other physical and organoleptic characteristics desirable in a product such as bread. In these studies, cassava was used as the main source of starch, as cassava flour or cassava starch opening in this way new possibilities of utilization of this tropical crop. Through this technology it has been possible to substitute 30 parts of wheat flour by cassava flour on the production of bread. It has been also found that cassava starch is better for this purpose than cassava flour [6].

Table 8 shows some physical and organoleptic characteristics of a bread made from wheat flour mixed with cassava flour as compared with a normal wheat bread with and without the addition of a surfactant agent. The addition of the surfactant improves loaf volume, as well as other loaf characteristics of the bread as it can be observed from the final score obtained. Although not shown in this Table one of the major improvements obtained was in crumbs softness.

Despite the possible economic advantage of this procedure for the wheat importing countries it was realized that the total or partial replacement of wheat by other starch foods would affect the nutritive value of this food item. Therefore in further studies, the nutritive value was increased by the use of composite flours made of starches from different sources mixed with other protein-containing materials such as soyabean, cottonseed and peanut flours [6].

3. *Starchy Roots and Oil Seeds*

Composite flours based on starchy roots plus oil seed proteins have also been proposed for the production of bread in the tropical area of the world. This approach has been based on the fact that these countries are better producers of oil seeds and grain legumes, as well as starchy roots and tubers.

The nutritive value of bread made from cassava/soya and cassava/peanut in the ratio 4:1 plus an additive is shown in Table 9. Although protein digestibility was high and similar for the three types of bread evaluated, the nutritional quality of the breads made from the composite flours was superior as compared to the common bread. It is also clear that the bread made from cassava/soya gave the highest protein value, which can be explained on the basis of the higher amount of lysine present in this oil seed as compared to peanut flour. This same approach can be applied to other protein sources, such as leguminous seeds, or protein isolates prepared from these various protein-containing materials.

4. *Wheat and Oil seeds*

Another possibility to prepare composite flours refers to the partial replacement of wheat flours by full-fat or defatted oil seeds flours. This approach can be developed in those countries that are wheat producers but not in sufficient amounts to meet the need of their population. Some of the South American countries are in this situation. Therefore, these protein concentrates will play a role as wheat extenders which becomes important from the economic as well as from the nutritional point of view, since oil seeds protein supply the protein quality and quantity lacking in wheat protein. This nutritional improvement can be observed in Table 10 which shows the optimum levels of cottonseed flour and soyabean flour to supplement wheat flour [7].

As it can be seen, the optimum levels found were 12 per cent of cottonseed flour and 10 per cent of soyabean flour. An example of a bread development in Peru [8] and made of a mixture of wheat and cottonseed flour is shown in Table 11. Although physical characteristics, such as crumb and crust texture as well as baking quality, were very good up to the 15 per cent addition of cottonseed protein concentrate it was observed that beyond this level, colour was impaired as compared to the

Table 9. Protein value of bread made from composite flours based on starchy roots and oilseeds*

Bread	Weight Gain (g/28 days)	PER**	Digestibility (%)	Biological Value
Cassava - soya	58.6	2.06	92	65
Cassava - peanut	37.4	1.57	91	54
Common bread	20.1	0.97	94	51
Casein	87.8	2.81	-	-

* Taken from reference 6.

** Weight gain/protein consumed.

Table 10. Effect of adding oilseed flour on the protein quality of wheat flour*

Treatment	Supplement (%)	PER**
None	-	0.85
Cottonseed flour	10; 12	1.85; 1.96
Soyabean flour	6; 10	1.66; 2.01

* Taken from reference 7.

** Weight gain over protein consumed.

the control bread. As a matter of fact, the yellow colour of cottonseed flour has been one of the main drawbacks in the utilization of this protein source as a supplement to several food commodities [9,10]. Soya, sesame, peanut and sunflower have also been used to produce composite flours and evaluated in terms of the rheological properties of the mixture such as water absorption and viscosity, and the physical characteristics of the bread such as loaf volume, as well as crumb colour and texture.

It seems that loaf volume and to some extent, crumb colour, have limited the levels of these materials in the production of bread. Some of these undesirable effects seem to be due to the different processing methods to which these oil seeds are subjected at the industrial level. Therefore, it is important to stimulate collaborative studies among different scientists involved in the technological and nutritional aspects previously discussed.

Table 11. Physical, organoleptic and nutritonal characteristics of bread made from composite flour of wheat and cottonseed flour*

Cottonseed Flour Added	Volume of Loaf (ml.)	Texture of Crumb	Texture of Crust	Baking Quality	Protein Content (N x 5.7)	PER (10% Protein)
0	854	100	100	v. good	8.93	0.83
5	878	110	100	v. good	9.70	0.98
10	815	95	100	v. good	10.93	1.08
15	708	90	100	v. good	12.18	1.06
20	648	80	90	fair	13.35	1.06
25	564	70	80	poor	15.64	1.11

* Taken from reference 8.

Table 12. Composition and protein quality of soup base formula of high nutritive value.

Ingredients in the basal formula	g	Soup base formula	g
Precooked beans flour	45.00	Base formula	90.00
Cereal flour (corn, rice)	25.00	Seasoning and other ingredients	10.00
		Total	100.00
Cottonseed flour	27.00		
Torula yeast	3.00		
Total	100.00		
Percentage of protein in the diet	12.5		
Weight gain, g	97		
Protein Efficiency Ratio	2.19		

Taken from reference 15.

5. *Combination of Legume Grain Flour*

From the nutritional point of view legume foods contain about twice the level of protein found in the cereals [11] and much more than in root crops [2]. They are rich sources of lysine [11], and limiting in the sulphur-containing amino acids, which in turn are present in adequate amounts in the cereal grains. Therefore, those two food commodities should complement each other. Grain legumes represent an excellent food resource in the American continent, which has not been fully utilized. They comprise approximately 600 genera with around 13,000 species [11]; however, only a few about 20, are of economic importance and used as human food. Of the legume grain more often consumed by the population of Latin America, the most popular is *Phaseolus vulgaris* in all its varieties of forms and colours. Other legumes consumed in specific regions are cowpea *(Vigna sinensis)*,gendul *(Cajanus cajan)* and broad beans *(Vicia faba)*. Also consumed in lower amounts for reasons of price are lentils *(Lens esculenta)*, and chick peas *(Cicer arietinum)*.

Therefore, the purpose of this section in this presentation, is to analyse some present and potential aspects related to the processing of legume foods in order to utilise more efficiently this basic resource. It is obvious that the raw material to be used in the various processes to be described will depend on the local availability as well as on the consumer's preference.

The types of processing to be discussed in this opportunity will be the following: (i) pre-cooked, dehydrated, whole beans; and (ii) pre-cooked bean flour. In the case of the first process, in general terms (Fig. 1) this consists of soaking the beans in water, steam-cooking followed by dehydration [12]. A blanching step before soaking has been recommended to ensure complete dehydration [13, 14] and destroys lipoxidase activity, improving in this way the stability of the product during storage. The cooking time required to soften the final product varies according to the process employed and the variety of beans utilized, as well as the previous conditions of storage. Dipping in a sugar solution is carried out to avoid *butterflying* a condition represented by the development of fissures which appear during drying of cooked beans. Mixtures of whole pre-cooked legumes grains can be prepared, since many people prefer to consume legume grains in such a form.

The technology used in the preparation of pre-cooked bean flour is very similar to the process previously described. The material is subjected to soaking, cooking and dehydration, followed by grinding. The final product is ready for consumption after cooking for 10 to 15 minutes. Two problems have been found in relation to the physical characteristics of the final product: (a) the final texture of the preparation and discoloration of the flour, and (b) partial loss of the colour is mainly observed when black beans are used. However, both of these problems can be solved by controlling the processing conditions [15].

This type of product can be used to prepare composite flours based on different varieties of legume grains. One possibility is to use other legume grains less consumed by the population but capable of being used in processed foods. As an example of this, it is possible to replace beans *(P. vulgaris)* partially by other legume grains in the production of precooked composite flours, without affecting the nutritional or organoleptic characteristics of the product. Combinations of black beans with other legume grains such as pigeon peas *(Cajanus cajan)* could also be used, possibly reducing the price of the product and developing interest in the production of new legumes in a specific region.

This type of composite flour can be used as soups of different types and flavours, as well as it can be combined with other foods in the preparation of thick soups of a high nutritive value. Table 13 shows the composition and nutritive value of one of these products developed by INCAP [15]. As it can be seen, the quality of the protein of the basal formula, as evaluated by protein efficiency ratio, is quite high.

Table 13. Protein and fat content and protein value of corn, soyabeans and a mixture of the two.

Food	Protein (%)	Fat (%)	Protein Efficiency Ratio
100% Corn	9.9	4.5	0.69
72% Corn 28% Soyabean	17.6	10.3	2.54
100% Soyabean	40.0	25.6	2.03
Casein	-	-	2.87

Source: Bressani, Murillo & Elias, *Food Science,* 29: 577, 1974.

Soyabean Enriched Foods

As already mentioned, soyabeans and its products are making significant contributions in increasing food availability. Its role in helping extend animal protein supplies is already well known, particularly with respect to the use of texturised soyabean protein, in ground beef and the isolate as milk extenders. A similar role can be given to protein isolate from the legume grains already mentioned.

In this final section of the document mention will be made of the use of whole soyabeans in the preparation of high protein, high energy containing foods and a simple technology which has already given encouraging results. A basic mixture called Maisoy made from 70 per cent cereal grain and 30 per cent whole soyabeans developed through biological trials [17] proved to have a high nutritive value. As shown in Table 13, the mixture contains 18 per cent protein and 10 per cent fat, making it high in both nutrients. The mixture can be prepared by various techniques, from home cooking as practiced for corn processing in Mexico and Guatemala to extrusion cooking. Varieties containing bananas or starchy root flours have also been prepared.

Of interest for the present situation are the results obtained with the Brady Crop Cooker, a simple machine of low cost which can heat process mixtures of whole soyabeans and cereal grains to give expanded products as well as flours or texturized foods. Development work with this machine is going on at INCAP and other places, but results already obtained are quite good. In Bolivia Maisoy is already being produced at a lower scale.

Summary

The information presented represents but a few examples on how countries may become self-sufficient in quite a large number of food items. Basic to this objective, however, is a close co-operation between the agricultural sector, producer of the raw materials, and industry through food science and technology. For self-sufficiency to be truly effective, it must be based on the development of local food industries using at a maximum local natural resources.

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