OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

RESTRICTED

20092

DP/ID/SER.A/1633
15 March 1993
ORIGINAL: ENGLISH

TECHNOLOGIES FOR THE FOOD AND AGRO-BASED INDUSTRIES

DP/SRL/86/016

SRI LANKA

Technical report: Experimental test runs of convenience food production by means of extrusion cooking with a twin-screw extruder type Berstorff ZE 25x180*

Prepared for the Government of Sri Lanka
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Kurt Seiler, UNIDO consultant

Backstopping Officer: A. Sabater de Sabatés
Agro-based Industries Branch

United Nations Industrial Development Organization
Vienna

* This document has not been edited.

V.93 82810

The first mission of the experts' extrusion-cooking assignment has been in February 1991, the second part of the assignment, according the code "DP/SRL/86/016/-4", was accomplished in September/October 1992 at Ceylon Institute of Scientific and Industrial Research (CISIR).

CISIR was established in 1955 to conduct scientific and industrial research, technical investigations, and disseminate the results of such activities, thereby contributing to the countries economic growth and development.

The former Industrial Research Laboratory and Rubber Services Laboratory functioned prior to 1955 under the Department of Industries, they fulfilled the scientific research function of a limited scale. After a World Bank Mission in 1952 a recommendation to establish a fully fledged Institute of Scientific and Industrial Research was given to undertake multi-purpose research and service functions.

Over the years, CISIR has expanded its scope and range of activities, so that today it is a leading multidisciplinary research organization which employs a large number of specialised staff with a wide range of expertise, dedicated to the promotion of industrial advancement through research, consultancy and other services.

The CISIR engages in a wide range of research and bio-technological development activities, based on the needs of existing industries, and those with potential for future developments within Sri Lanka. Present subject areas include - only to name a very few -:

- fruits and vegetables,
- cereals and legumes,
- starch based products,
- coconut products.

After the first stay of my assignment (Febr. 91), an internal modification in the organization of CISIR has been installed, and some details are given in the "Annual Report of the Ceylon Institute of Scientific and Industrial Research for the Year 1991".

The CISIR prepared and presented its "First Corporate Plan" for the period 1992 to 1996 in March 1991. Within the framework of its main objectives, the Corporate Plan outlined the strategy, R&D-policy, priority areas and activities to be undertaken during the five year period scheduled. This plan also proposed organizational and structural changes and enhancement and allocation of resources in order to achieve the identified goals.

In view of the countries' resource constraints and the need to cater to immediate demands from a rapidly growing industrial sector, CISIR adopted a selective strategy to maximize resource utilization and to enhance its services to industry.

The R&D-policy since 1992 clearly laid emphasis on the services to industry on a contract basis to cater to immediate and future needs of industry. It also emphasised the need to enhance self sufficiency through contract-work. However, a justifiable amount of resource allocation for mission-oriented projects with long term objectives was also highlighted. Development and dissemination of technological know-how for special self-employment programms formed another important area. Enhancement of technical capability of the CISIR, particularly in areas of techno-economic and marketing, process-engineering and technology information will be undertaken on a priority basis.

In view of the need for a selective strategy, the CISIR Corporate Plan identified following areas for a immediate, result-oriented programme, some of them are named as follows:

- food and beverage industry,
- agro-based industry,
- value addition to selected natural resources.

Even in the Governing Board of CISIR modifications took place, and the board was reconstituted in August 1991 with an enhanced representation from industry and commerce. This change from a former predominantly academic participation in the past years clearly indicated the thrust towards an industry-oriented policy and strategy for the CISIR.

This very important step from academic behaviour to a policy of moving towards industry through contract work on well identified needs of the industrial sector, will promote the general R&D and even special problems of food-technology and food procession remarkably forward.

One of those modern food-technology processes in a carefully selected area was carried out with long term objectives and with sponsorship from international and national founding agencies. The main objective of these project(s) was to develop technologies for future needs of the local food-industry and to deversify and expand the product palette and enhance utilization of local raw materials, mainly of agricultural origin. Caloric enhancement, value addition of indigenous plants was considered as one of the main aspects of this efforts. Especially the technology of extrusion cooking provided considerable amount of funding for purchase a modern pilot-plant equipment and for staff training in state-of-the-art technology. Since the new Corporate Plan is guiding CISIR's main objectives to involve relevant industries right from the inception of a new programme in order to facilitate know-how-transfer and commercialization of the technologies developed, the R&D works have changed their "mentality" in Colombo.

The extrusion cooking process - a UNIDO/UNDP-funded project - is especially designed for the local food and agro-based industries. A multidisciplinary team of CISIR staff is at present dealing with different fundamental questions:

- development of technologies for enriched food products, produced by using local cereals and legumes,
- development of process technologies for value added products for local spices and additional staff training,
- enriched and value added products from cereals and legumes.

New technologies and process techniques are to be developed to get new and modern formulas by using several cereal and legume based food products, such as infant and children's food, snack food, breakfast cereals and dessert mixes, instand food mixes, string hoppers and similar products are highly favoured in Sri Lanka. Special attention should be given to the caloric value, the digestibility, palatability and other nutritive value of this extrusion cooked products. After final product development, it is scheduled to transfer technology and process know-how to interested industries for process commercialization.

Protein and soy beans

The food and nutritional situation in Asia today, for example in India or Sri Lanka, is quite similar in nature, though perhaps not in magnitude, to that confronting many developing countries of the world. In spite of technological and especially in scientific breakthroughs, in food technology and -production the rise in annual agricultural productivity is by no means adequate to feed the growing population in this area.

The diets consumed by a large majority of population in the above mentioned parts of the asian world, consist predominantly of calorie-yielding creals and contain small amounts of protective and protein rich foods. The incidence of protein malnutrition and the deficiencies of vitamin A- and B-complex and riboflavine are particularly high among weaned infants and young children. Anaemias, due to deficiencies of iron, folic acid and vitamin B12, are fairly common among expectant and nursing mothers.

The present rate of infant mortality (death before one year of age) in the named region is about 91 per 1000 live births - major causes being malnutrition and infection. Malnutrition in early stages of life has lasting effects on the future growth and performance of each child. This crisis has deprived millions of human beings from exploitation of their physiological, mental and intellectual potential. In addition to diseases directly attributed to malnutrition, it is knowr that malnutrition aggrevates the clinical course of many infection diseases.

It is estimated that starvation and diseases resulting to malnutrition kill every year some $40x10^6$ people in all parts of the world. Worst of all, more than half of the victims are children under five years of age. In addition, FAO sources reveal that at least 400 to $500x10^6$ children living in the world's poorest countries suffer from chronic malnutrition, which has permanently retarded their physical and mental ability.

The incidence of malnutrition is highest in the rural areas of Sri Lanka among the small households, subsistence farmers and landless labourers, which, due to low productivity and/or purchasing power, cannot consume the 2200 kilocalories daily, which are recommended by the Government authorities. It is known that currently 50 % of the ca. $3x10^6$ Sri Lankan households are receiving food stamps with a fixed monetary value to buy such foodstuffs as rice, wheat flour, sugar, dried fish as well as kerosene for cooking. It is also said that $7,5x10^6$ people are encompassed in this group of the population living below the Governments' "poverty line" of having a very low family income a month. In this poor income group almost 80 % of the children are suffering from moderate to severe degrees of malnutrition. About three quarter of the pre-school children have body weights below 80 - 75 % of normal weights. Even due to deficient diet means that there has been a decline in the average height and weight of the young generation, and malnutrition must be responsible for this.

In the India-Sri Lanka area it is a custom to breast feed infants for prolonged periods ranging from 6 month up to 3 years. A mother who could be secreting 800 ml of breast milk a day would secret 640 mg of lysine a day. This represents doubling of her lysine requirement over non-pregnant, non lactating situation. But generally, cereals are too low in lysine to provide for the growth of foetus. In the area almost one third of the babies are born with low birth weights, and about 65 % of the pregnant women suffer from nutritional anaemia.

Another mark is that clinical studies suggest malnutrition could stop cell division and cause stunted growth and impaired function of the brain and the body. Inadequate nutrition during the critical period of rapid growth can cause irreversible damage to the brain and health of the child. Mothers of those unfortunate children often fail to notice this growth retardation, which takes place slowly and silently.

A further remarkable point of view is the protein requirement of people above 50 years of age, which is about 67 % of that of the youths, but the elderly human beings calorie demand is only 40 % of the youths. The calorie need decreases much more with age than the protein consumption of the organism. If this dietary imbalance is not corrected, the starch consumed with the daily intake by them in excess is stored in the body with the danger of obesity, diabetes and coronary heart disease, which may eventually can short their life expectancy.

The lack of nutritional education and inequality in distribution of food within a household will all continue to adversely influence the nutritional status in the country as before. To wait for a generation or longer, would be risking the damage to the physical and mental development of the Sri Lankan people to a point where it would be almost irreparable. Since the incidence of malnutrition is of such a massive dimension, any further inaction will raise a generation of physically and mentally stunted people.

Thus, malnutrition is undoubtedly the biggest health problem in India, Sri Lanka and other neighbour nations. To overcome this grave situation, a search for new, unconventional sources of protein - beside other types of new foodstuffs - is sought. Soybean with about 40 % protein content and about 20 % oil holds a great promise tc release half of the pediatric beds of the area.

Cereals like rice, wheat, jowar, ragi and dhal carry proteins with adequate levels of methionine-cystine, but seriously lacking in lysine, an important essential amino acid. Since soya proteins are good sources of lysine and threonine, they effectively supplement cereal proteins. This reinforcement balances amino acids to a level very close to the protein of milk or egg that resembles FAO standards.

Several of the regions vegetarian foods are totally deficient in proteins. As per the studies conducted by Government, Institutes- and FAO-scientists, some vegetarian diets show 10 to 14 % protein instead of having a minimum of 20 % proteins in these daily foods, for substantial quantities of proteins (up to 50 %) are lost during digestive and absorptive processes.

Figures are known that in the Indian-Sri Lankan area the daily per capita availability of edible oil is 11 g as against the requirements of 30 g! The availability of pulses is 51 g as compared to the necessity of 85 g for the organism, and similarly the availability of meat, fish and eggs are cnly 12 g against the daily needs of 35 g for a balanced diet.

In Sri Lanka people are predominantly vegetarian. Animal foods, though adequately contain essential amino acids, are not consumed by a sizable group of the population. Animal proteins are also very expensive and in short supply, since animals are poor converters of feed into protein. With alround increase in the price of milk, eggs, meat etc. beyond the reach of low and middle income groups, expectation of improving the protein availability through animal sources would be only a fallacy. Hence, there is an urgent need for the large scale production of low cost proteins which can substitute meat proteins.

Studies and inquiries of FAO-scientists have shown that the daily protein intake should be 1 g per 1 kg of body weight. Growing children require more protein because new tissues are being laid during the growth period which are built up of elements drawn from protein. Likewise, the protein need of women are also greater during pregnancy and lactation.

Soyabean solution is highly relevant for all Asian at this juncture. Soyabeans contain (roughly) 2 times as much protein as meat, 3 times as much as eggs and 11 times as much as fresh milk. The protein quality of soybeans is in fact unique for vegetarians as the level of essential amino acids matches that of animal protein.

Soyabean has multiplicity of uses as cereals, pulses, oilseeds, vegetarian meat, milk beverages and numerous other products. It can be blended with other foodstuffs in all daily preparations from 5 % to 25 % to correct the dietary imbalance.

Soybean has largely contributed to the nutritional hunger of the third world. With its high nutrient density and excellent palatability, it can be successfully included in the asian foods. Consumer preference and acceptability of soya derivates are much favourable as evident from the experiences, and all test runs of innumerable institutions and industries in many countries.

At present, soybeans are mostly used as a raw material to gain edible oil which is worldwide used for human diets. The remaining oilcake finds its way to farmers, who get an excellent cattle feed. FAO appraisals gave a worldwide yearly production rate of 36 x 10^6 t/a of soybeans and only 4,6 % equivalent to 1,7 x 10^6 t/a are processed into human nutrition, which is indeed a very low amount of plant energy. Compared with this figures, a further FAO estimation give the production of milk-protein to 22,6 x 10^6 t/a, and the production of animal protein to 22,8 x 10^6 t/a. In table 1 one can see the composition of some pulses.

Plant proteins, which should be processed and should be suitable for human nurishment, must have specific chemical, physical and functional properties as well as sensoric attributes. Besides this, it is expected by the industry that the product processing could be done economically.

Table 1: Composition of different pulses (weight % in dry substance)

	raw protein	lipids	digestible carbohydr.	dietary fibre	minerals
Soybeans	39.0	19.6	7.6	-	5.5
Peas	25.7	1.4	9.1	7.5	2.7
Beans	24.1	1.8	54.1	19.2	4.4
Peanut	27.4	50.7	9.1	7.5	2.7

When soyaprotein or other plant proteins are processed and manufactured into a marketable foodstuff, some important functional properties must be given, as there are:

- Dispersing effect of plant proteins enable the property of this type of protein to build up a dispersion in an aqueous phase; an adjustable dispersibility is necessary in the beverage producing industry, for instance.

- **Jelly effect** is a measurement for compressibility of protein jellies. The maximum of this effect is given with soluble proteins, they are available in most of the meat products.
- In numerous recipes the **waterbound effect** with proteins shows considerable influence onto the process of food production. This depends on an important degree from the physical type of the proteins, their forms and size of the particles: powdershaped, granules, textured/formed or extruded proteins. In some cases the addition of lecithins helps to improve the waterbinding effect.
- The **viscosity** is a very significant criterion of the flow resistance of foodstuffs, and is used as a characteristic sign for the food quality. The viscosity is increasing with a growing concentration of plant proteins, the treatment with heat cause modifications of the product viscosity.
- **Emulsifying effect and development of foams** is the result of the attitude of proteins to develop this effekt at the border line of the surface area on oil-water or air-water border lines. This emulsifying process is of some importance, if plant proteins are used for the production of milk- and meat foodstuffs. In contrast to the characteristic properties - described up to now - the colour, taste, smell and residue are not the features, depending directly on the plant proteins itself. This features are mostly dependent on the influence of the non-protein components and/or the mutual effect with the proteins directly. Most of the undesired accompanying components are removed when the raw materials - here the soybeans - are processed, and the technical procedure is suitable to eliminate this foreign matters. This could be done by heat treatment, extraction procedure, precipitation processing, acidification or drying of the substances.

Plant proteins, which should be manufactured in the food industry, must be totally free of substances producing/developing off-flavour smell. This off-flavour components are developed by enzymes or by oxidation processes of unsaturated fatty acids. Therefore, it is very significant and absolutely necessary to inaktivate the appropriate enzymes and to remove the unsaturated fatty acids.

The plant proteins exhibit many advantages, which allow a positive influence, concerning health or the nutritional value of the food. Especially in the western countries obesity is a health problem. On the other hand malnutrition and deficiency of protein- and calorie-rich food is the drawback of the India-Sri Lanka area. The total lack of cholesterole of the plant proteins and the possiblity of decreasing the cholesterol-content of the blood and even the decreasing effect of the contents on LDL, VLDL and the triaycylglycerides in blood of human beings is a remarkable success of soy protein.

Another problem in human nutrition is an increasing tendency of food allergy. The scientists assume, that environment loads are one important factor of this allergy. The tests carried out to find the causes for this allergenic properties have a very small potential in this regard. For that reason, soy isolate is suggested worldwide as an alternative of infant food, particularly on children, who are allergic to milk-proteins.

The lactose-intolerance is increasing worldwide and is a serious problem in the nutrition for the children. Plant proteins based on soy proteins are free of lactose and could be used in this cases of lactose allergy.

The most serious problem in utilization of plant proteins on human nourishment is that most of the proteins show a lack of one or several of the essential amino acids, or that the composition of the amino acids is inbalant - which causes problems with the absorption of the essential amino acids. Inbalant proteins or such with lack of essential amino acids can only be used in foodstuffs, if this deficiency is compensated by supplementary protein sources; table 2 is demonstrating the contents of some essential amino acids from different materials.

Table 2: Essential amino acids in plant and animal proteins

	Soyabeans	Beans (g/16 g N)	Meat (beef)
Methionine	1.3	0.7	4.3
Lysine	6.4	6.5	9.3
Isoleucine	4.5	4.0	5.2
Leucine	7.8	7.1	8.4
Phenylalanine	4.9	4.3	4.1
Threonine	3.9	3.4	4.8
Tryptophane	1.3	n.n.	1.1
Valine	4.8	4.4	5.1

The composition of plant- and animal proteins is very distinctive. The nutritional characterization of amino acids is highest within the soy proteins, the requirements of all essential amino acids for adult people are available. The limitating amino acids are - with small restrictions - sulphurous amino acids, as there are methionine and cysteine. Therefore, it could be advisable to add methionine to food preparations for children, if necessary. In comparison to other plant proteins, soy protein shows high contents on essential amino acids, for example, on lysine, threonine and tryptophane. According to the WHO/FAO suggestions, the best amino acid profile to cover all requirements on essential amino acids is given with soy isolates, which even cover the need of sulphurous amino acids for children (Table 3).

Table 3: WHO/FAO (1985) recommendation of contents of limitating essentail amino acids to cover the need of this amino acids within isolated soy protein (ISP)

Amino acid (mg/g raw protein)	ISP	2-5 of age	10-72 of age	adults
Lysine	63	58	44	16
Methionine and cysteine	26	25	22	17
Threonine	38	34	28	9
Tryptophane	13	11	9	5
Valine	50	35	25	13

The nutritional value of proteins does not only depend on the composition of amino acids - the digestibility of the protein is as important as the configuration of the plant protein. It was found that the digestibility of plant proteins is variable in a wide range, and is influenced by the comformation of the amino acid composition. Isolated soy proteins represent a protein digestibility of > 90 %. This wellknown attribution is very important in processing of special foodstuffs; so far protein quality mostly is determined by evaluation of the biological valuability (BV) or the net protein utilization (NPU). In Table 4 a comparison of BV and NPU of wheat, soy protein and meat is shown.

Table 4: Biological valuability (BV) and net protein utilization (NPU) of proteins in different foodstuffs

	Meat	Wheat	Soybean (heat treatmt.)
Biol.valuability (BV)(rats tests)	74	65	73
Net prot.utilisation (NPU) (rats tests)	67	40	61

It is shown by the given figures that soy protein is absolutely comparable with the nutritional values of animal protein, but there is an obvious deficiency to wheat protein. In context with table 4, it must be accentuated once more that with alterations of the protein conformations and the elimination of foreign matters (colour, taste, smell, residue) from the protein while processing soy isolates, is extremely amended.

The plant proteins and their functional properties which should be processed successfully into foods or should be transformed to new foodstuffs, must be similar as much as possible to the protein components of the traditional food, to give a marketable new food in taste and mouthfeeling. Furthermore, the accustomed sensoric properties of the supplemented foodstuffs (animal protein exchanged, plant protein, e.g.) as there are taste, smell, texture and colour, are not permitted to be changed. For example, if one is looking to so-called 'light foods' - which are popular in the western countries - from the nutritional point of view, one has to notice the ingredients of vitamins, minerals, tracer elements, proteins, fats, carbohydrates, and even the energy content is to be taken into account, if the food technologists are producing this modern type of food. Generally, plant proteins are employed to reduce the content of cholestrol, fat and energy constituents in this types of foodstuffs. The range of application for the production of this group of food is used in processing of beverages, alternative milk products, meat products and bakery goods; table 5 shows a recipe of an alternative milk product, the contents of the compontents are given in table 6. Another recipe o a very common meat product is demonstrated in table 7, the change of this composition in table 8.

Table 5: Composition of Yasoya

	100 g Yasoya comprise
Water, g	75.0
Soy protein, g	14.2
Milk protein, g	2.8
Fat, g	5.3
Carbohydrates, g	1.7
Minerals, g	1.0

Table 6: Ingredients of important components of Yasoya

	100 g Yasoya contain
Methionine, g	0.35
Oleic acid, g	1.18
Linoleic acid, g	2.66
Linolenic acid, g	0.40
Cholesterol, mg	5.50
Purin, g	n.n.
Carbohydrates, g	1.70
Energy, kJ/kcal	527/125

Table 7: Recipe for processing of "Frankfurter sausages" with and without using isolated soy proteins (ISP)

Constituents	usual recipe (g/100 g)	recipe with ISP (g/100 g)
Beef (90 % lean meat)	36.1	39.2
Beef (50 % lean meat)	17.4	1.3
Pork (42 % lean meat)	20.0	15.0
Water	20.0	36.0
Salt, spices	6.5	5.0
ISP	-	3.5

Table 8: Composition change in "Frankfurter sausages" with and without use of isolated soy protein (ISP)

Fat	- 45 %
Cholesterol	- 25 %
Energy	- 25 %
Protein	+ 21 %
Texture	comparable

With this general view, given on the range of applications of proteins obtained from 'oil-free' soybeans, the scientific-technological development in this special branch of the food industry of the western countries is shown in this short survey.

An equivalent course of developments in special foodstuffs could be done by the excellent scientists in Sri Lankas 'Ceylon Institute of Scientific and Industrial Research', whom I met there and whose possiblities I know best.

As it was pointed out above, the food and nutritional situation in Sri Lanka today is quite similar in nature to the southern part of India. In spite of the scientific and technological development highlights in food processing and food production in the western countries, the increase in annual agricultural productivity is by no means adequate to feed the growing population in Sri Lanka as well as in India.

In studies, undertaken in the last twenty years by Sri Lankan Government institutions, Ministry of Health, Centre for Desease Control and Hospital, have conclusively determined the type and magnitude of nutritional disorders, and have also identified that malnutrition is highest in the rural (!) areas of the country: small landholders, subsistence farmers and landless labourers, who - due to lack of money - cannot get the daily recommended calories they need. Those groups get, according to informations available, food stamps with a fixed monetary value to purchase foodstuffs, such as rice, wheat flour, sugar, dhal, dried fish as well as kerosene for cooking.

Three major nutritional problems in Sri Lanka are mentioned prior in this report: protein energy malnutrition, the nutritional anemia and, to a certain degree, Xerophtalmia.

Protein energy malnutrition, unlike other 'pure deficiency diseases', is a multi-dimensional problem, affecting principally the group of low income and large sized families. This severe type of malnutrition in young children results - as said above - in the retardation of physical and mental growth and the incidence of acute undernutrition, chronic undernutrition and, worst of all, mortality. In a study of the Ministry of Health it was found that approximately one million preschool children (1-6 years of age) required nutrition intervention, this figure was calculated by the 1975/76 Nutrition Status Survey, carried out by this Government organization.

The nutritional anemia in female people is mostly acute during pregnancy and lactation, that term when the mother's nutritional requirements are highly strained. In this period women need iron fortification in their daily food, and in addition to that a protein-energy rich supplement. A depressing consequence of this type of malnutrition is a birth-weight of Sri Lankan infants in the range of 2.5 to 3.0 kg, which confirms the inadequacy of the mother's nutrient intake during pregnancy.

Vitamin A deficiency (Xerophthalmia) encompasses the entire syndrome of acute Vitamin A deficiency and is often manifested in its advanced form - Keratomalacia - leading to permanent blindness.

To diminish and reduce these nutritional disorders in Sri Lanka, the 'Thriposha Nutrition Intervention Programme' was installed in 1973. The

Ministry of Health in cooperation with CARE and USAID intended to produce and distribute free of cost a high protein fortified cereal based product for selected nutritionally at risk infants, primary and preschool aged children and pregnant as well as lactating women all over the country (Table 9). The foodstuff - even now twenty years after start up the 'Thriphosha-Project' - consists of extruded indigenous corn and soybeans, blended with a fortified instant corn soy milk and nowadays enriched with vitamins, vitamin groups, minerals and - within the fortification - essential amino acids. Two packages of 'Thriposha', each weighing 750 g, is being distributed monthly to 600-700x10^3 recipients in 1992 through Maternal Child Health Centres, Clinics, Primary and Pre-Schools, Plantation estates and Social Service Institutions.

Thriphosha-food is provided for a daily food supplement of 50 g only. The nutritional contribution of the daily allowance as a percentage of the daily recommended nutrient for Sri Lanka is shown in Table 10. In this tabulated representation of special nutritional interest are given the significant concentrations of protein, calcium, iron, vitamin A, folic acid, vitamin B12, and ascorbic acid, present in instant corn soy milk. Beyond that, there is also a high concentration of lysine, which is the limiting amino acid in cereals. Indigenous legumes and grains are blended in the Thriposha formula to some extent, the mineral and vitamin fortification at present is unfortunately mixed together with the starchy raw material and the defatted soybeans, and then treated in a modern hydrothermic process to disintegrate the starchy components of the food and to transform all of the constituents into a digestible form after cooking the mixed and especially manipulated powder in an extruder. Table 10 demonstrates the nutrient value in Triposha supplement foodstuff, consisting of instant corn soy milk (ICSM), blended with local cereals and legumes (rice, green gram, etc.), but without minerals and vitamin fortification. This fortification will start up later, when the Thriposha recipe is adjusted to include 40 % corn and soya, blended with 50 % ICSM.

Table 9: Thriposha food of 50 grams as a percentage of daily recommended supplement nutrient allowance for special groups of inhabitants of Sri Lanka

Nutrient allowance		Type of participant: Male/female* 1-3 years	4-6 years	20-29 years	Female 20-29 years lactating
Food energy,	kcal	16	11	10	8
Protein,	%	42	32	24	14
Calcium,	%	100	100	100	45
Iron,	%	110	110	32	23
Vitamin A,	%	340	283	113	71
Thiamine,	%	80	57	44	36
Riboflavine,	%	38	27	23	18
Niacine,	%	44	33	30	22
Ascorbic acid,	%	100	100	66	66

*) Individual average weight per kg:
Ages 1-3 = 12.0 kg; 20-29 (female) = 47.0 kg
Ages 4-6 = 18.2 kg; 20-29 (female, lactating) = 47.0 kg

Source: Department of Nutrition, Medical Research Institute, Colombo 1976

Table 10: Nutritive value of selected nutrients, contribution of 50 g daily

Substances		Thriposha product	Thriposha totally indigenous without minerals and vitamin fortific.
Food energy,	kcal	190	185
Protein,	g	10.0	9.9
Crude fat,	g	3.0	3.1
Crude fibre,	g	0.6	0.9
Ash,	g	2.0	1.8
Carbohydrate,	g	30.0	31.5
Calcium,	mg	450.0	340.0
Iron,	mg	9.0	6.9
Folic acid,	mg	100.0	-
Vitamin B12,	mg	2.0	-
Vitamin A,	IU	850.0	698.0

The technical process of manufacturing this rather important foodstuff for mostly low income groups of the Sri Lankan population started in early springtime in 1977. The technical core of the whole equipment was the installation of a single screw extruder, the first machine was a Brady extruder, type 206, with a throughput capacity of 100 kg/h raw material. This first plant was installed in Kundasale north-east of Colombo. The successfully producing Kundasale factory demonstrated its capacity to produce a nutritious extruded food product acceptable to the target group of recipients in Sri Lanka. The formulation of cereals passed through the Brady extruder has changed numerously; sorghum/soybean, maizegrits/soybean and blends of maizegrits/navy bean/coconut oil in various proportions were tested.

In the beginning of the eighties, the factory of Kundasale was reconstructed, and a new plant was errected in Kapuwatte next to Colombo, with an increasing capacity and now with two Brady extruders type 206; that means that the production rate doubled to 200 kg/h raw material under processing. In 1990 - I was told - a third single-screw extruder was taken in operation to satisfy the need of the Thriposha foodstuff throughout the whole country. This type of extruder is a rather modern machine for continous production 24 hours a day, it is a wellknown Anderson extruder with a throughput rate of 120 kg/h raw material.

In this new Thriposha processing complex at Kapuwatte all technical facilities are included: surge tanks for storage grains and beans and other raw materials and bulk tanks for the final Thriposha product, grain cleaning, processing, proportioner grinder mill, cooling equipment for the extrudates and packaging section and the quality control laboratry as well.

When we visited the Kapuwatte complex, all the three extruder maschines were running, and the whole equipment and technical machinery were well in order, as I could review this in the first moment. The production room was very clean and facilitated a very good impression. The raw materials were processed with the Anderson extruder and the two elderly Brady extruders as well, when I visited the Kapuwatte plant, the formula was equivalent to 65 % corn grits and 35 % fat containing (18 %) soybeans plus fortifiers, all together a production capacity - I was told - 120 kg/h Anderson plus 450 kg/h (!?) two Brady machines. The interesting chemical-analytical data of the Thriposha food were not available to me. There is only one remark that should be given to the plant manager that could help to increase the quality of the supplement food for pre-school children, pregnant and lactating women: do not mix and feed the vitamins, the essential amino acids and all these other expensive fortifying substances together with the starchy materials and soybeans <u>into</u> the extruder maschine! According to my impression, the temperature-control of the Anderson machine is not very exact, and with the Brady extruders the temperature readings are sero. So, what can the Thriposha people do to prevent vitamin and amino acid losses, caused by heat? On top of each extruder inside the headplate a thermocouple should be installed to get exact temperature readings, opposite to the place of temperature measurement a Dynisco-instrument should be installed to get continous readings of the pressure conditions inside the gap within the thermoplastic material of the extruded mass, before expansion takes place beyond the die-head. The absolute necessary equipment an extruder should be fitted with, is an precise working water- and/or fluid substances dosing instrument to steer the water and/or liquids running into the feedings section of the extruder.

These regulation and controlling apparatus were not to be seen at the Brady extruder, and rather incomplete or deficient (water, steam) or totally missing (pressure, temperature) at the Anderson extruder. The consequences of this defective fittings are certain lacks of product quality which could be avoided very easily. Cue to this conditions, the starch particles in the extruded corn grits are unsufficient disintegrated, and due to the lack of heat control, the Trypsin inhibitors - which stop the protein-splitting enzymes - could not be destroyed, or the protein is going to be partially denaturated.

According to general experiences in extruder technology, a controlled production of a marketable food quality for low income groups and for the normal market will be extraordinary difficult, for all is depending from the intensive experiments of the operator of the extruder how to run the machine properly, and not from the marketing or foodtype developing experts, for they are only giving the formula but not the extrusion parameters to produce edible foodstuffs.

So far, all the test runs in the Thriposha plant for producing breakfast cereals by using new formulas and only by means of the Anderson extruder as a centre of the new production line is a thing that cannot work if the preconditions are not fulfilled!

To declare the problem, one has to declare and define, what the Thriposha-company is interested to do.

The production line of breakfast cereals, where the flakes are coming from an extruder machine, needs behind the expander a roller-set and a following drying equipment as the main types of the necessary machinery. But this equipment is even missing at the Kapuwatte plant, and so far the processing of breakfast cereals is not possible at present.

Even the alternative of installation a snackfood-line needs additional equipment, as there should be snackfood drier with indirect fresh-air heating, a tumbler for spraying spiced oil onto the surface of snacks, a spray oil mixer-tank including mixing vessels and pumping and spraying systems and a packaging machine, as well. But there is no production chance, if the machinery appropriate is not available. I tried to convince and inform the plant manager, that further investments are unavoidable, if they intend to expand their production capacity.

In meantime, it would be very commendable to develop new recipes and try to get reasonable extrudates, coming from the Anderson extruder; as it was pointed out, there will be a lot of difficulties to guide the extruder properly (water content and temperature) and adjust the most suitable dies in the headplate. Regarding the cutting device-knife and knifecover-, a very important remark must be given: it is absolutely necessary and significant to prepare die Anderson knife-cover in that way, that the steam, emerging from the dies installed in the headplate, is able to vanish instantly. Otherwise the expanded extrudates clog together (as they do at the moment), and the remarkable disadvantage of a disproportionate drying of the extrudates appears.

Test runs of new formulas on the Anderson machine with corn grits, rice grits, ground greengram and dehulled soybeans (fat content about 18 %!) as well, also added with milk powder, coconut scrapings, sugar and salt had been unsuccessful (in that stage, I had seen them), according to the indifferent regulation and steaming possibilities. I think, a lot of further tests will be necessary if marketable extrudates are produced by means of the Anderson extruder used at the Thriposha plant.

On the other hand, if one reads the "Program for Anderson Expander Control", it is seen, that a lot of experience and acquired skill of the operator is necessary to run the expander properly:
"Only the feed rate of material to the extruder (volumentric dosage), the water input rate and the steam input rate through the injection valves can be controlled directly by the operator. Other factors, such as temperature, degree of expansion, cook, etc. are controlled by manipulation of the three directly controlled factors"
and·
"It is impossible to write out a detailed list of instructions on how to control each factor during the operation of the expander. This is an acquired skill which must be learned by the extruder operator. However, a discussion of control in general and how temperature and pressure levels can be changed during operation would be helpful as a guide line for the operator!"

In this regard, questions raise up: who of the operators in Sri Lanka are able to bring in his own ideas while running his job, especially an expensive and sensitive extruder, respectively, for the hierarchy between the employers and employees is too rigid and strict. Therefore, it must be pointed out once more: it is highly important that the water, feed, and steam input rates are to be controlled, in order for the extruder to produce a uniform product; this is particularly true for the feed, where a homogeneous material fed at a uniform rate is essential for proper extruder operation.

Later the stay of my mission we decided to find out the extrusion conditions by means of the CISIR owned Berstorff extruder, if the same raw materials are used as it is usual at present in Kapuwatte plant. We tried to get best expanded extrudates with controlled temperature and pressure readings and a fixed water dosing rate for each test run, this experiments were operated by means of a Berstroff twin screw laboratory ZE25x18D extruder, which is stationed at CISIR, Colombo, Sri Lanka. Later in the year the results of the CISIR experiments should be transfered to the Anderson extruder at the Thriposha plant.

The following tables show the technical data of the Berstorff test runs. Comparable values later on should be tried to follow with the Anderson extruder in operation on appropriate raw material mixtures - an extra column within the table gives decisive indications to the specific volume per 100 g expanded material of extrudates and, in consequence, the degree of expansion index is demonstrated. After some time it is scheduled to repeat the same type of test runs, but with a diminished fraction of soybean/corn grits ratio - for example 20 %/80 % - to find out what happens with the specific volume, the crispyness and the porosity, for this details are critical qualifications for snack products.

Table 11: Different mixtures of starchy materials and plant proteins, extruded with a Berstorff Ze 25x18D Twin Screw Extruder

		Test run no. 1	2	3
Temperatur readings, at different sections:	°C,			
- Z1		30	30	30
- Z2		50	50	50
- Z3		100	100	100
- Z4		110	101	102
- Z8		120	121	120
Gap:				
- Head,	°C	165	167	157
- Head,	bar	15	20	20
Technical data:				
- Rpm,	min^{-1}	250	250	250
- Feed rate,	g/min	200	200	200
- Electrical power,	kW	3.0	3.2	3.2
- Electrical power,	A	17	18	20
Product data:				
- Water content,	%	16	16	16
- Specific volume,	ml/100g	500	425	450

Composition of mixture of raw material in test run no.:
1 - 80 % corn grits + 20 % soybean (18 % fat)
2 - 40 % corn grits + 40 % green gram + 20 % soybean (18 % fat)
3 - 50 % corn grits + 30 % green gram + 20 % soybean (18 % fat)

Table 12: Different mixtures of starchy material and plant protein, extruded with a Berstorff ZE 25x18D Twin Screw Extruder

		Test run no.			
		4	5	6	7
Temperatur readings, at different sections:	°C,				
- Z1		30	30	30	30
- Z2		50	50	50	50
- Z3		80	80	79	81
- Z4		108	108	112	119
- Z8		96	93	84	89
Head:					
- Head,	°C	132	135	141	146
- Head,	bar	20	24	21	21
Technical data:					
- Rpm,	min^{-1}	200	230	250	250
- Feed rate,	g/min	160	160	200	200
- Electrical power,	kW	1.8	2.5	2.0	2.4
- Electrical power,	A	13	16	16	15
Product data:					
- Water content,	%	18	16	16	16
- Specific volume,	ml/100g	245	370	375	250

Composition of mixture of raw material, test run no. 4-7:
65 % corn grits + 35 % soybean (18 % fat

Table 13: Corn grits/soybean mixture (65/35), extruded with increasing head-plate temperatures (5°C) to control the specific volume in the extrudates

Test run no.		8	9	10	11	12	13	14	15	16	17
Temperatur readings, °C, at different sections:											
- Z1		30	30	30	30	30	30	30	30	30	30
- Z2		52	50	51	51	52	52	52	52	52	51
- Z3		60	74	78	80	83	81	81	81	90	93
- Z4		94	100	106	114	114	121	122	133	137	145
- Z8		70	69	71	79	86	97	98	105	109	115
Gap:											
- Head,	°C	121	125	130	135	141	147	150	156	161	165
- Head,	bar	20	22	25	24	20	21	20	20	22	22
Technical data:											
- Rpm,	min^{-1}	230	230	230	230	230	230	230	230	230	230
- Feed rate,	g/min	200	200	200	200	200	200	200	200	200	200
- Electrical power,	kW	2.6	2.4	2.6	2.6	2.5	2.4	2.4	2.2	2.2	2.2
- Electrical power,	A	16	16.2	17	16.5	16	15	15	15	15	14.1
Product data:											
- Water content,	%	27	24.5	16	16	16	16	16	16	16	16
- Specific volume,	ml/100g	180	190	270	310	300	340	310	320	340	420

If we look at table 12, the test runs no. 4-7, it is to be seen in the rubric 'product data' that the experiments 5 and 6 resulted in best specific volumes, due to appropriate headplate measurements of gap-temperature and gap-pressure in accordance with a suitable mass moisture content and turn speed of the twin screws of the Berstorff extruder as well.

At table 13, test runs 8-17 show a systematic increase of the gap-temperature, starting with 120°C upt to 165°C, stepwise rising with 5°C. A constant feed rate and turn speed of the twin screws in connection with an invariable water content of the extruder mass-material inside the extruder cylinder (except the tests 8 and 9, where the water content must be adjusted to 27 % and 25 % to keep the headplate-temperature at 120 and 125°C) resulted in a distinct rise of the specific volume of the expanded extrudates, demonstrating best results at 340 and 420 ml/100.

To get products of snack foods like this, when employing the Anderson single screw extruder, the Thriposha people have to run a series of test runs, as it was done in CISIR before, otherwise their success in producing new products will be not very remarkable.

Another point of interest between industry and CISIR was demonstrated by an idea of meat industry; the extrusion of a mixture of different types of meat with starchy materials was planned. Industry proposal was to employ a maximum of meat input into the meat/starch fraction, favoured figures should be 50 %/50 % mixture.

According to the general experience of the expert on mission, the success of this form of extrusion test runs must be denied, for maximum of meat addition could be 5 % - 15 % only.

In spite of my indication, we initiated another series of test runs with the Berstorff extruder at CISIR to find out some positive extrusion results. From a meat company we got minced meat, as there are beef, chicken meat and seafish meat. This animal protein was much more similar to a purée or meat pulp instead of pure meat as it is common known; inside a lot of blood and meat-fibre a water content of estimated 85 to 90 % was found in the samples we got from the industry! When it was tried to compose a mixture of 90 parts of rice grits and 10 parts of soybean (18 % fat) and add 5 %, 10 % or 15 % of this minced meat to a rice grits/soybean sample of 3000 g, we got three samples (a) 3150 g; b) 3300 g; c) 3450 g) of a meat/rice/soya composition.

First that happend was, that the powdered plant materials were clogging together with the minced meat, and when starting the dosing screw of the feed hopper, all the fibre residues of the minced meat began to hang around the paddles of the mixing screw, which are additionally stirring the raw materials inside the hopper. So we got the meat particles very disproportionate, not uniform and sometimes only the starch/animal-protein mixture into the extruder cylinder. That means, the test runs - the same happend with minced fish - were totally unsuccessful. Only if a dried minced meat is used, we can hope to get positive results. But before getting this type of animal protein, the meat blood compound has to be better vacuum dried, before blending with plant material takes place. This types of tests will be done later the year.

During my stay at CISIR in 1992, we got the opportunity of having a visit in Candy, some 80 km north-east of Colombo, where we have had a survey in a Canadian/Sri Lankan joint venture - a small soybean processing plant, named 'Plenty Canada'. Centre of the interesting processing hall is an 'Insta-

Pro' single screw extruder with electrical heating system and pressure/temperature monitoring and preconditioning of soybeans before extrusion processing. After extrusion cooking of soy the material is used for gaining the oil or to get soyflakes for further processing.

In a section apart from the machinery building, hand selected (!) soybeans were classified and packed in small parcels, later to be used in Sri Lankan households as normal food for the family members.

It seems to me that this small soybean production plant is - and will be - a very good start for the country to find out in cooperation with CISIR-Colombo in a series of test runs - with or without using extrusion cooking - the best formulas suitable for the population of Sri Lanka for the future. To have an idea what are the possibilities when using soybean in recipes for human food, I have written down some latest scientific cognitions about fatfree soybean flakes with 40-50 % protein content, soy concentrate with about 70 % protein and, last not least, the soy concentrate with a protein content of about 90 %, just at the beginning of my report.

There are very good conditions and possibilities with the Berstorff extruder in CISIR and even skilled and scientific personnel is sufficient available to work strictly and with a certain purposeful behaviour to get safe and good baby food for the Sri Lankan infants.