6 plates high. For a production rate of 2,500 kilos/hr and 4–5% blowing steam, pressure decreased 6 mm Hg. That is 1 mm Hg per tray.

This deodorizer was modified to increase production to 4,000 kilos/hr, i.e., 78% above design value, with a pressure drop 1 mm Hg per tray.

According to Bates (2), the calculation of the number of theoretical plates needed to make an effective deodorization, is simple, using his formulas. He concluded that "you can lower the FFA content, but it is not so easy to obtain an acceptable flavor of deodorized oil."

PARALLEL COUNTERCURRENT DEODORIZATION

Since the blowing steam flows countercurrently, the total flow is divided in half at two points in the deodorizer, with the result that the ones before the last trays are at maximum vacuum in the top, which helps eliminate volatiles after the retention section. According to Gonzáles Flores (1), this design results in smaller diameter, and lower cost construction.

The distillation plates are the valve type, and have a low theoretical pressure drop: 2.2 mm Hg per tray.

This equipment probably has several other advantages not mentioned here; I have not operated this type of deodorizer, but most references indicate that it meets quality and production rate guarantees. The first of this type deodorizer used in Mexico was built by Blau-Knox Co. for Industries 1-2-3, S.A.

DEODORIZATION IN HORIZONTAL FLOW WITH MAMUTH PUMPS

This design has the advantage that blowing steam injected into each stage is fresh, and its action is very effective in stripping volatiles. This is a European design and normally it is built for 2–3 mm Hg absolute pressure; this balances the high level of oil in the tray (about 2 feet), which gives us an average pressure decrease of 20 mm Hg. European designs allow heat exchange between outgoing and incoming oil, which saves 50–70% heating fuel. References about this equipment are satisfactory regarding product flavor and quality.

DEODORIZATION USING WECKER INVENTION IN TRAYS WITH A LABYRINTH AND SAME ABSOLUTE PRESSURE ON EACH TRAY

This equipment has an interesting modification, i.e., the use of a multiporous steam sparger which produces many small bubbles, giving a high contact surface for a given volume. Volatile stripping is very effective. The Wecker design has been modernized recently, and we have not seen it in operation yet. However, the team of experts that designed it is very experienced, and this equipment should produce good results. However, Bates (2) and White (3) point out that, if steam bubbles are very small, entrainment losses can increase. No doubt this deodorizer design must have additional features to have individual characteristics.

Any of the deodorizers discussed can, with some changes, accomplish physical refining. One possibility is operation at 3 mm Hg with more distillation trays—normally two more, one with heating and the other without. This helps to increase temperature. Physical refining requires a different pretreatment than traditional refining plus strong bleaching, which can be preceded by acid treatment and even prefiltering.

After the correct pretreatment, which is different for each oil, oil goes to the modified deodorizer, which lowers free fatty acids, improves color, and removes peroxide, flavor and odor. This process is acceptable for coconut, tallow, palm and, probably with time, for other oils.

Our idea of the future continuous deodorizer would have heat economy, low steam and water consumption, low radiation losses, fatty acid recovery, bubble cap trays, parallel countercurrent flow for steam, and microporous steam sparger.

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Replacement of Egg and Milk with Soya Protein in Pasta

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ABSTRACT

The object of this paper was to investigate the replacement of egg and milk with soya protein in pasta—their chemical and biochemical changes, rheological effects, test of pasta quality and nutritive values.

INTRODUCTION

The need for vegetable protein, especially soya protein, to partially replace egg and milk in pasta production is becoming economically important.

In many parts of the world, particularly in undeveloped countries, imbalances in animal protein food are more and more prevalent. Today these foods are filling a greater proportion of the world's food requirements. Investigations of Yugoslav nutrition indicates that consumption of animal and vegetable protein is not well-balanced. The use of cereal proteins in the structure of food is over 51%—and that is very high.

In looking for a solution to these problems of protein malnutrition, we directed our investigation to how to replace expensive animal proteins in high-carbohydrate foods such as pasta and bread and without creating an imbalance in the essential amino acids.

MATERIALS AND METHODS

In this investigation, we used full-fat soya flour, "Nurupan," from Edel Soya, Hamburg, as replacement for egg and dry milk in pasta. Flours of hard and soft wheats were prepared by milling for pasta flour. Egg powder and nonfat dry milk were replaced with soya flour at levels of 10, 20 and 30% in the flour blends.

PROXIMATE ANALYSES

Standard AACC methods were used for moisture, protein and fat evaluation. Wet gluten was determined by the AACC procedure. Amino acid composition of samples was determined with a Beckman Aminoanalyzer-Multichrom liquid column chromatograph (methodology—flour protein hydrolysate).

Separation of protein fractions was by gel filtration on Sephadex G-75.

Determination of sulfhydryl (SH) groups was done by Ellman's spectrophotometric method. All measurements were performed with phosphate buffer, pH 7.09.

Rheological Properties

Farinograph characteristics of the flour blend were studied using Brabender Instruments and the AACC Farinograph Method for flour. The rheological properties of the different blends and level replacement were studied with Brabender instruments—Farinograph, Extensigraph and Amilograph, according to AACC procedures.

Preparation and Evaluation of Spaghetti

Control formulas consisted of (a) 1,000 g of wheat flour plus 33 g egg powder or (b) 1,000 g wheat flour plus 25 g nonfat dry milk. In the test formulas, the egg and nonfat dry milk were replaced with 0, 10, 20 and 30% full-fat soya flour. The doughs were mixed and formed into spaghetti on the Braibanti (Italy) long pasta line by the normal process. After drying, the spaghetti was kept in plastic bags until quality tests were performed. The volume of spaghetti after cooking, cooking time, and the resistance to disintegration were evaluated by AACC methods.

RESULTS AND DISCUSSION

Chemical Properties

Chemical characteristics of wheat flour, animal protein (egg and milk) and soya flour, are shown in Table I. The full-fat soya flour is considerably higher in protein and fat than the wheat flour. The soya flour protein value is lower than that of egg protein and higher than that of nonfat dry milk protein. This high protein content makes soya products suitable protein sources.

Protein contents of experimental products are given in Table II.

TABLE I

Chemical Properties of Wheat Flour, Animal Protein (Egg and Milk) and Soya Flour

Sample	Moisture (%)	Fat (%)	Protein[a] (%)
Wheat flour	13.82	2.8	9.89
Egg powder	5.78	39.55	50.98
Nonfat dry milk	7.19	2.6	35.97
Full-fat soya flour	6.37	19.00	45.20

[a]Protein content is Nx6.25, except Nx5.7 for wheat flours.

Protein content of egg spaghetti with indicated substitutions was similar to controls, but replacement of nonfat dry milk in milk spaghetti with full fat soya flour resulted in a somewhat higher protein content.

Biochemical Characteristics

The quantity of soluble protein fraction (albumin and globulin) was determined (Table III) by gel filtration on

TABLE II

Protein Content (N x 6.25 dry basis) of Experimental Spaghettis

Replacement (%)	Spaghetti with egg powder	Spaghetti with nonfat dry milk
	Protein (%)	
0 (Control)	12.81	10.19
10	12.78	11.33
20	12.77	12.03
30	13.06	12.76

TABLE III

Soluble Protein Fractions

Samples	Protein fraction (albumin and globulin) I	II	III	IV	Extracted by
Wheat flour	46.55	25.34	20.16	7.95	Dilute salt solution
Full-fat soya flour	28.24	58.68	12.08	1	Water, 70% alcohol
Egg powder	76.96	17.69	2	3	
Nonfat dry milk	41.82	50.74	5.29		Dilute acid

TABLE IV

SH Group (mol/100-g Sample)

Wheat flour	0.825[a]
Full-fat soya flour	2.194
Nonfat dry milk	4.169
Egg powder	20.037

[a]Values times 10^{-2}.

TABLE V

Change in Number of Thiol Groups (SH) at Different Times (60 C)

	Time (min)	SH (mol/ml x 10^{-6})
Wheat flour	10	1.8
	30	2.0
	60	2.4
Full-fat soya flour	10	1.2
	30	1.38
	60	1.6
Nonfat dry milk	10	3.4
	30	4.21
	60	5.3
Egg powder	10	2.75
	30	4.75
	60	8.00

TABLE VI

Farinograph, Extensograph and Amylograph Characteristics of Wheat-Blend Flour with Replacement of Animal Protein (Egg and Milk) with Soya Flour

Blend composition	Absorption (%)	Peak time (min)	Stability (min)	Weakening angle (0°)	Resistance (BU)	Extensibility (mm)	Viscosity peak (BU)	Temperature (C) of gelatinization
Control wheat flour	55.7	5	2.0	40	430	137	1260	91
Control wheat flour + egg powder	55	6	3	25	480	129	1270	91
Control wheat flour + dry milk	54.5	5.5	1	60.0	335.5	165	1115	90
Egg blend with soya flour replacement of								
10%	55	5	3	25	520	110	1250	90
20%	56	4.5	3	35	380	150	1880	99
30%	53.5	4.5	2	50	540	105	1700	90
Dry milk blend with soya flour replacement of								
10%	55	3.5	2	75.0	500	128	1860	90
20%	56	5	1.5	55.0	365	164	1560	90
30%	56	5	2	60.0	350	167	1790	89

Sephadex G-75. Protein fractions with higher molecular weights are responsible for rheological dough properties. This is important because, in successive extraction of the protein fractions, the highest percentage of soluble protein is obtained from full-fat soya flour. It has influenced the improvement of rheological properties of pasta flour.

Changes in Thiol Groups (SH)

Thiol groups were determined by Ellman's spectrophotometric method. Gluten properties and viscosity depend on the molecular network of protein. Rheological properties of that network depend on the number and types of bonds between protein molecules.

In this investigation, replacement of animal protein with soya protein in the pasta blend resulted in significant increases in the number of thiol groups (Table IV). Soya flour has five times more thiol groups than does wheat flour, but fewer SH groups than egg and dry milk.

We determined the number of thiol groups when the protein solutions (wheat flour, soya flour, egg and dry milk) were heated to 60C and held for 10, 30 and 60 min. The results indicated that heating these protein samples increased availability of "masked" thiol groups as shown in Table V.

ESSENTIAL AMINO ACID COMPOSITION

In cereal products, a deficiency of lysine and other essential amino acids is marked. Soya flour represents a rich source of lysine, as well as other essential amino acids. By incorporation of soya flour, one obtains a balanced product of biologically high value with increased lysine content.

RHEOLOGICAL PROPERTIES

Rheological properties of the blends with different levels of substitution of animal protein (egg and milk) with full-fat soya flour were examined and are shown in Table VI.

Farinograph absorption gradually increased with increased levels of substitution in the formulations, except with 30% level substitution. Peak time at all levels of replacement in the blends decreased, whereas dough stabilities were identical with control sample.

Extensograph characteristics varied with changes in the level of substitution of full-fat soya flour. At 20% substitution of egg protein, the resistance was reduced by 20%, whereas at 30% substitution, it increased. Resistance was increased at all levels of dry milk replacement by soya flour. Extensibility of dough was the most favorable for 20% substitution of egg protein.

TABLE VII

Characteristics of Spaghetti with Partial Replacement of Egg Powder and Nonfat Dry Milk by Full-Fat Soya Flour

Samples	Volume	Cooking loss (% dry mat)	Cooking time (min)
Control:			
Egg pasta	3.6	6.1	14
Dry milk pasta	4.7	5.8	18
Experimental:			
Egg pasta with substitute			
10%	3.8	5.5	15
20%	4.4	5	18
30%	3.5	5.9	17
Dry milk pasta with substitute			
10%	2.2	6.4	16
20%	3.7	8.5	15

Amylograph viscosities of blends increased at all levels of substitution. The soya flour increased the dough firmness.

TEST SPAGHETTI QUALITY

The quality characteristics of spaghetti prepared with 10, 20 and 30% substitution of the animal proteins with soya flour are given in Table VII. In this test, the spaghetti having the best quality was obtained with pasta with 20% egg substitution by soya flour. These spaghettis had a better volume (4.4) than the control spaghetti (3.6) and a cooking loss of only 5%.

At 30% substitution of egg, pasta quality decreased. Pasta with dry milk replacer was of good quality at 10% substitution with soya flour. Spaghetti with 30% level dry milk substitution was not produced because of problems with stickiness at the press. Pasta with 20% egg substitution had excellent pastication and sensory characteristics; it was better than control pasta.

Particular Design Aspects of Very Large Extractors

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Three thousand MT/24 hr corresponding to 125 MT/hr means 100 big trucks per day. A shutdown of an extraction plant for 3 days having this nominal processing capacity corresponds, speaking in volume of beans, to a pyramid with a square basis of 30 m length and a height of 60 m close to the size of one pyramid in Gizeh/Egypt.

It is easy to imagine what the economical consequences are and what a nightmare for the plant manager an unexpected breakdown of an extractor in such a huge extraction plant means.

Therefore, concept and design of a plant of such size and the equipment used should eliminate all potential for breakdowns. That means that the expressions "redundancy" and "fail safe" should be headletters when conceiving such a plant.

When looking at the ship/truck unloading and loading system, the bean storage and conveying system for beans and meal, usually sufficient redundancy is existing, which means that a series of similar equipment handles the mass flow and a breakdown of one unit does not stop the whole plant but only reduces the capacity in accordance with the throughput of the failed unit. This redundancy usually also applies for the cleaning and preparation section because sieves, sifters, crackers and flakers that are available on the market can only handle a few hundred tons/24 hr. Therefore, rows of units are required to cope with the multithousand tons capacity. Some attention is to be paid to the conveying system to warrant a certain redundancy by using at least two, instead of one, conveyor to handle the mass flow between the different sections of the plant.

Economic calculation has proved over the years that, from the viewpoint of investment, energy savings and operational costs, a huge extraction plant for soybeans is a more profitable alternative than two or three separate extraction lines in parallel. Therefore, the design of a large extractor and the matching desolventizer-toaster should have integrated the same reliability and redundancy, although they are single units, as provided in the seed pretreatment equipment.

Another important aspect is the hazardous atmosphere generated in the extractor during operation, which means that not only the net time required to repair a failed element, but a multiple of this time is necessary when the hexane gas must be removed. Besides the imminent danger, additional loss of solvent and required fire protection measures must be considered.

The design for a multithousand ton extractor should: (a) locate all movable parts such as bearings, drives and similar elements outside the hexane atmosphere to provide easy access and changeability. (b) Provide sufficient redundancy for such parts as well as easy access without the need to empty the extractor when those parts must be replaced when it is physically impossible to place such movable parts outside. (c) Use external drives in such a number that the

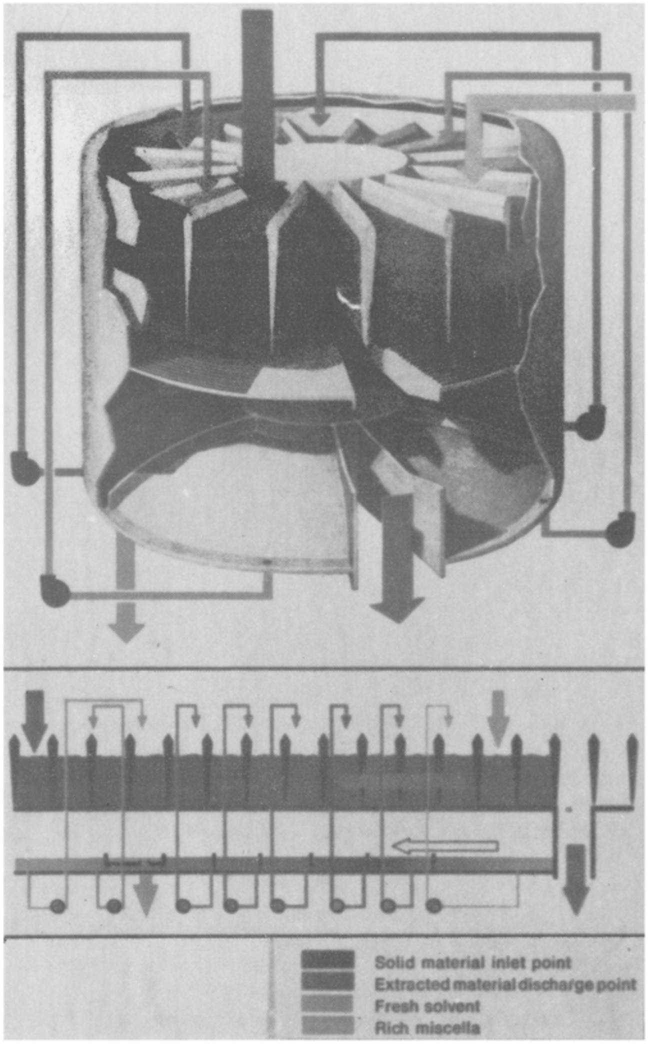

FIG. 1. Material flow through the carousel extractor.