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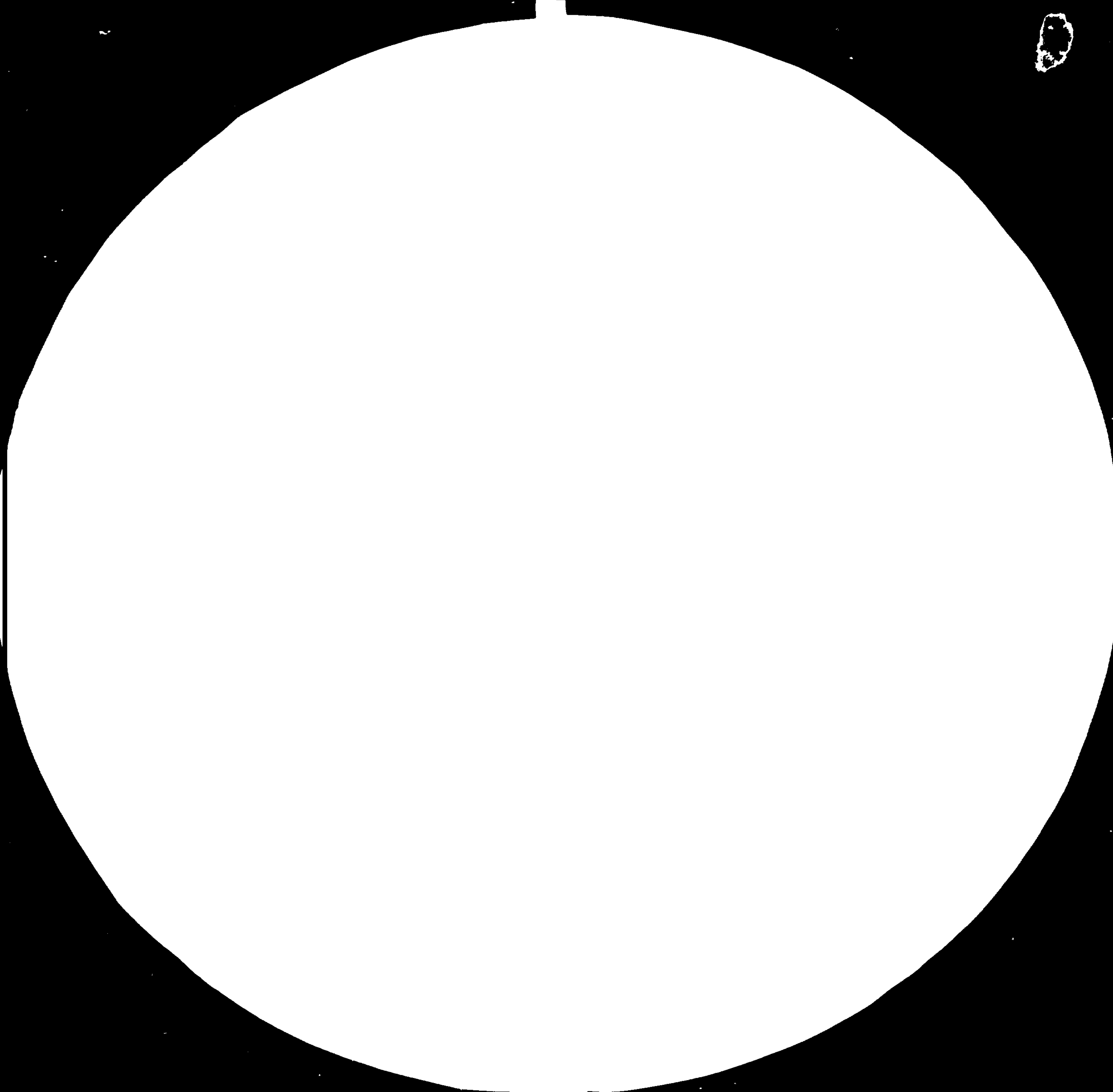

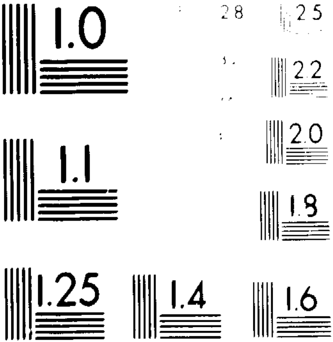

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13 April 1983

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THE EXPERIENCE OF THE ANDEAN PACT COUNTRIES IN THE FIELD OF COMPOSITE FLOURS FROM THE TECHNOLOGICAL, ECONOMIC AND SOCIAL ASPECTS

Presented to the Composite Flour Workshop (FAO-UNIDO)
Dakar, 6-10 December 1982

by

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V.83-54315

Explanatory notes

Reference to "tons" indicates metric tons, and to "dollars" ($) United States dollars, unless otherwise stated.

The following abbreviations have been used throughout the paper:

c.i.f. cost, insurance and freight

GNP gross national product

ppm parts per million

The following symbols have been used in the tables throughout the paper:

Two dots (..) indicate that the data are not available or are not separately reported.

A point (.) is used to indicate decimals.

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INTRODUCTION

The Andean subregion is highly dependent on imports for wheat because the local crop is in complete recession. In 1977 87.5 per cent of wheat was imported. Various policy measures have been tried out to counteract this situation with some or no success.

Composite flours, as an additional option, have been explored from the technological aspect in the subregion since 1967. They showed great versatility in wheat substitution for relatively high levels. The concept was accepted by different agents involved in the system but problems arose concerning the availability and price of the substituting raw materials, which frequently produced negative results at the microeconomic level, but indicated advantages for the agroindustrial development of the country in a macroeconomic analysis. These results led to the conclusion that no additional technological work was required for wheat replacement in bread and pastamaking, but that a harmonization of policies concerning the production and consumption of wheat was needed.

On the basis of this conclusion the Andean Projects for Technological Research in Foods, co-ordinated in the subregion by the Junta del Acuerdo de Cartagena, promoted feasibility studies at the country level in the Andean subregion.

A methodological approach was used, including the use of a manual and of a mathematical model for numerical experimentation designed within the projects for the analysis and programming of the production-consumption system. This method measures, at the micro and macro levels, the effects produced by the introduction of a given technological change into the system. It also permits the simulation of effects caused by changes in policy instruments that regulate the different components of the system.

The application of this instrument to the feasibility studies on composite flour at the country level has permitted the:

(a) Evaluation of the economic advantages of a set of options for the replacement of imported wheat with respect to the present situation;

(b) Quantification for different options of efforts to be made in a given country in natural and economic resources as well as the selection of the economic policy instruments to be used for the project to be feasible at the micro and macro levels on a continuous basis.

This paper includes a summary of the subregional technological experience in the field, a brief description of the methodology used and preliminary results obtained in the feasibility studies at the country level.

I. THE ANDEAN PACT

In order to provide a background to this report, it should be explained what the Andean Pact is and some demographic and socio-economic data on its member countries should be given.

Five Andean countries, Bolivia, Colombia, Ecuador, Peru and Venezuela, located in the north-west of South America, signed the Andean Pact in 1969 with the aim of making a concerted effort to speed up the progress of the countries through the enlargement of their market. The Subregional Integration Agreement proposes to lay the groundwork for the creation of a true economic union among the signatory countries [1].

Tables 1 to 3 give selected statistics for the Andean group countries. The Group has a population of 73 million, of which 21.6 million are economically active, and about 36 per cent live in rural areas. A certain degree of heterogeneity is found in the five Andean countries, not only in demographic but also in the economic and social aspects; life expectancy varies from 49 to 66 years and infant mortality rate varies from 32 to 135 deaths per thousand live births. The least populated country, Bolivia, has a population of 5 million and the largest one, Colombia, has a population of 26 million. The gross national product lies between $US 3,000 million and 28,000 million giving a total for the Andean group of countries of 81,000 million, close to that of Sweden or Switzerland in 1977. In 1979 the gross national product (GNP) per capita varied greatly, from $580 to $1,781. There was an unequal income distribution, 60 per cent of the population received 23 to 26 per cent of the GNP. The unemployment rate, lowest in Ecuador (3.3 per cent) and highest in Peru (7.1 per cent), had an average of 6.9 per cent for the Group. Underemployment was high and varied, with an average of 30.5 per cent. Illiteracy was lowest in Venezuela (18.5 per cent) and highest in Bolivia (37.3 per cent). These data are typical of developing regions in the world, although an impressive progress has been made in the last two decades [3].

Table 1. Selected statistics for the Andean Group: demographic, 1980 [2]

	Bolivia	Colombia	Ecuador	Peru	Venezuela	Andean Group
Total population (millions)	5.57	26.89	8.02	17.62	14.93	73.04
Urban (%)	40	67	44	65	78	64
Rural (%)	60	33	56	35	22	36
Density (inhabitants/km^2)	5.1	23.6	29.6	13.7	16.3	15.5
Economic active poopulation (millions)	1.75	7.80	1.39	5.21	4.46	21.64
Life expectancy (years)	48.6	62.2	60.0	57.1	66.4	...
Infant mortality rate[a/]	135.1	53.5	80.0	108.8	32.5	...

a/ Number of deaths per thousand births.

Table 2. Selected statistics for the Andean Group: economic, 1979 (2)
(Dollars)

	Bolivia	Colombia	Ecuador	Peru	Venezuela	Andean Group
GNP (millions)	3 146	28 642	6 951	16 948	25 744	81 431
Exports (millions)	246	2 194	662	2 141	3 252	8 495
Imports (millions)	399	2 417	945	1 223	7 141	12 125
GNP per capita	580	1 091	894	968	1 781	1 146

Table 3. Selected statistics for the Andean Group: social, 1979 (2)
(Percentage)

	Bolivia	Colombia	Ecuador	Peru	Venezuela	Andean Group
Unemployment rate						
Unemployment	6.3	8.6	3.3	7.1	6.0	6.9
Underemployment	59.7	14.7	50.0	51.4	15.0	30.5
Illiteracy rate	37.3	19.2	26.6	23.1	18.5	..
Population having access to drinking-water						
Urban	47.6	80.0	45.0	73.0	88.0	75.3
Rural	15.0	33.0	13.0	10.0	42.0	24.0
Population supplied with sewage facilities						
Urban	35.0	65.0	35.0	50.0	52.0	53.3
Rural	20.0	15.0	11.0	..	..	..

II. THE PRODUCTION-CONSUMPTION SYSTEM OF WHEAT

An analysis of the production and consumption of wheat in the subregion for the 1960-1980 period is given in the following paragraphs.

A decrease by half of the cultivated area and volume of production of local wheat with no remarkable changes in average yields - with the exception of Colombia (25 per cent from 1960 to 1970) and Peru (18 per cent from 1970 to 1980) - indicates that very little or no technological change took place in this agricultural subsector as well as a complete absence of the effects of the Green Revolution (see figure 1).

The reduction experienced in the cropping area and in the volume of locally produced wheat has been attributed mainly to the favourable conditions for the purchase of imported wheat from the United States of America under the P.L. 480 Law.

The application of this law had a considerable impact on the prices paid to the local producers for their wheat, since they were fixed on the basis of the imported wheat from the United States. (American wheat was produced not only under much more efficient conditions, but also had a government subsidy.)

The price difference between the wheat produced in the Andean Pact countries and that imported from the United States over a period of 13 years is given in figure 2. In the early 1960s the local wheat could compete with the c.i.f. price. From 1966 on, local wheat was always more expensive except for the year 1973, when the shortage of wheat in the world made its price rise greatly [4, 5].

Under the circumstances the local production of wheat was no longer an attractive enterprise and the traditional competition of wheat with other crops for the same land increased greatly. Table 4 shows the competition that the local production of wheat faced during the 1975-1978 period in terms of cost/benefit and net income per hectare in all Andean countries [4].

The data indicate the decreasing rate observed in the local production of wheat and in the area allocated to this crop in the period under consideration (figure 2). Potatoes were the most competitive crop in terms of net income per hectare. With the exception of barley in Peru it was difficult for wheat to compete with any other crop.

The prevalence of small plots producing wheat only (table 5) explains the lack of technological improvements [7].

Figure 1. Area, production and yields of wheat in the Andean subregion, 1960-1980 [4]

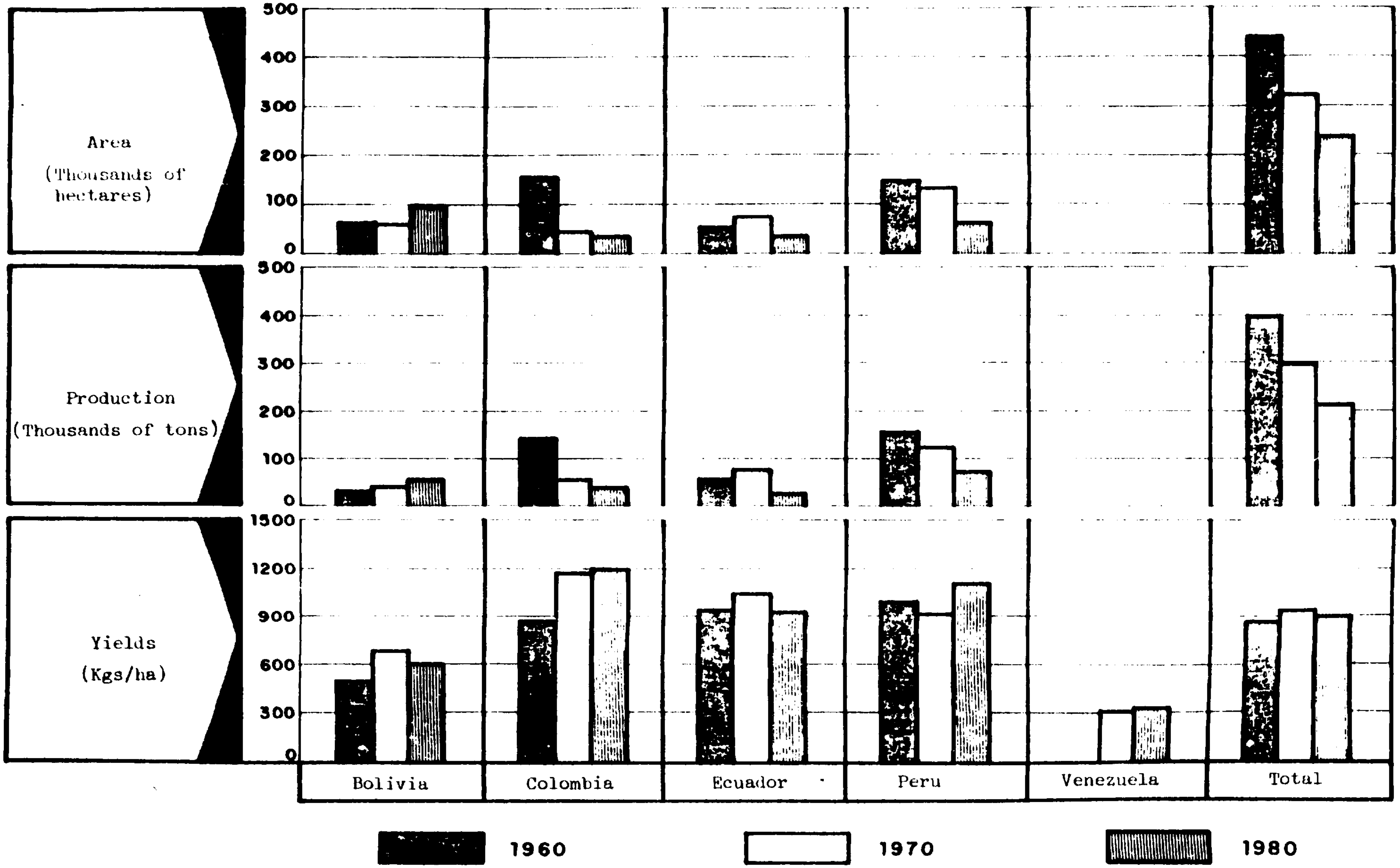


Figure 2. Price difference between imported and locally produced wheat, 1963-1976 [4, 6] (Dollars/ton)

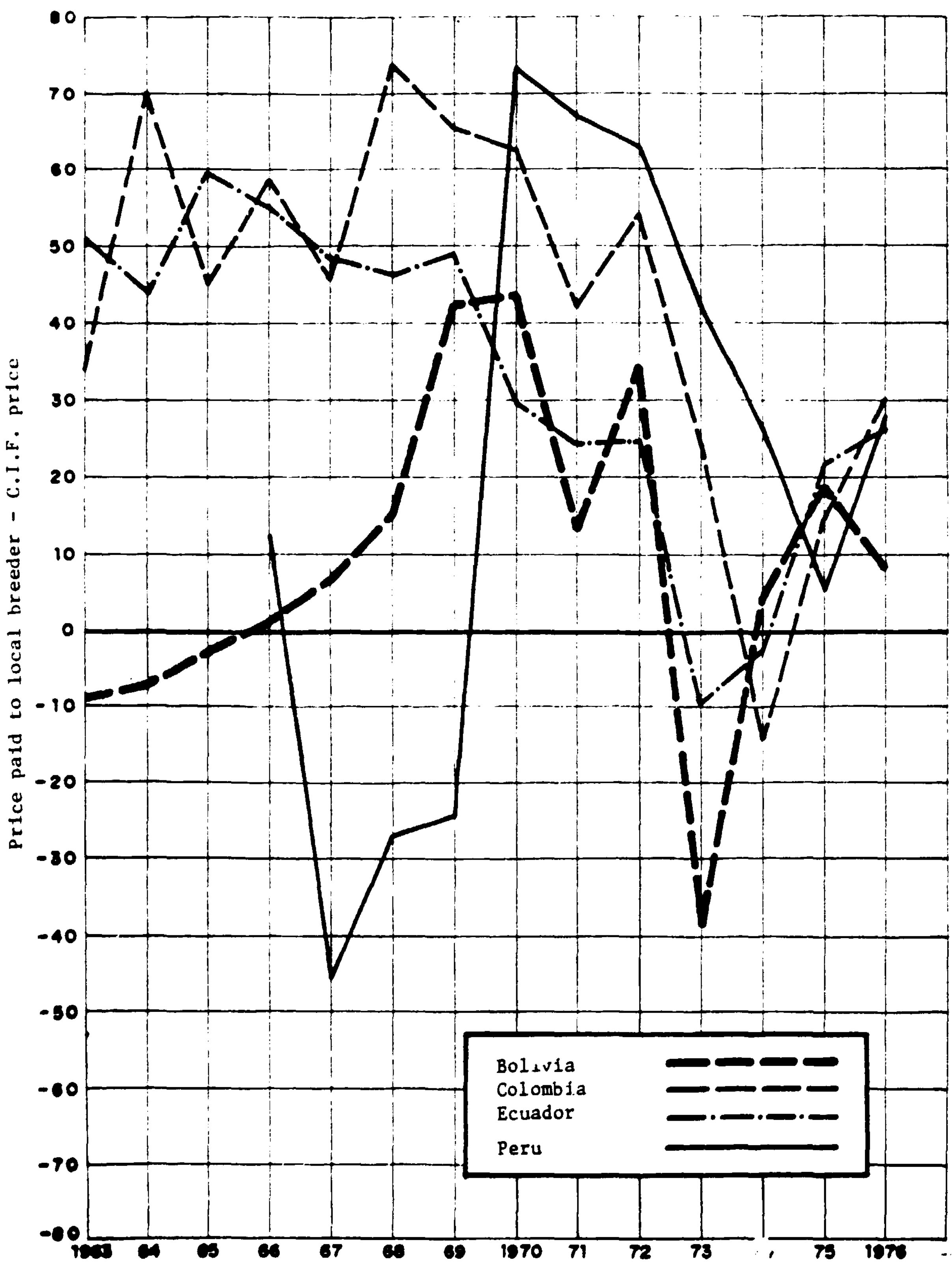


Table 4. Profitability of wheat crop compared with competitive crops (Mechanized system - market prices) (4)

Country	Cost-benefit				Net income/ha (Index)			
	Wheat	Barley	Potato	Corn	Wheat	Barley	Potato	Corn
Bolivia (1975)	1.28	1.83	1.70	2.22	1.00	1.20	5.40	2.70
Colombia (1978)	1.09	1.40	1.46	-	1.00	1.30	5.80	-
Ecuador (1977)	0.97	1.22	1.98	1.15	1.00	3.50	87.20	3.10
Peru (1977)	1.56	1.46	-	1.68	1.00	-	8.00	1.90

Table 5. Methods of wheat production in the Andean subregion, 1980 [4]

Crops	Traditional	Semi-mechanized	Mechanized
Size (ha)	0.1 - 5	5 - 10	>10
Total area (percentage)	78.9	9.6	11.7
Total production (percentage)	65.3	18.7	16
Yield (kg/ha)	820	1 400	2 000
Cost of production, 1977 ($/ton)	140	250	270

In the per capita consumption of wheat in the subregion (figure 3) there was a major increase in Bolivia, from 20 to 60 kg from 1970 to 1980, and a moderate growth in the other countries. A small decrease is observed in Venezuela in the last 10 years, while Colombia has the smallest consumption figures (20 kg/capita) [4, 6].

To meet the growing demand for food in general - caused by income growth, rate of urbanization and population growth - and the need for low-cost foods, Governments found a solution in importing wheat under the P.L. 480 Law, which was less expensive than making investments in technology and infrastructure for the local production to grow and expand [5].

Figures 4 and 5 show that the volume of imported wheat during the 1960-1980 period increased 2.6 times and that the value increased 7.5 times, figures for 1980 being 2.6 million tons and $580 million. Annual increase in volume was 5.3 per cent and in value 8.7 per cent. Table 6 shows a high prevalence of imports from the United States, probably a consequence of the long-term application of the P.L. 480 Law in the subregion [4, 6].

Table 6. Origin of wheat imports: 1975-1977 average [4]
(Percentage)

	Originating country			
Importing country	United States	Argentina	Canada	Others
Bolivia	65.0	31.0	-	4.0
Colombia	86.0	14.0	-	-
Ecuador	100.0	-	-	-
Peru	64.0	21.0	8.0	7.0

Figure 3. Per capita consumption of wheat in the Andean subregion, 1960-1980

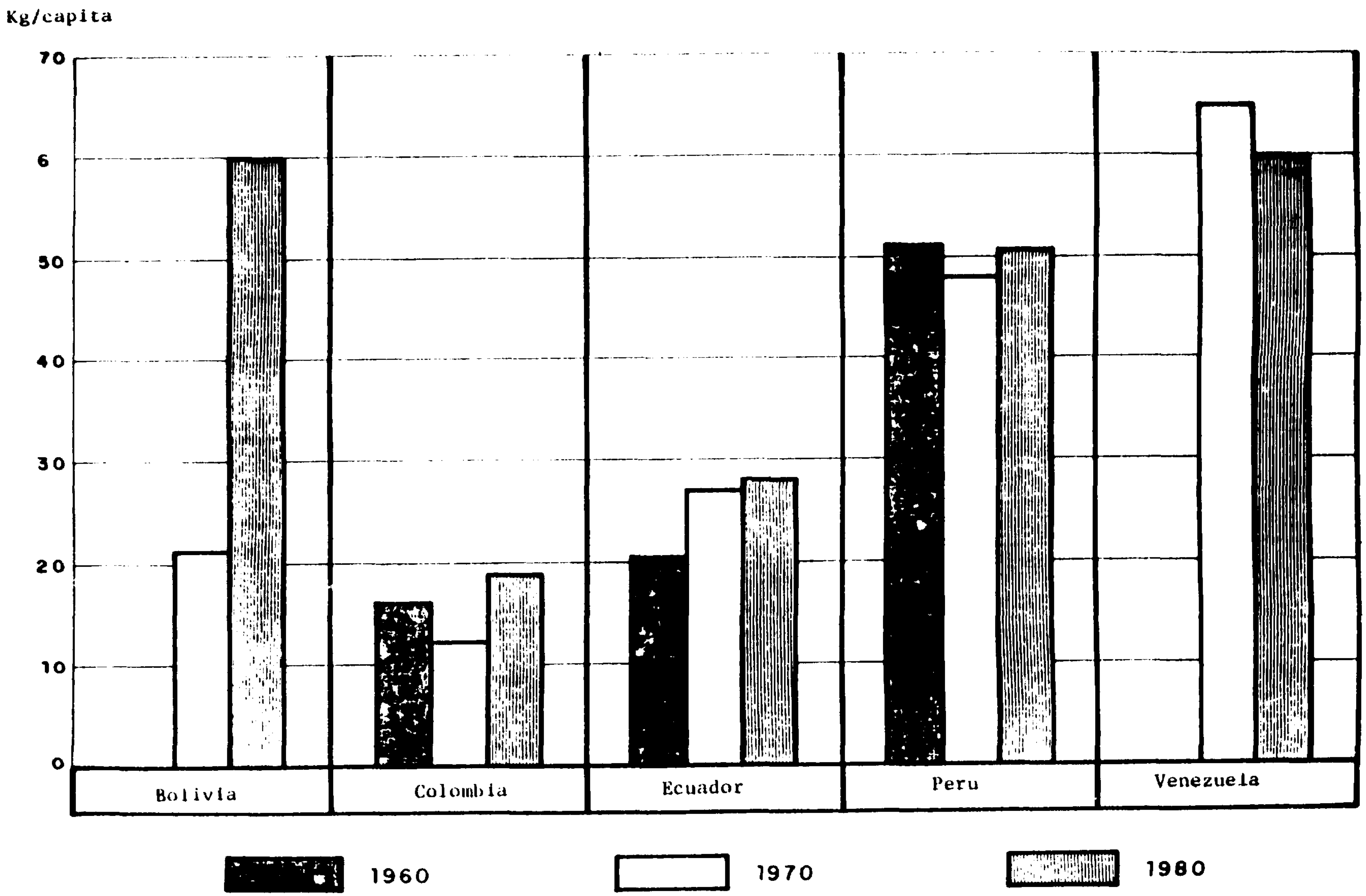


Figure 4. Wheat imports in the Andean subregion, 1960-1980: volume

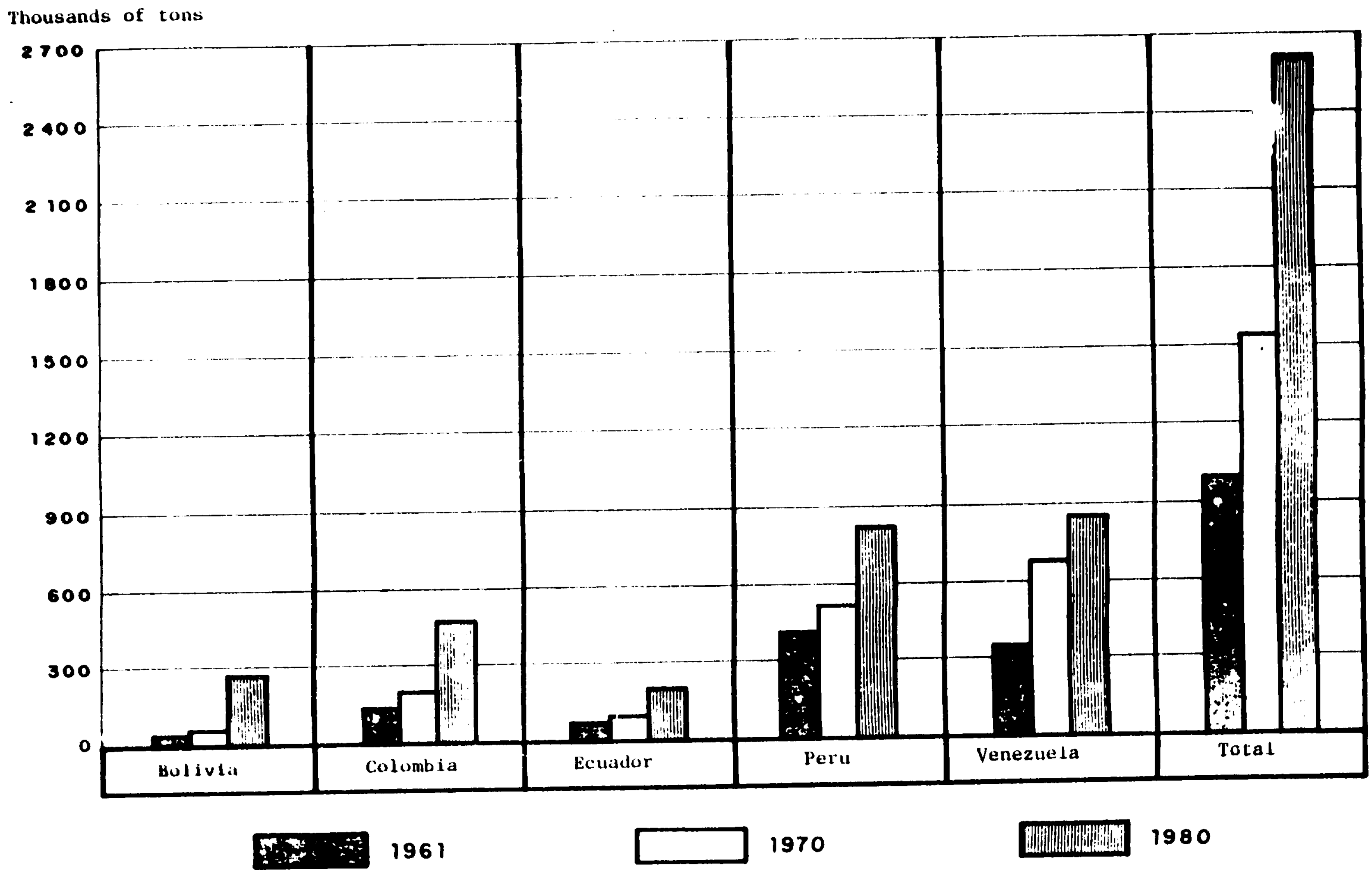
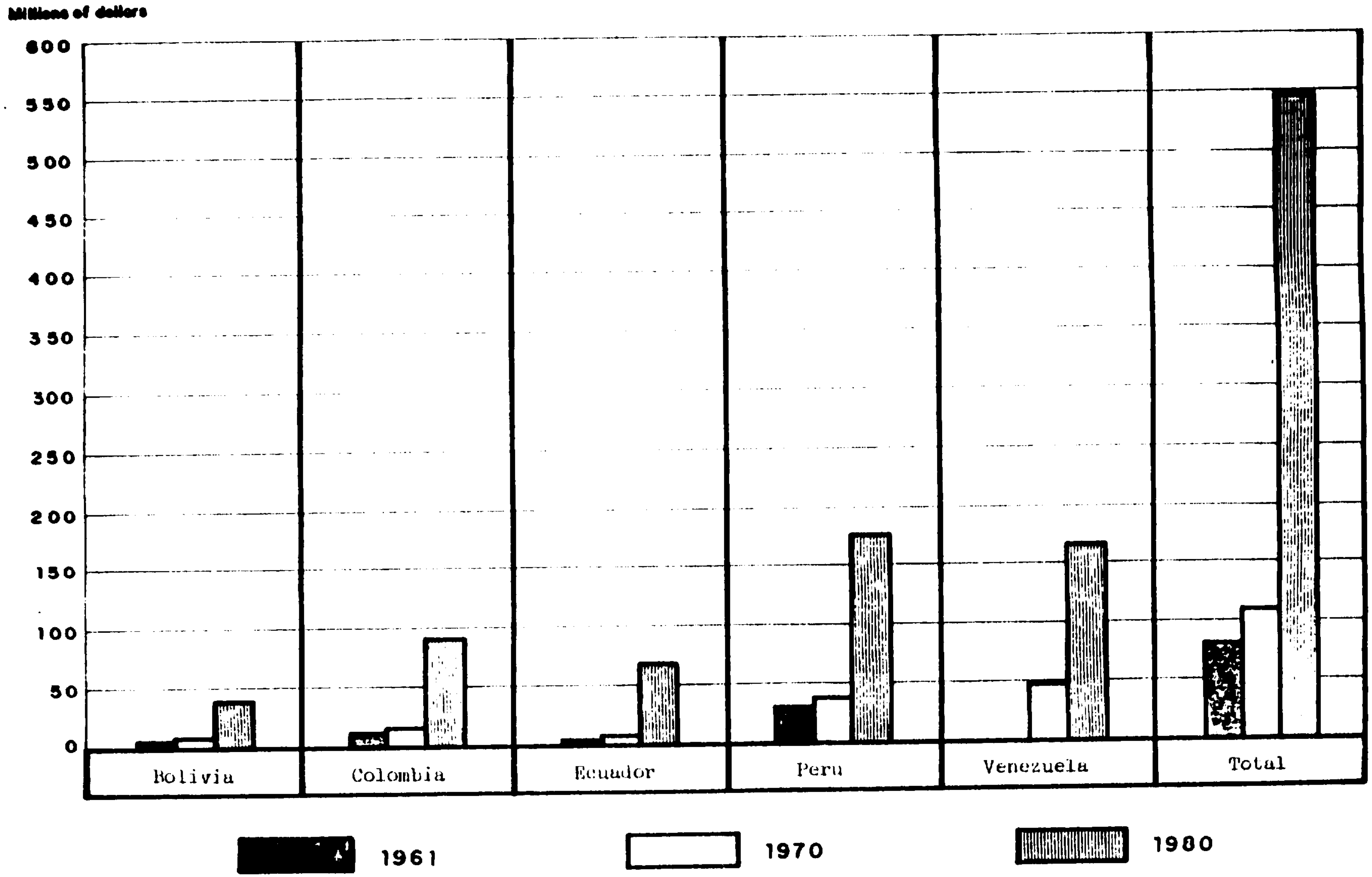


Figure 5. Wheat imports in the Andean subregion, 1960-1980: value



III. COMPOSITE FLOURS AS A PARTIAL SUBSTITUTE FOR IMPORTED WHEAT

In order to reduce their dependance on imported wheat, Governments imposed measures oriented to promote the production of local wheat, such as:

(a) Subsidies on seed and fertilizer purchases (Ecuador, 1973) [4];

(b) Subsidies on the transportation cost from the grower to the mill (Peru, 1973) [4];

(c) Elimination of subsidy on imported wheat (Colombia, 1974)1/ [4];

(d) Local wheat absorption quota for mills.

The first two measures have not proven to be effective because a wide coverage was not possible. The positive effect produced by the quota mechanism could not often counteract the competition for land for the more profitable crops mentioned above.

The use of composite flours was considered a solution to the problem of dependence on imports for wheat, for the first time in the mid 1960s, as a means for reducing foreign currency needs, food dependence, and fiscal deficits, as well as for promoting agricultural development and improving nutritional quality of bread and pastas.

From 1967 to 1978 various raw materials, such as cereals, roots, tubers and oilseeds, were tested as a substitute for wheat at different subregional technological institutions. The results showed, with different degrees of progress, the technical feasibility of substituting wheat in bread and pastas. The need for a rapid and precise method for the quantitative assessment of the ingredients in the composite flours was detected. In 1978 the Andean Projects for Technological Development in the Field of Foods were approved by the Commission of the Andean Pact.

One of the projects to be implemented by institutions in the five Andean countries concerned composite flours. The main purpose of this project was to level up the technical knowledge in the field of composite flours in the five countries, to work out a quantitative analytical method applicable to composite flours and to study national and subregional feasibility of introducing composite flours to the productive sector.

To undertake this project the methodological sequence described in the following paragraphs was applied.

1/ The results of this measure have not been sufficiently analysed.

A. Methodological approach for micro- and macroeconomic evaluation of technological alternatives

The methodological sequence for micro- and macroeconomic evaluation of technological alternatives, developed within the Andean Projects for Technological Development in Foods [8], is given in diagram 1. Stages A, B and C of the sequence are the common ones followed by technological researchers in their work. Stage D introduces a technological alternative into the production-consumption system, given in diagram 2. The components considered are:

(a) The consumption sector represented by two triangles (population and income);

(b) The manufacturing industry of final goods (central rectangle);

(c) Sectors articulated to the manufacture of the final goods (rectangle at the extreme left);

(d) Storage, transportation and distribution activities;

(e) The external sector (imports and exports);

(f) Explicit policies that regulate the internal and external behaviour of the system [8].

The introduction of a new technological option into the system or into any component of the system as shown in diagram 1, will produce a set of effects on the rest of the components linked to it within the system. It is necessary to evaluate these effects in order to see the advantages or disadvantages of introducing a technical change [8, 9].

The evaluation should be at both the micro and macro levels and performed at stage E of the sequence. The level of efficiency reached by the introduction of a technical change should be evaluated against standards built up on the basis of specific development objectives of the country.

The results of this macroeconomic evaluation (annex II) indicate whether changes should be introduced in technological and economic policies for the system to reach, in the most efficient way, the standard set up by the development objectives of the country [8, 9].

Once the micro and macro evaluations have been completed, the following three situations may arise:

(a) If the results of both the micro and macro evaluation are positive, a final feasibility study should be undertaken and the start-up of the programme can take place;

(b) If the results of the micro evaluation are positive but those of the macro evaluation are negative, it means that there are restrictions in the components linked to the one in which the technical change is to be introduced. In that case policy measures should be designed to overcome those restrictions and to evaluate the effects produced by their incorporation. If the results are positive at this stage, the feasibility study can be undertaken and the start-up of the project can take place;2/

2/ If results are negative, it is advisable to go back to the prefeasibility study to determine whether the project can be compatible with the system or whether it should be rejected.

Diagram 1. Methodological sequence for micro- and macroeconomic evaluation of technological alternatives [8, 9]

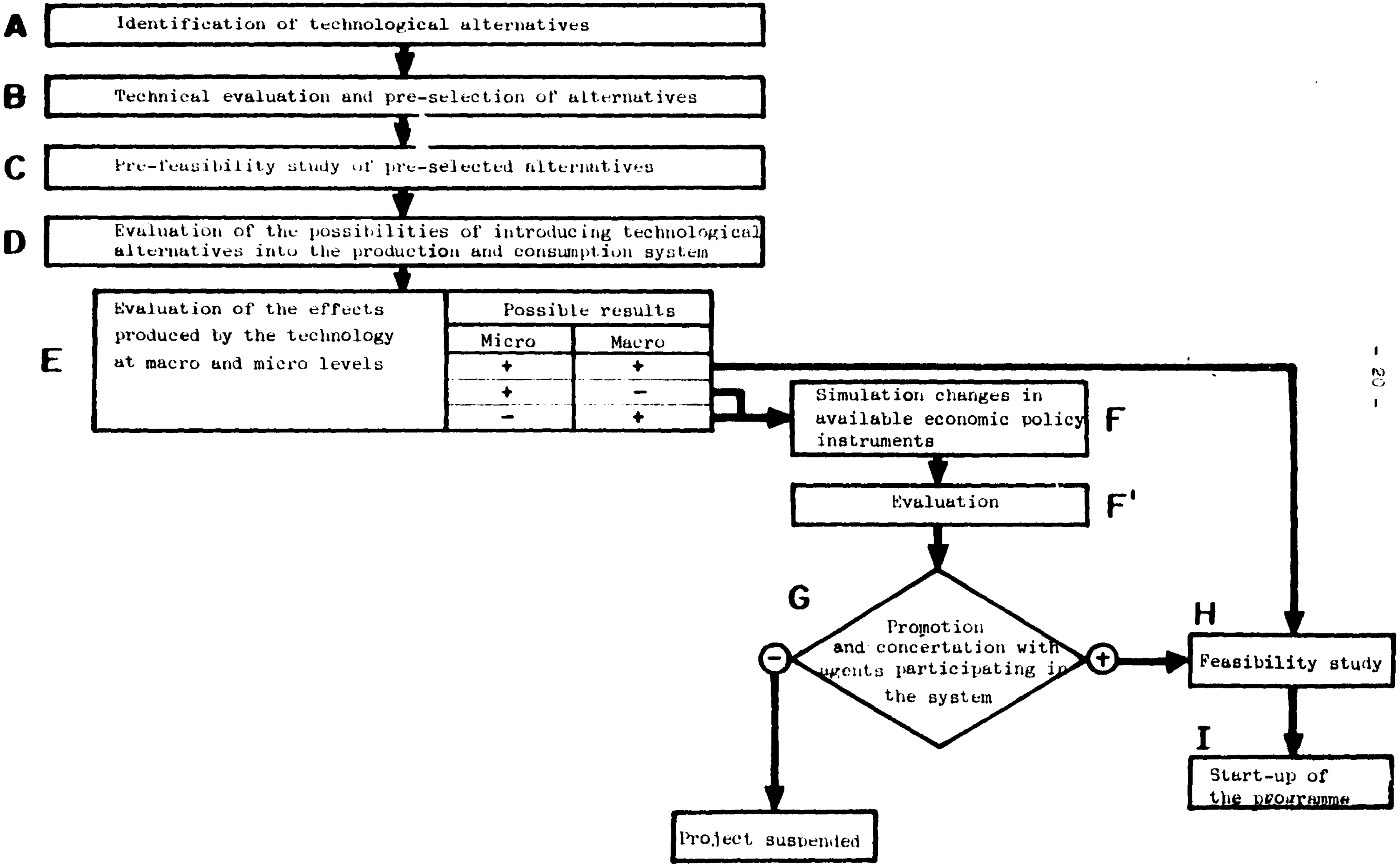
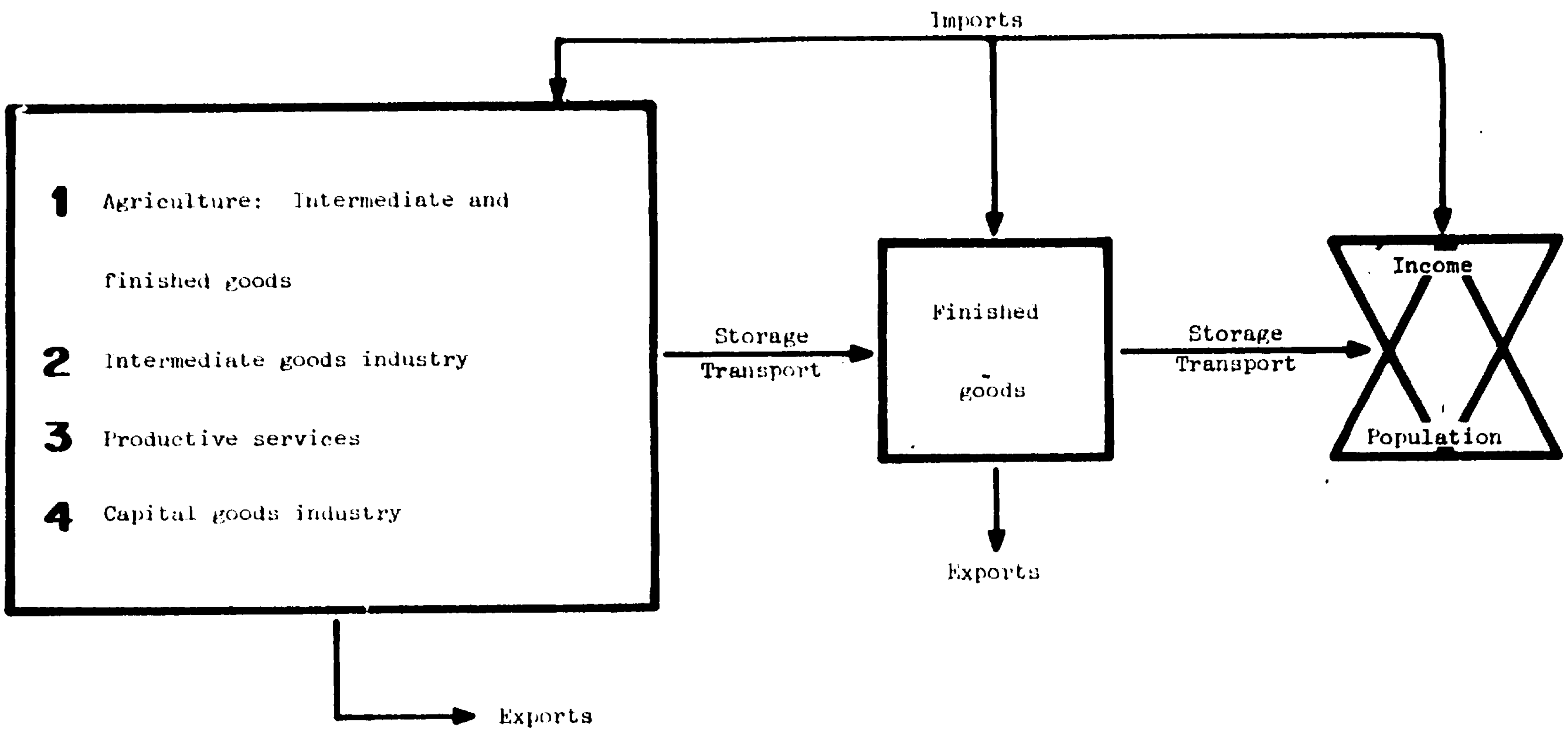


Diagram 2. Basic scheme for production-consumption system [8]



Policies	Prices, subsidies, finance, tax Exports promotion, tariffs, tax, foreign exchange		Property Tax Financial Salary		Incomes Price Tax Subsidies

(c) If the results of the micro evaluation are negative but those of the macro evaluation are positive, indicating that technical changes should be introduced, then modifications should be simulated in the policy instruments[3] that regulate the system, in order to make feasible the introduction of the technology in question (stage F) and evaluate the effect of those changes (stage F') against standards built up on the basis of specific development objectives of the country.

B. The methodological approach as applied to composite flours

The results obtained in applying the methodological approach to composite flours in the Andean countries, are given in the following paragraphs.

Composite flour alternatives[4]

Table 7 shows the different alternatives tried out in the subregion, five cereals, three tubers and three types of oil-seeds as protein enrichers. The cereals have been used mainly as flours. Grits, precooked flours and isolated starches were additional options tried out for pasta or bread making. With regard to tubers, fresh roots have been used for small-scale work. For larger operations raw flours and precooked potato flours were studied. Soybean, sesame and cottonseed flours have been used as protein enrichers.

The substitution intervals subject to study are shown in table 8. The maximum level of substitution allowed for bread making has been 30 per cent, for pasta making up to 88 per cent when precooked flour was used. Minimum level of substitution has been 5 per cent, but the most frequent level lies between 10 and 15 per cent. For protein enrichers or fortifiers, the levels have been from 3 to 30 per cent. For wheat the protein level has been 3 per cent, for bread from 8 to 30 per cent, for pastas from 15 to 25 per cent.

Technical evaluation and criteria used for preselection

A successful application of the concept of composite flours involves the need of complying with the following restrictions:

(a) Minimum changes introduced in the bread and pasta conventional operations;

(b) An acceptable and constant quality of the end products.

3/ Policy instruments related to subsidies (inputs and/or outputs), tax reduction on capital goods or other inputs, preferential credit lines, tax returns etc.

4/ See also diagram 1.

Table 7. Options examined for wheat substitution

	Whole seeds	Fresh roots	Grits	Dry flakes	Flour	Precooked flour	Starch
Cereals							
Corn			x		x	x	x
Rice			x[a/]		x	x	
Quinua (Chenopodium quinoa)					x		
Barley					x		
Sorghum					x		
Tubers							
Manioc					x		x
Potato		x			x	x	
Sweet potato (Ipomea batata)		x			x		
Oil/legumes							
Soybean						x[b/ c/]	
Sesame					x	x	
Cottonseed						x	

a/ Broken polished rice.

b/ Full-fat.

c/ Defatted.

Table 8. Substitution intervals for bread and pasta making
(Percentage)

	Raw seeds	Fresh root	Grits	Dry flake	Flour	Precooked flour	Starch
<u>Cereals</u>							
Corn	...	...	5-70	...	10-30	10-88	10-50
Rice	...	...	5-50	...	10-30	50	...
Quinua (Chenopodium quinoa)	...	...	...	...	5-30	...	...
<u>Tubers</u>							
Manioc	...	...	...	...	10-80	...	10-75
Potato	...	10-30	...	...	10-30	10-20	...
Sweet potato (Ipomea batata)	...	5-15	...	...	15	...	...
<u>Oil/legumes</u>							
Soybean	...	...	...	...	3-8 a/	...	...
Sorghum	...	...	10-30	...	3-30 b/	...	...

a/ Defatted.

b/ Full-fat.

Taking these restrictions into consideration, a set of parameters has been chosen for the evaluation of different alternatives of composite flour application in bread and pasta making. These are shown in tables 9 and 10.

The compliance of these restrictions had to be tested not only at the laboratory or pilot plant of the research centre but also at the production level - wheat mills and other mills for succedaneous materials, bakeries and pasta industries - and at the consumer level.

The activities required for testing alternatives are given in table 11.

Technical results obtained

Bread production

In applying the criteria described above, 15 formulae were found technically acceptable at pilot plant stages and were preselected. These formulae are given in annex II, tables A.II.1 to A.II.11. The levels reported are the maximum permissible levels, i.e. the highest possible levels within the restrictions mentioned above.5/

Corn. The maximum level of substitution was 17 per cent using grits and starch (25 per cent). A bread improver was required (CSL, SSL). The use of starch or precooked flours did not show additional advantages over the raw flour or grits [9, 12, 13, 14].

Rice. The use of this cereal has been successfully tried out on industrial scale in Colombia, milling it together with wheat at the mill. The level of 27 per cent is considered the best option for Colombia. Similar results were obtained in Ecuador [10, 12, 13, 14].

Sorghum. Little work has been done but it appears to be a good alternative to corn if the decortication of the seed is efficient [10].

Quinua. This pseudo cereal requires the elimination of saponines before producing the flour. The level of 8 per cent was found adequate at industrial scale in Bolivia [15].

Barley. A good option without requiring the use of bread improvers [16].

Manioc. Work done in Colombia with 25 per cent manioc flour (food grade) gave results close to those obtained with manioc starch, thus eliminating the need for the more expensive starch, which had been proposed by TNO and other groups as the only option for manioc in composite flours. Technologically, manioc behaves best of all as wheat substituent. The addition of 5 per cent of soya flour is recommended for formulations with manioc. The absence of high-yielding commercial manioc varieties, however, eliminates manioc as a short-term option for composite flours from the economic point of view [10, 13, 14].

5/ For characteristics of the raw materials used as wheat substituents see annex III.

Table 9. Parameters and specifications used for evaluating bread production with composite flours

Parameter	Points	Condition
Flour		
Moisture		
Protein		Within the average of commercial wheat flours
Colour		
Granulometry		
Farinographic characteristics		
Bread[a/]	Points	
Loaf volume		
Croist colour	5	
General appearance	5	Total score should be minimum 6.0 with characteristics typical of the local bread
Crumb texture	10	
Crumb colour	5	
Total score	0.4	
Production process		
Time extension before moulding dough		Should not exceed 30' over the usual time
Water percentage		Should not require reductions higher than 4 per cent from the usual water percentage

a/ Using TNO Backing Test applicable to the hand mixing and "cilindradora" [10].

Table 10. Parameters and specifications used for evaluating pasta production with composite flours (11)

Parameter	Condition
Flour	
Moisture Protein Colour Granulometry	With the average of commercial wheat flour
Pasta	
Weight increase	≤20% max. with respect to 100% wheat pastas
Volume increase	≤10% max. with respect to 100% wheat pastas
Solids in suspension	≤8%
Colour (Hunter model D-25)	Dry - L 88 min Moist - L 65 min
Flavour	No strange flavours permitted. Local cereal flavour allowed
Texture	Adhesiveness should be minimum
Production process	
Premixture Hydration Kneading Extrusion	Modification to standard process allowed within equipment versatility and standard cost of production process
Predrying Drying	Essential to keep good mechanical properties in the product all through the process

Table 11. Technical evaluation and preselection of alternatives: activities required for testing alternatives

Mills (Other than wheat mills)	Wheat mills	Bakeries and pasta industries	Consumer
Experimental production at industrial level	Experimental production at industrial level	Training in handling of flour	Panel
			Intramural acceptability test
		Experimental production at industrial level	Preference test
			Control location test

Potatoes. Two technical options have been tried out successfully in three Andean countries, one with the fresh roots cooked at the bakery, applicable for small-scale business and the other with the precooked flours applicable to industrial bakeries. The permissible level of substitution is lower with the precooked flour (20 per cent versus 30 per cent) and the use of a bread improver is required in the latter case [10, 15, 16, 17].

Camote (Ipomea batata). An option for small-scale commercial installations that has been tested at the La Molina University of Peru for many years involves the cooking of the tubers at the bakery, and the production of a pure' before adding the sponge and dough process [18].

Oil-seed flours. The best results with oil-seed flours as protein enriching agents have been obtained with 5 per cent defatted flour, at industrial level in Bolivia and 15 per cent full-fat soy flour at pilot scale in Colombia. The presence of these flours always had a positive effect in the keeping quality of bread during storage over the whole wheat bread.

There are a great number of options technically feasible for bread production. No bread improvers are required if substitution levels are below 15 per cent.

Pasta production

Corn and rice have been the most studied wheat substitutes in the subregion. (See annex II, tables A.II.10 and A.II.11.) The maximum permissible levels that comply with the selected criteria are 70 per cent using precooked flours (D.I. 50).6/ With raw flour the level of corn is 15 per cent or 12 percent of corn flour and 3 per cent of defatted soya flour [9, 13, 14]. Pastas constitute an interesting vehicle for protein enrichment, using defatted soya flour. The pasta made from 25 per cent of semola, 25 per cent of soya flour and 50 per cent of precooked flour has been produced at industrial level successfully. Other alternative with 85 per cent of wheat and 15 per cent of defatted soya flour, has been sold in Colombia through the National Food and Nutrition Program since 1977.

Pasta making has advantages over bread making as far as wheat substitutes go because permissible levels are higher and the number of commercial enterprises to be attended during the introductory phases of the programme is smaller than the number of bakeries.

The loss of solids during pasta cooking is still a problem at high substitution levels, except when pastas are used in soups. More work should be carried out in the field.

6/ D.I. = Dextrose Index [19].

C. Pre-feasibility studies[7]

When the work of Stage B was finished, one short-term alternative was selected for each country on the basis of the following:

(a) Availability, price situation and future development of raw materials;

(b) Use of available installed capacity;

(c) Minimum investment required.

The result of the work done at this stage was the design of the following three subregional industrial lines, two of them applicable to urban areas and the third one to be installed in a rural area:

(a) Production of the composite flours at the wheat mill;

(b) Production of the substituent flours outside the wheat mill;

(c) Production of composite flours at the bakery.

Production of composite flours at the wheat mill

Line description

This line is feasible for countries where there is ample availability of semi-processed cereals and oil-seeds, such as corn grits, soya flour, polished rice, dehulled sorghum and pearled barley, and an unused installed capacity at the wheat mills.

Diagram 3 corresponds to this line set up in Colombia according to the formula with 80 per cent of wheat, 17 per cent of rice and 3 per cent of soya flour with 0.25 per cent CSL and 50 ppm KBr.

Polished rice, broken if available, is stored in a silo (S-040) and directly enters the mill simultaneously with wheat, previously cleaned, polished and conditioned. Rice and wheat are subject to the regular milling operation. Before the packing stage a dosifier (D-270) installed on the transportation line, adds the premix (soya flour - CSL + KBr.) to the wheat-rice flour. The composite flour is then packaged in bags and stored.

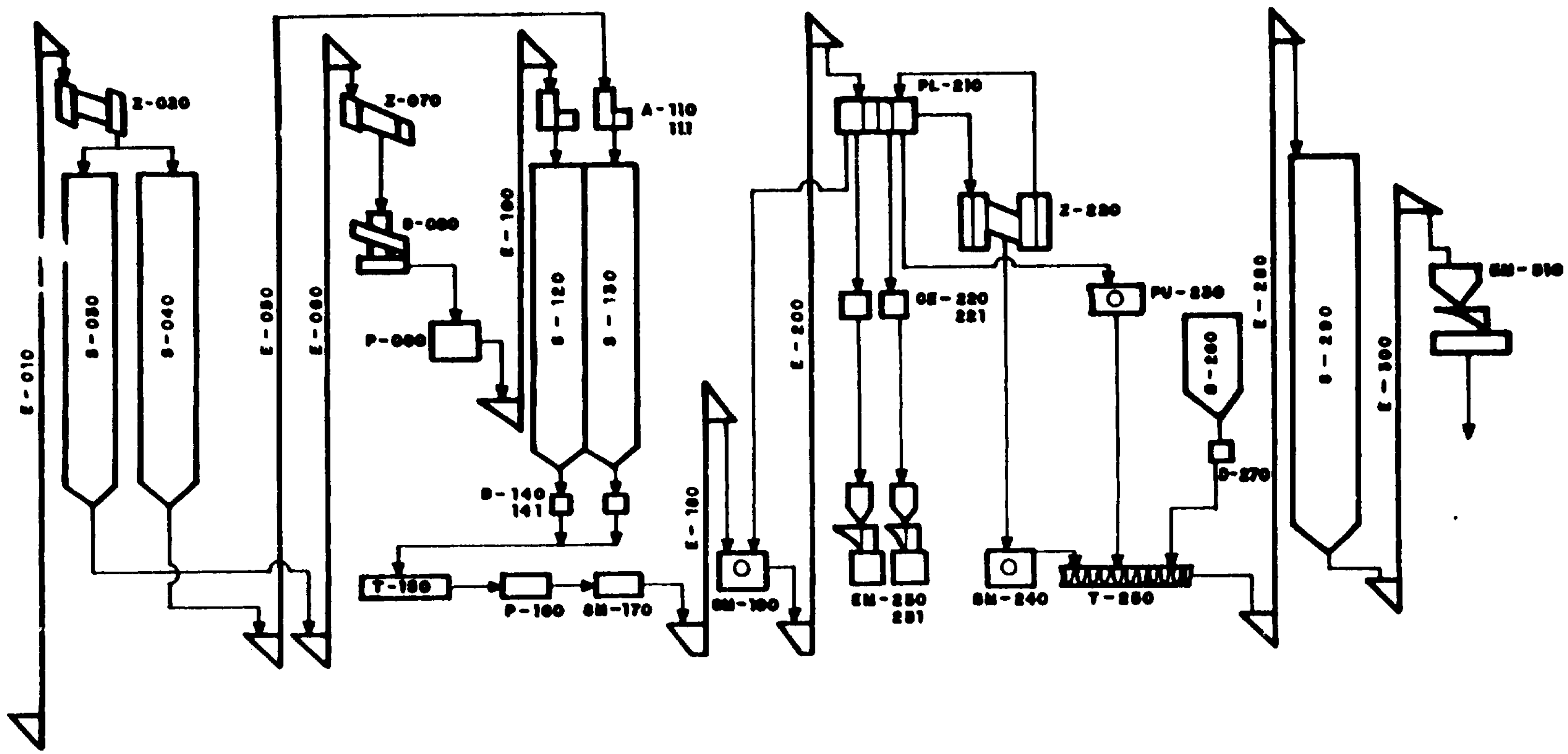
For regular wheat mills, the only additional equipment required for this line is the dosifier and the reception bin.

Microeconomic analysis

Results of the microeconomic analysis of composite flour made for a Colombian wheat mill with an installed capacity of 52,500 tons/year, are shown in table 12. Each of the three options considered has 80 per cent of wheat and either rice or corn or sorghum as the main ingredient.

7/ See diagram 1.

Diagram 3. Production of composite flour in wheat mills



Cleaning and conditioning				Milling		Mixing		Packing	
Code	Equipment	Code	Equipment	Code	Equipment	Code	Equipment	Code	Equipment
E - 010	ELEVATOR	Z - 070	SIEVE	D - 140 - 141	DOSIFIERS	E - 200	ELEVATOR	S - 260	SILO
Z - 020	SIEVE	D - 080	STONER	T - 150	TRANSPORTER	PL - 210	PLANSIFTER	D - 270	DOSIFIER
S - 030	WHEAT SILO	P - 090	POLISHER	P - 160	POLISHER	Z - 220	SIEVE	E - 280	ELEVATOR
S - 040	SILO (Other cereals)	E - 100	ELEVATOR	SM - 170	MAGNETIC SE-	PU - 230	PULVERIZER	S - 290	SILO
E - 050	ELEVATOR	A - 110 - 111	CONDITIONER		PARATOR.	BM - 240	MILLING UNIT	E - 300	ELEVATOR
E - 060	ELEVATOR	S - 120	SILO	E - 180	ELEVATOR	T - 250	TRANSPORTER	EM - 310	PACKING MA-
EM - 230 - 231	PACKING MACHINE	S - 130	SILO	BM - 190	MILLING UNIT	CE - 220 - 221	DOSIFIERS		CHINE.

Table 12. Production of composite flours in wheat mills: results of a microeconomic evaluation, Colombia (14)

Formulation (percentage)	Wheat 80 Rice 17 K Bromide/CSL Soybean 3	Wheat 80 Corn 17 K Bromide/CSL Soybean 3	Wheat 80 Sorghum 17 K Bromide/CSL Soybean 3
Reference capacity (tons/year)	52 500	52 500	52 500
Required investment (thousands of dollars)	Approximately 30	Approximately 30	Approximately 30
Production (dollars per ton)[a]	458	460	507

a/ Production cost of wheat flour per ton is $438.

The additional investment required amounts to $30,000, which is 1 per cent of the fixed investment. The lowest cost of production of $458 is achieved with the rice formula, followed by $460 with the corn formula [14].

The price of the wheat flour being $438, the composite flour project, under the prevailing market conditions, is not economically feasible for the private investor. The project, which has shown positive results at the macro level, is at the moment being worked out at Stage F (diagram 1).

Production of the substituent outside the wheat mill

Substituents can be produced outside the wheat mill in countries where roots and tubers are the most feasible wheat substituents or where there is no installed capacity for the industrial production of semi-processed cereals. The final mixing of the composite flour should be done in the wheat mill.

Lines description

Diagram 4 shows three of the lines considered for Bolivia, precooked corn flour, quinua and defatted soya flour [20].

Investments are needed for quinua and for the adjustment of an already installed soya mill for the production of defatted soya flour for human consumption. For quinua, a complete line for the elimination of saponines of quinua grain is required, which uses a two-phase process, dry decortication and water washing [20].

For the soybean flour additional equipment needed are a dehuller/toaster and a mill. The installed capacity for precooked corn flour is available, as no additional investments are needed.

Microeconomic analysis

The results of a microeconomic analysis made for a production capacity of 30,000 tons/year of composite flour are shown in table 13 [15]. Fixed investment in the wheat mill, a dosifier, a microdosifier and a mixer amount to $16,000. Investments needed outside the mill are $450,000 for the soy flour required by two of the formulae and $100,000 for the quinua plant.

Production cost is lower than that for the wheat flour, the wheat substitution varying from 5 to 25 per cent and the cost from $586.50 to $615.50 per ton. The price of wheat flour is $630.20 per ton.

The production of composite flour as given in the table seems to be economically feasible for the wheat miller, although he may stipulate for greater price differential and stabilizing price policies.

Production of composite flours at the bakery

Line description

This option is applicable to small town or rural bakeries located near a root or tubers production area. It has been applied for several years at a pilot bakery of La Molina University, Lima, Peru, where it has been in continuous commercial operation [17, 18].

Diagram 4. Production of composite flours with the use of substitute flours prepared outside the wheat mill

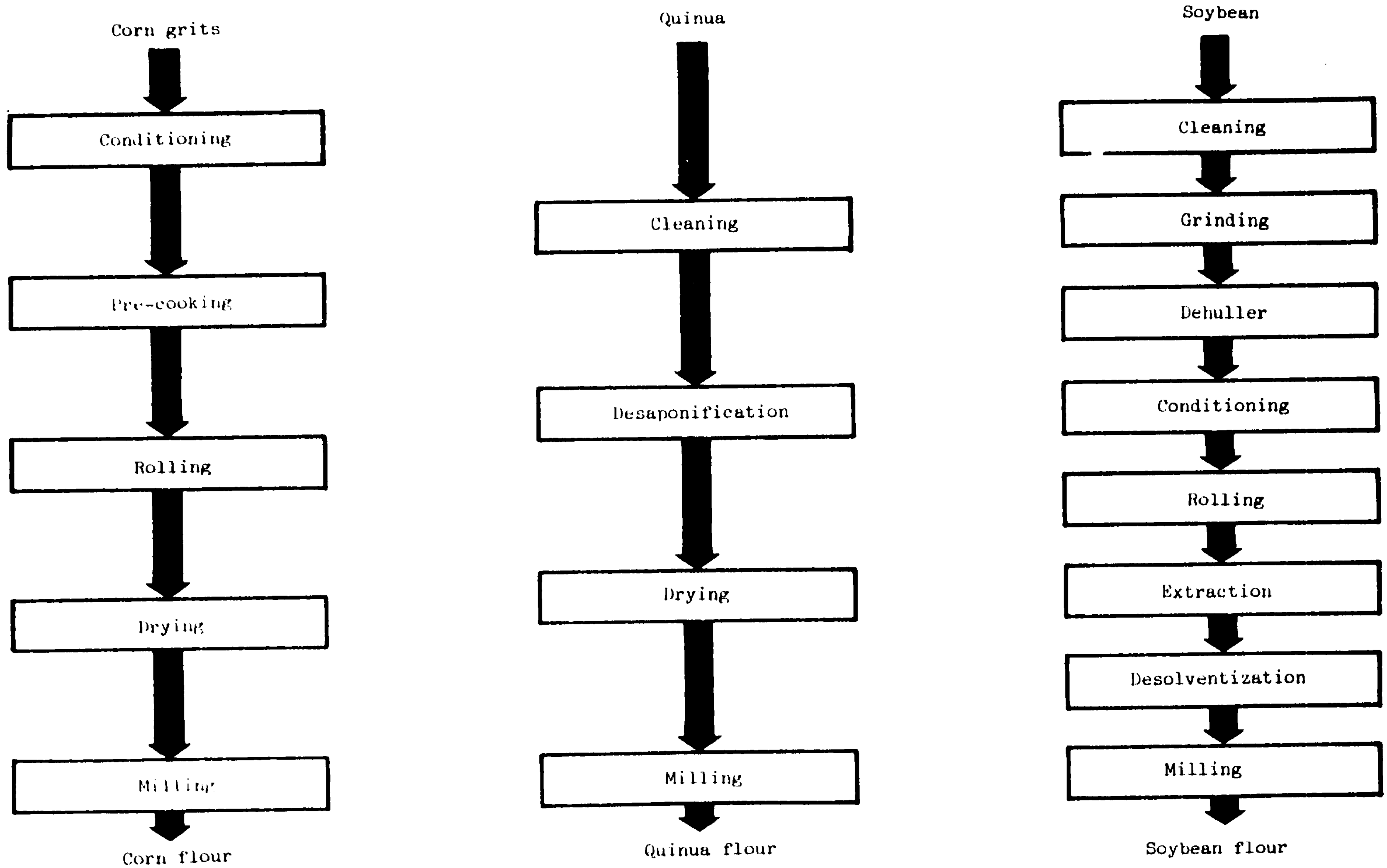


Table 13. Production of composite flours from substitute flours prepared outside the wheat mill: results of microeconomic evaluation, Bolivia

Formulation (percentage)		Wheat 90 Corn 5 Soybean 5	Wheat 95 Soybean 5	Wheat 75 Corn 25	Wheat 90 Quinua 10
Capacity (as a reference) (tons/year)		30 000	30 000	30 000	30 000
Required investment (thousands of dollars)	At installation for succedaneous flour production	450.0[a]	450.0	-	Approx. 100.0[b]
	In wheat mill	16.1	16.1	16.1	16.1
Production cost[c] (dollars per ton)		615.5	625.0	586.5	645.0

a/ In a production plant of soybean flour with a capacity of 50 tons per day.

b/ Capacity of 300 tons per year.

c/ Production cost of wheat flour is $630.2 per ton.

Diagram 5 illustrates this process. The equipment for the preparation and handling of fresh roots or tubers required at the start of the line is a washer, a peeler, a kettle and an extrusion mill. This extra line permits the preparation of the puree. The raw materials frequently used are potatoes and sweet potatoes (Ipomea batata).

The bread is produced by the sponge and dough process. The puree is added to the mixer at the end of the sponge stage. From there on the rest of the bread making process goes on without modification except for the fermentation time, which is shortened. The concentration of the wheat substituent has been fixed at 20 per cent dry basis with respect to wheat flour. No addition of bread improvers is required.

Economic data

For a bakery with a capacity of 300 tons/year the additional investment required is $8,000. The sale price of the composite bread with 20 per cent of sweet potato, is $0.77 per piece of 483 g. The price of wheat bread is $1.10 per piece of 483 g. The composite flour bread presents therefore a price differential of 30 per cent (see table 14).

These figures show an economically interesting option for small bakeries. There are limitations, however, caused by the required storage and handling of the fresh raw material.

D. Evaluation of introducing the technological alternative into the wheat production-consumption system and of its effects at macro and micro levels

For Bolivia, four alternatives for replacing imported wheat have been considered. They correspond to the two systems shown in diagrams 6 and 7.

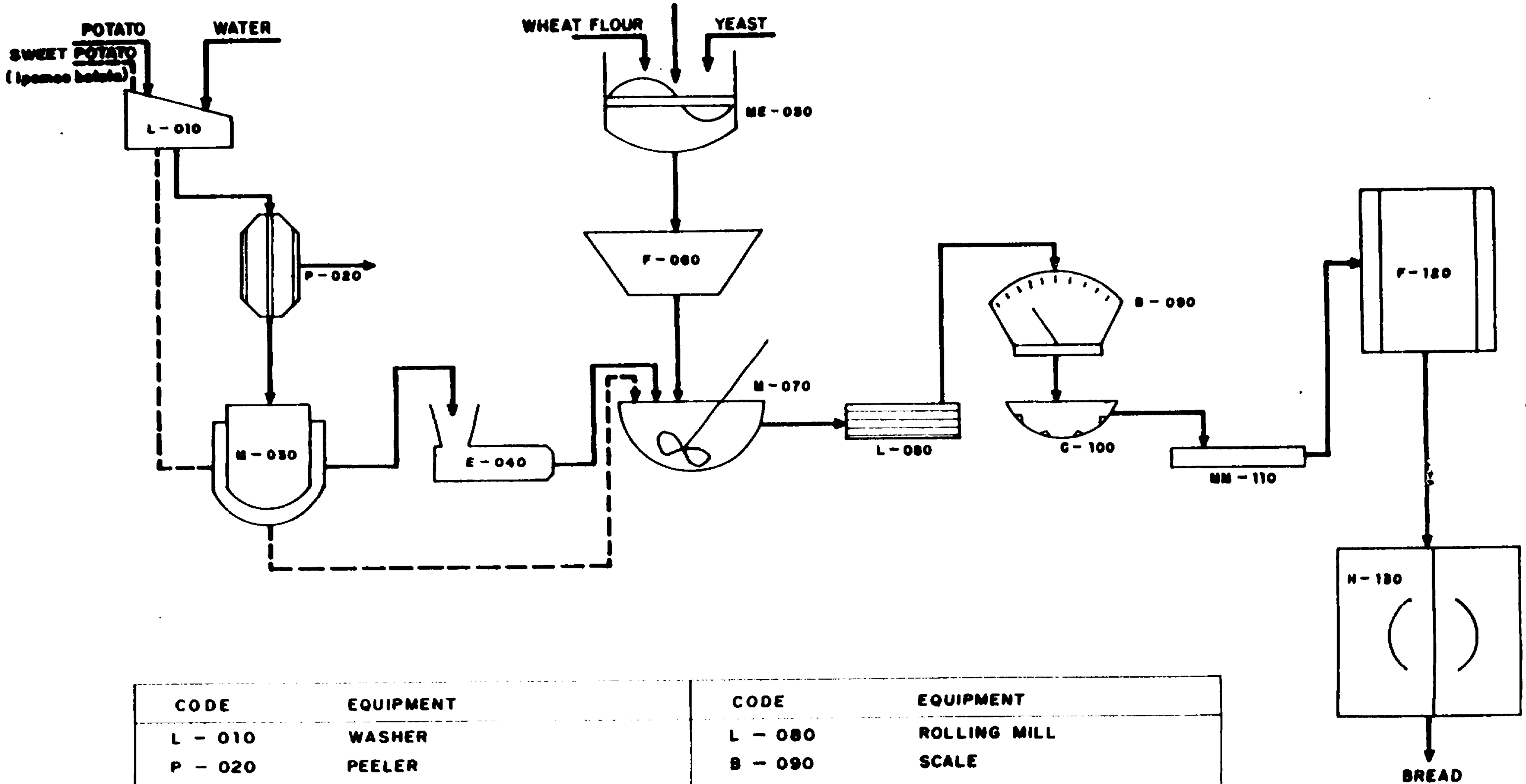
The alternatives chosen for a period of five years are given in table 15. Their selection was based on the results obtained at previous stages, which were modified by increasing the production of local wheat. Quinua was not taken into consideration in the first five-year period.

Alternative I is the present system, with 95 per cent of imported wheat and 5 per cent of locally grown wheat. Volume changes during the period correspond only to population growth. Alternative II considers the replacement of imported wheat by local wheat up to 26 per cent in the fifth year. Alternative III considers the use of composite flours where the substitution is done with corn flour up to 10 per cent in bread and up to 30 per cent in pastas, i.e. precooked flour, maintaining the ratio 95:5 imported wheat to local wheat. Alternative IV is a combination of II and III.

Price of the end flour is maintained constant for the four alternatives.

The comparison of the two systems, given in diagrams 6 and 7, indicates that in the new system, shown in diagram 7, the number of industrial sectors involved is greater, i.e. corn flour and soybean flour are included. A similar effect is shown for the agricultural sector, which includes soybean and corn production.

Diagram 5. Bread making with composite flours prepared at the bakery



CODE	EQUIPMENT	CODE	EQUIPMENT
L - 010	WASHER	L - 080	ROLLING MILL
P - 020	PEELER	B - 090	SCALE
M - 030	KETTLE	C - 100	CUTTER
E - 040	EXTRUDER	MM - 110	BREADBOARD
ME - 050	MIXER	F - 120	FERMENTATION CABINET
F - 060	FERMENTATION CABINET	H - 130	OVEN
M - 070	MIXER		

Table 14. Production of bread from composite flours prepared at the bakery: results of microeconomic evaluation, Peru

Formulation (percentage)	Wheat 80 Potato 20	Wheat 80 Sweet potato 20
Capacity (tons/year)	300	300
Required investment (thousands of dollars)	Approx. 8	Approx. 8
Price per unit of 483g [a/]		0.77

a/ Price of wheat bread is $1.10 per unit of 400 g.

Table 15. Alternatives chosen for replacing imported wheat in Bolivia [20]

Alternative		I	II	III	IV
Imported wheat (percentage)		95	95-74	95 [a/]	95-74 [a/]
Local wheat (percentage)		5	5-26	5 [a/]	5-26 [a/]
Composite flour [b/] (substitute percentage)	For bread	-	-	5-10	5-10
	For pastas	-	-	25-30	25-30

a/ Percentage in wheat fraction.

b/ Wheat, corn, soybean.

Diagram 6. Base scheme for the wheat flour production-consumption system: alternatives I and II

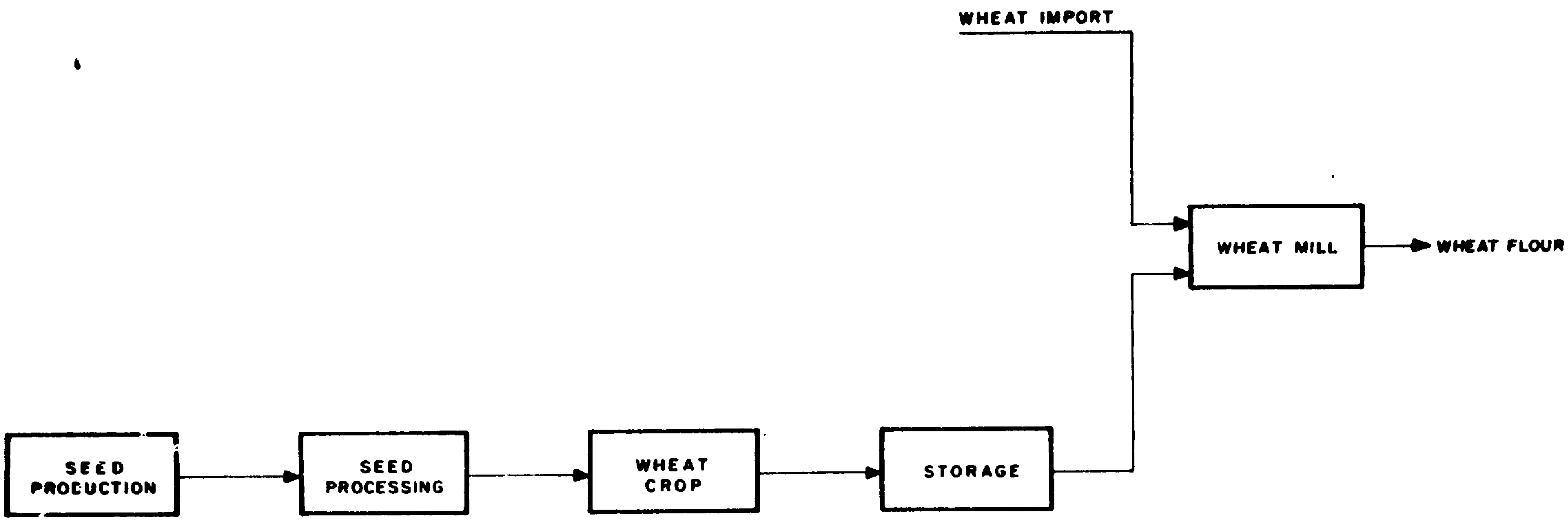
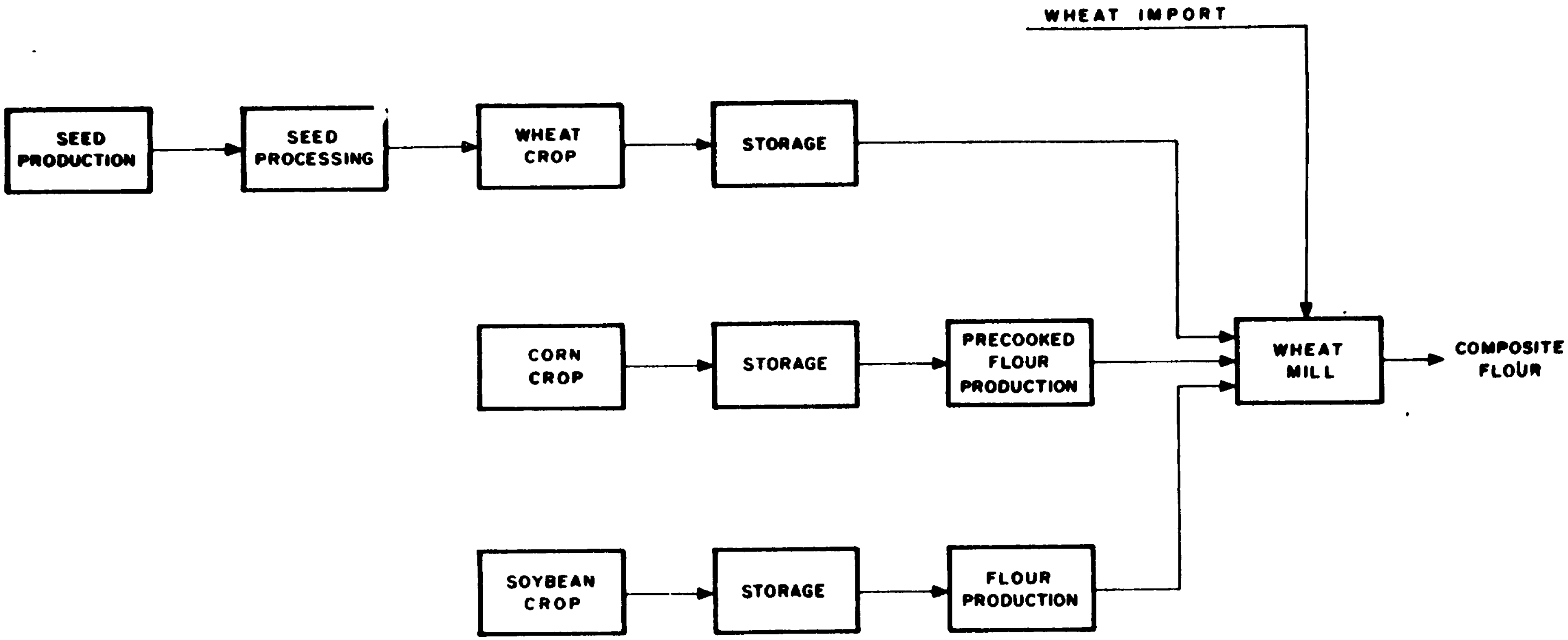


Diagram 7. Base scheme for the composite flour production-consumption system: alternatives III and IV [20]



These differences show the modifications in the local economic activity caused by the introduction of a given technology to the bread and pasta production industry.

Results obtained

The analysis of the quantitative changes produced on the system by alternatives II, III and IV, compared to alternative I gave the results shown in table 16. Comments are given in the following paragraphs.

Natural resources

Alternatives II and IV, which require an increase in the volume of local wheat, are the most demanding. A five times increase in land use would be needed in the five-year period.

Foreign exchange, financing and investment

The greatest savings in foreign exchange for wheat purchases are achieved by alternatives II and IV, from 18 to 24 per cent, but at the same time these two are the most demanding as far as investment goes, i.e. they require $85 million. It is interesting to note that alternative III requires only $70,000 and conduces a foreign currency saving of 8 per cent.

Government costs

Alternatives II, III and IV show savings in government costs from 30 (II) to 60 per cent (IV). This is an important aspect in the face of prevailing fiscal deficits.

Added value and labour demand

Alternatives III and IV, which include composite flours, have the greatest effect on added value, between 5.5 and 6.0 times, with respect to alternative I. All three cause considerable increase in the demand for labour, reaching a maximum of 1.5 times with alternative IV.

From the above analysis it can be concluded that all three alternatives present important macroeconomic advantages[8/] for the country, with regard to foreign exchange savings, government costs, added value and labour demand.

For the three alternataives, greater investment is required as well as intensive agricultural promotion programmes to give incentive to the local production of wheat, corn and soya within an articulated production-consumption system.

At this point the results from the macroeconomic analysis are evaluated against a standard built-up from the country's development objectives.

Work will be carried out in Bolivia next month, following stages F, F', G and H of the sequence (see diagram 1). Results will be used by the Government for setting up a wheat national policy as a component of its national food and nutrition plan.

8/ Over the present situation of 95 per cent of imported wheat.

Table 16. Comparison of alternatives considered, Bolivia [20]

Factors for fifth year \ Alternatives	I	II	III	IV
Natural resources required				
Agricultural areas (ha)	19 593	102 260	47 592	117 769
Foreign currency requirement (dollars)	118 584 240	97 331 840	109 119 440	90 777 960
Additional financing required (dollars)	581 880	17 976 400	1 157 800	9 542 600
Additional gross investment (dollars) a/	-	85 460 600	70 612	85 531 240
Added value (dollars)	10 761 760	18 627 280	55 627 280	61 849 800
Employment generated (W.U.)	2 320	3 738	4 746	5 950
Costs in government accounts (dollars)	13 505 800	10 418 560	8 030 560	5 373 520

a/ In the first year.

In the meantime, taking into account the prevailing economic conditions of the countries and the requirements in natural and economic resources of the different alternatives analysed above, preliminary hypothesis can be drawn with respect to the constraints that may arise:

(a) Limitations in availability of funds. Here alternative I, which requires lower additional costs and smaller investment, and alternative IV, which decreases government costs, are appropriate;

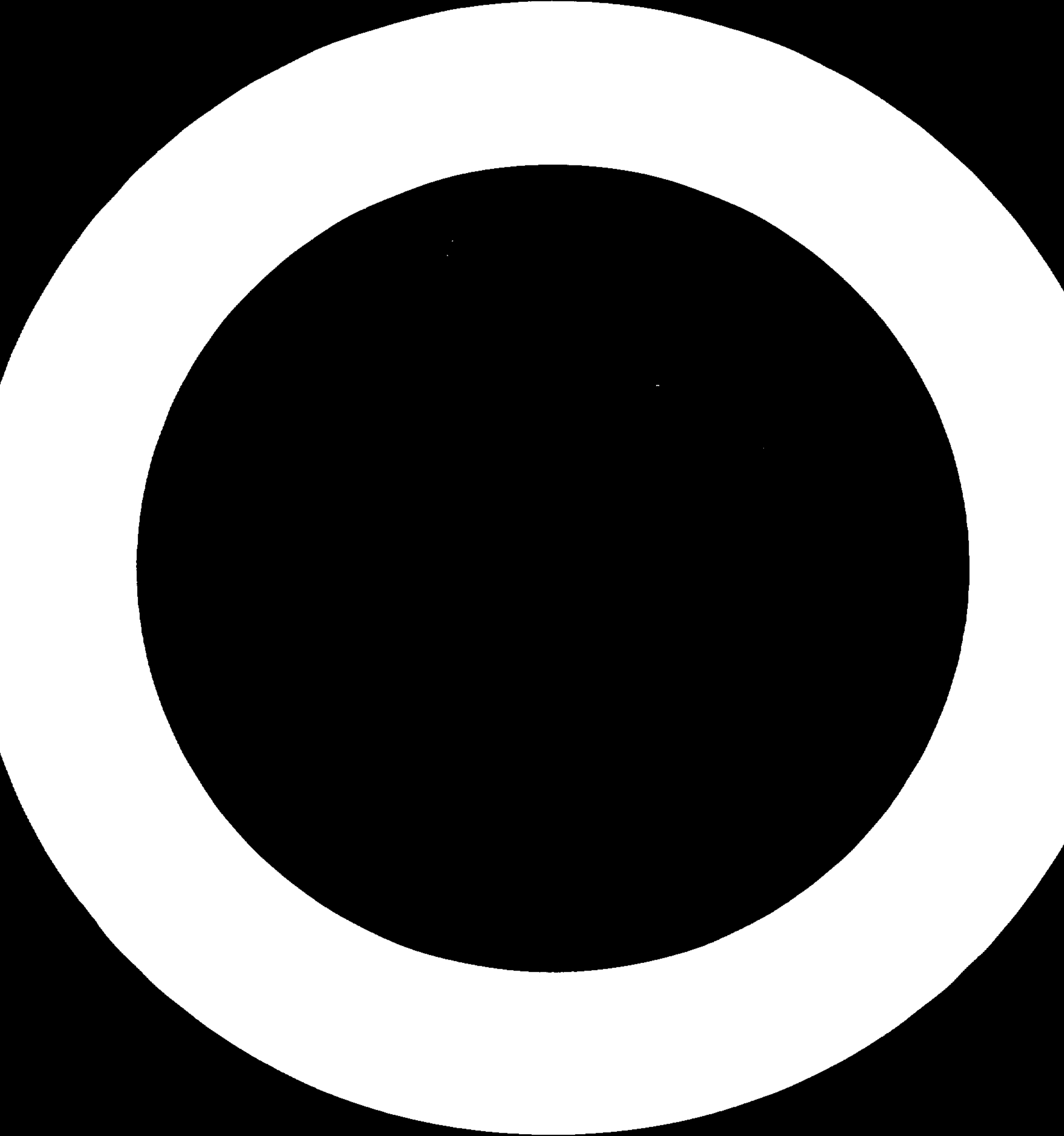
(b) Decrease of fiscal deficit, a national priority. This situation favours alternative IV, which decreases government costs and foreign currency demand;

(c) Techno-economic limitations for agricultural land expansion. In this situation, the best perspectives are given by alternatives I and III, which do not consider the need for locally grown wheat;

(d) A combination of a, b and c may be a more realistic situation, for which a single alternative cannot be a solution. The experimental simulation of changes introduced into the system by the use of the available instruments for regulating economic policy, will be required (see annex I). With the use of the mathematical model the most appropriate set of conditions will be found to make the partial replacement of imported wheat economically feasible at the micro and macro levels.

The Andean experience in the field of composite flours may be very useful to countries with similar problems and levels of development.

Results obtained for Bolivia and for the other four Andean countries applying the methodology described above and in the Composite Flours National Feasibility Studies, will be published this year.



Annex I

MACROECONOMIC EVALUATION: SPECIFIC OBJECTIVES AND INSTRUMENTS

In the evaluation methodology of the production-consumption system, designed within the work of the Andean Projects for Technological Development Foods, a set of specific objectives can be reached when the evaluation instruments are applied at the macroeconomic evaluation stage [8].

A. Objectives

The specific objectives are to evaluate:

(a) The productive structures, operation and performance of components;

(b) The technical, economic, financial and social characteristics of the components and of the system;

(c) The characteristics and the sign of internal and external articulations of the components and of the system;

(d) The use of natural resources;

(e) The use and assignment of national and external resources used in the components and the system;

(f) Policies, their economic instruments and its interactive effects:

Policies for exploitation of resources
Policies of income distribution
Employment policies
Population policies
Tax policies
Credit policies
Monetary policies
Tariff duty policies
Other policies;

(g) Revenues and expenses made by the state in the system and its components;

(h) External dependence of the system;

(i) External competitivity of the components;

(j) Use of installed capacities and the potential product;

(k) Productive agents participating in the system;

(l) Importance of the system in the overall economy;

(m) Coverage or per capita deficit in the consumption of food;

(n) Consumption patterns of national or imported food in different population groups.

B. Instruments

Instruments for the macroeconomic evaluation of the technical change are accounts of production and demand. They are part of the Numerical Experimentation Model designed within methodology [8]. The list of accounts is as follows:

(a) Accounts for the evaluation of demand:

1. Coverage of demand
2. Origin of the final consumption of goods
3. Distribution of national consumption into alternatives
4. Total final demand for goods.

(b) Accounts for the evaluation of the productive components:

1. Production account
2. Productive structures of the productive components of the system
3. Effects on resources: investment, employment, natural resources
4. Effects on external resources
5. Agents' accounts: distribution of income-salary-rentability
6. Agents' accounts: Government account
7. Added value and income distribution in commercialization
8. Imports to the system
9. Input-output matrix
10. Price gap in the sectorial linkages
11. Price gap in the external sectorial linkages
12. Commercialization margins in national linkages
13. Commercialization margins in external linkages
14. Subsidies in national sectorial linkages
15. Subsidies in the external sectorial linkages
16. Duty tariffs in the external sectorial linkages

17. Taxes on external sectorial linkages
18. Exchange differences on external sectorial linkages
19. External competitivity of the system
20. Participation of the system in the demand of the economy
21. Structural evaluation coefficients.

Annex II

BREAD AND PASTA MAKING WITH COMPOSITE FLOURS:

SUBSTITUENTS, TYPE AND PLACE OF PRODUCTION

Table A.II.1. Composite flours for bread production: best conditions obtained using corn as the main substituent (maximum level of substitution)

Way of use	Grits		Flour
Level of substitution (percentage)	17		20
Other components (percentage)	Defatted soya	3	
	Potassium bromide	0.05	SSL 0.5
	CSL	0.25	
Level of experiment	Industrial commercial		Pilot
Countries	Colombia		Ecuador

Table A.II.2. Composite flours for bread production: best conditions obtained using rice as the main substituent (maximum level of substitution)

Way of use	Grits	Flour	Precooked flour	Starch
Level of substitution (percentage)	27	20	20	25
Other components (percentage)	Defatted soya 3 CSL 0.25 Potassium bromide 0.005	SSL 0.5	SSL 0.5	Defatted soya 5 CSL 0.5
Level of experiment	Pilot	Pilot	Laboratory	Pilot
Countries	Colombia	Ecuador	Ecuador	Colombia

Table A.II.3. Composite flours for bread production: best conditions obtained using sorghum as the main substituent (maximum level of substitution)

Way of use	Flour
Characteristics of substitute (specifications)	Light (flour obtained from peeled sorghum)
Level of substitution (percentage)	20
Other components (percentage)	CSL 0.5
Level of experiment	Laboratary
Country	Colombia

Table A.II.4. Composite flours for bread production: best conditions obtained using quinua (Chenopodium quinua) as the main substituent (maximum level of substitution)

Way of use	Flour
Characteristics of substitutes (specifications) (percentage)	Desaponificated flour Moisture 10.0 Protein 10.9 Fiber 1.9 Ash 2.3
Level of substitution (percentage)	8
Other components	Potassium bromide 30 ppm SSL 0.3%
Level of experiment	Industrial
Country	Bolivia

Table A.II.5. Composite flours for bread production: best conditions obtained using barley as the main substituent (maximum level of substitution)

Way of use	Flour
Level of substitution (percentage)	10
Other components	-
Level of experiment	Laboratory
Country	Peru

Table A.II.6. Composite flours for bread production: best conditions obtained using manioc as the main substituent (maximum level of substitution)

Way of use	Flour	Starch
Level of substitution (percentage)	25	30
Other components (percentage)	CSL 0.5	CSL 0.5
Level of experiment	Laboratory	Laboratory
Country	Colombia	Colombia

Table A.II.7. Composite flours for bread production: best conditions obtained using potato as the main substituent (maximum level of substitution)

Way of use	Fresh tuber	Precooked flour
Level of substitution (percentage)	30	20
Other components (percentage)	-	CSL 0.5
Level of experiment	Commercial pilot	Laboratory
Countries	Peru	Ecuador and Colombia

Table A.II.8. Composite flours for bread production: best conditions obtained using sweet potato (Ipomea batata) as the main substituent (maximum level of substitution)

Way of use	Fresh root	Precooked flour
Characteristics of substitute (specifications)	White varieties	Light (from white varieties)
Level of substitution (percentage)	15	15
Other components	Raisins or sweetened fruit	Raisins or sweetened fruit
Level of experiment	Commercial	Pilot
Country	Peru	Peru

Table A.II.9. Composite flours for bread production: best conditions obtained using soya as the main substituent (maximum level of substitution)

Way of use	Flour (Defattened)	Flour (Full-fat)
Level of substitution (percentage)	5	15
Other components	Ascorbic acid 50 ppm	CSL 0.25 Potassium bromide 50 ppm
Level of experiment	Industrial	Laboratory
Countries	Bolivia	Colombia

Table A.II.10. Composite flours for pasta production: best conditions obtained using corn as the main substituent (maximum level of substitution)

Way of use	Flour	Precooked flour
Level of substitution (percentage)	15	50 - 75
Other components (percentgage)	Soybean flour 3	-
Level of experiment	Industrial	Industrial
Countries	Ecuador	Colombia

Table A.II.11. Composite flours for pasta production: best conditions obtained using rice as the main substituent (maximum level of substitution)

Way of use	Precooked flour
Level of substitution (percentage)	70
Other components	-
Level of experiment	Industrial
Country	Colombia

Annex III

PHYSICAL, CHEMICAL AND MICROBIOLOGICAL CHARACTERISTICS OF RAW MATERIALS USED AS WHEAT SUBSTITUENTS IN COMPOSITE FLOURS

Factor	Corn flour	Rice flour	Sorghum flour	Manioc flour	Quinua flour	Soybean	
						Full-fat	Defatted
Chemical							
Moisture (% max)	12.5	12.5	12.5	8.0	12.5	6.0	12.0
Ash (% max)	1.0	1.0	1.0	2.0	2.5	4.0	6.0
Protein (% min)	7.0	6.7	8.0	1.4[a]	11.0	45.0	50.0
Fat (% max)	1.5	1.5	-			25.0[d]	1.0
Crude fibre (% max)	1.5	1.0	-	4.0	2.0	2.0	3.5
NSI						30.0	50-60
Dextrose index	50%[b]					-	
Physical							
Granulometry bread[c]	90% (-60+100)	90% (-60+100)	90% (-60+100)			100% (-40)	95% (-100)
Granulometry pasta	100% (-100)	100% (-100)	100% (-100)				
Microbiological	Suitable for human con-sumption	Suitable for human con-sumption	Suitable for human con-sumption	Suitable for human con-sumption	Suitable for human con-sumption		Suitable for human con-sumption

a/ Not critical.

b/ For precooked flour.

c/ US standard mesh.

d/ Not maximum.

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