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POTENTIALS AND IMPACT OF BY-PRODUCTS OF THE SUGAR CANE INDUSTRY 1/

by

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INTRODUCTION

The installation of sugar cane mills constitutes a highly attractive alternative, specially for developing nations.

This attraction, however, contains always the dilema of the technological type to be chosen between the large scale mills and the almost artisan installation of small scale (open pans).

This report offer a general survey of the possibilities of the by-products of the sugar cane industry as an element capable of increasing the beneficial (advatageous) effect of the sugar cane production in the economy of the developing countries, and offering feasible alternatives to face the fluctuations of sugar prices in the world market.

It is evident that the possibilities of the by-products is an exclusive prerogative of the sugar production with large scale (vaccum pans) installation.

This factor cannot be ignored when a decision must be taken in regard with an investment program.

Although the first consideration might be inclined to favor the installation of small scale plants, this decision implies to give up a potential resource of considerable economical impact which could be industrialized. At the same time, it means the loss of building the means to protect the producer and allow the necessary diversification as a way of development.

This report also emphasizes the possibilities of the by-products to supply abundant and cheap sourcers of nourishment for the development of meat production, which for the developing countries is not only a problem of scientific and technological interest, but is a matter of pathetic reality.

It is not the purpose of this report to make a detailed analysis of all the by-products of the sugar cane industry; rather, through the analysis of the different possibilities of some of them, to draw the attention concerning the impact that their industrialization could have in the economy of developing countries.

I. THE POTENTIAL OF THE BY-PRODUCTS

When processing sugar cane to produce sugar in large scale factories is possible to obtain the following by-products. (see Table 1)

There are a great variety of products industrially obtained from the by-products of the sugar cane industry, most of them are world wide commercialized and others are used locally not yet introduced in the world market.

It is well known that many countries had devoted great efforts in the field of the by-products. Making an analysis of the situation we found that the present situation is characterized by an increasing amount of products obtained, introduction of new products, technological improvements of the processes, the development of equipments with better performances, and in general, the improvement of the economic efficiency of the industry.

At present, these existing conditions that show the advantages of the industrialization of the by-products in the cane sugar producing countries, among them:

(a) Allows a true diversification of the economies in the developing countries avoiding the harmful effect of a fluctuating price of a single product: the sugar.

(b) The increasing shortage of the non easy renewable raw materials such as wood enhance the importance of bagasse in the production of pulp, papers and particle boards.

(c) Give the possibility to diminish imports and/or represent valuable exporting funds.

(d) The world's fodder shortage offer to the by-products of the sugar cane industry the possibility to play an ever more important role in the development of the food production.

(e) The development in the Chemical Industry gives new possibilities to the by-products as raw materials for the production of different materials.

(f) The increasing tendencies of the prices of the products obtained from the by-products make those production much more profitables.

(g) There are products obtained from the by-products of the sugar industry which cannot be substituted by those obtained through petrochemical processes.

II. THE CANE TOPS

They are the upper part of the cane and the youngest portion of the plant. Their high fiber, starch and monosaccaride content make them undesirable for the production of sucrose, for this reason are separated from the stalk during the cane harvesting.

In Table 2 a comparison is made between the cane tops and the Napier, a forage grass very well extended in the tropical areas (see Table 2).

The cane tops have higher carbohidrate contents and lowest ash, and in general is possible to state that the composition point of view the cane tops compare very favorable with the Napier grass.

From the point of view of yields, an hectare of sugar cane could give between 2,0 and 2,2 metric tons of cane tops dry matter which represent from 0,8 to 1,0 metric tons of easily assimilable carbohydrates per Ha per year.

The cane tops could be used fresh but also be preserved as meal by milling and drying. The analysis of a typical cane top meal is shown in Table 3.

In Table 4 the aminoacid composition of the cane tops protein is given.

III. PROTEIN FROM THE CANE JUICE

The protein of the sugar cane plant is extracted during the milling and join the juice at the manufacturing process. Part of the proteins are separated from the juice during the clarification and go out with the filter cakes, other fraction goes through the whole process and becomes part of the blackstrap molasses and still a third part decomposes during manufacturing.

Making a complete analysis of the potencialities of the sugar cane industry is necessary to consider the possibility to recover the protein of the juice. This alternative constitutes a way which has not been yet put into commercial practice although many authors have mentioned it.

It is important to note that if the protein of the juice are extracted its amount in the molasses and filter cakes will be lower; however, it's possible to expect that the quality of the protein obtained -from the digestibility point of view- will be superior to those of the molasses and filter cakes because the protein separated from the juice, previous the manufacturing of the sugar, won't be submitted to extreme conditions of pH and temperature.

The scheme for the recovery of the protein from the juice has four stages:

- Coagulation
- Mechanical Separation
- Washing
- Drying

The coagulation coulb be carried by thermal or chemical methods, after the coagulation the juices are treated in a centrifugal separator, the

the solid residue obtained is washed and dried at a temperature not higher than 80ºC to avoid degradation.

D. H. Parish report that the material obtained by thermal coagulation from the sugar cane juice in the laboratory have a content of 50% of raw protein with the aminoacid composition shown in Table 5.

This composition is similar to those of the protein obtained from green leaves with lower triptophane content, the metionine content is also lower in comparison with the general range of that material.

The experiencies carried by Carpenter and March in 1967 compared the value of the protein from the cane juice with high quality fish meals as protein supplementation in chickens.

In the experiencies three different levels of supplementary protein were used.

The result shows that the proteins from the cane juice have 50% the efficiency of the fish meal due mainly by the limitation of one essencial aminoacid; however, it is possible to expect protein from the cane juice with a production cost of $80 per metric ton which supplemented with some aminoacids could results cheaper than the conventional protein sources.

From the point of view of yield it is possible to obtain -with a cane juice containing 0.05% of total nitrogen- from 2,5 to 3,0 metric tons of protein from every 1000 metric tons of sugar cane milled, considering a recovering process efficiency o. 75-80%.

IV. THE INDUSTRIALIZATION OF THE BAGASSE

The bagasse is the ligno-cellulosic residue obtained in the milling station of the sugar factory during the extraction of the juice.

The chemical composition of the bagasse from the milling station is shown in Table 6.

From the industrial point of view the bagasse could be considered divided into two fractions: the fiber and the pith. The fiber represents 70% of the whole bagasse and constitutes the industrially desired fraction for the production of pulps, paper and particle boards.

The pith which is the protoplasmatic fraction of the sugar cane and amounts 30% of the whole bagasse is separated by mechanical treatment from the fiber previous the processing of the last. The composition of each fraction is shown in Table 7.

The bagasse could be obtained as a surplus after the satisfaction of the fuel requirement in the sugar mill. Sugar mills with adequate capacities could obtain from 10 to 15% of their bagasse as a surplus operating at full capacity and without interruptions. This value could be increased to 25% when a remarkable thermal efficiency is attained.

When using oil instead of bagasse for steam generation in the sugar mill it is possible to save 6 metric tons of bagasse for every ton of fuel oil used. The value of the bagasse as raw material is then calculated in the base of its equivalent value as fuel plus the costs of preparation, handling, storage and transportation.

The most extended uses of the bagasse are as raw material for the manufacturing of pulps, papers, particle boards, furfural and of course, as fuel in the sugar mills.

A. Writing and printing papers from Bagasse

The writing and printing papers are used in books and magazines when quality and durability are required.

The bagasse is a fibrous raw material which could be efficiently use for the production of chemical pulps for writing and printing papers of adequate quality. The chemical pulps are obtained mainly by alkaline processes (soda and sulfate).

For the installation of a pulp and paper plant is necessary to insure:

- Sufficient capital due to the high investment cost.
- Adequate amount of bagasse to insure a full capacity operation 300 days per year.
- A high amount of water with the necessary quality.
- Efficient methods for the treatment of the effluents.

A plant for the production of 45,000 metric tons of writing and printing papers plus 15,000 metric tons of tissue papers will cost 75-80 million dollars.

The price of the writing and printing papers in the world market is around $600 dollars, per ton, and the cost of production will be in the range of $350/ton.

B. Newsprint for bagasse

This product could be defined as the type of paper produced at a reasonable low cost with good printing characteristics suitable to be used in the modern high speed printing machines. The main use of this type of paper is in newpapers, and pamphlets taking advantage of its low cost.

The traditional raw material for the production of newsprint have been the mechanical pulp from coniferous.

It is possible to produce different types of paper from bagasse without difficulties and in an efficient way but it have not been possible yet to manufacture newsprint from bagasse with the required technical and economical conditions.

At present various alternatives under study seem to offer interesting possibilities.

According to available information the investment cost for a paper mill with a capacity of 300 metric tons of newsprint per day will be 43 million dollars.

The price of newsprint is in the range of 400 dollars per ton and the production cost will be 260 dollars per ton.

In spite of the high investment cost the pulp and paper industry from bagasse can shows a favorable cash flow due mainly to the upward trend in the prices that will be stressed in the future as a consecuence of the increasing demand and the limited availability of wood to face it.

C. Particle boards from bagasse

The fundamental use of this product is in the construction of furniture for houses, offices, panels for the building industry, doors and other uses such as interior covers in buses and trains.

The technology for the production of particle and fiber boards is known and does not offer any difficulty.

The fundamental equipment for these plants consists of machines for the milling and preparation of the bagasse, gluers, forming machines, press, as well as equipment for the finishing.

The rest are mechanical and neumatical conveyers worldly known.

These plants may be installed in places where there are no great resources of water, the consumption of bagasse is low (3,0 ton of wet bagasse per ton of board).

A plant with a capacity of 120 t/d of boards costs approximately 13,5 million dollars with a production cost of 180 dollars per m^3 of board.

Another interesting industry would be the production of boxes and moulded elements from bagasse.

The technology of production is very similar to the one of the particle boards with the difference that instead of plate presses moulds are used which give the desired forms.

The consumption of water is also small and the investment costs are low. A plant with a capacity of 3,5 millions boxes per year costs about 6,0 million dollars.

Both iptions constitute the alternative of the industrialization of two by-products of the sugar cane of the higher rentability, with period of the recovery of the investment of 1 to 1,5 years.

D. Furfural production

The furfural is a product of wide use in the world with the characteristic of being produced only through hidrolysis of agricultural and forestal residues, and in particular, from bagasse.

Furfural as well as the furfurilic alcohol habe been scarce for years in the world market and their prices have increased systematically.

The development of the chemistry of the furfural has increased its uses with the new applications in the production of products of high demand.

Its main uses are:

- Raw material for the production of furfurilic alcohol, tetrahidrofurfurilic alcohol, furane tetrahydrate, and other by-products.
- Selective solvents of oleafines and other compounds insaturated in the production of oils and lubricating oils.
- Raw material for the production of resines, pharmaceutical products and pesticides.
- Intermediate product of nylon 66, plastics for moulding, source of textile suitable for tropical countries.
- There are no exact data of the furfural which is produced in the world, however, there is a estimated production of 230,000 mt.

The main exporters of furfural are:

- U.S.A.
- Dominican Republic
- People's Republic of China
- Italy
- France

- Belgium
- The Netherlands
- United Kingdom

Nowadays, of the 35 existing plants 10 employ bagasse with a capacity of 141 900 t/year (52% of the installed capacity).

The technology for the production of furfural is known, existing countries with experience in its production.

Furfural may be produced from the pith. It may be considered as a great economic advantage to install a plant of furfural combined with a plant of pulp and paper.

It should be observed that there are still some technological deficiencies for its production from the pith.

E. Soluble carbohydrates and protein for bagasse

Bagasse — integrally or through the pith— may be processed advantagegeously in order to obtain directly assimilable carbohydrates or single cell protein through fermentation.

The total hydrolyzed of bagasse through heat and sulfuric acid allows to obtain a solution that contains, in a hydrolyzed form, a good part of the celluloses and pentoses. It is possible to obtain a ton of soluble carbohydrates with this method employing from 2,0 to 2,2 metric ton of dry bagasse.

The hydrolystic molasses, obtained in this way, may be supplied, previous its neytralization, to the animals as an energetic source or may also be a raw material to obtain the protein through the fermentation with yeast.

Through this alternative, it is possible to obtain 1 metric ton of dry yeast with 50% of protein employing 4,4 to 4,8 metric ton of dry baggase or its equivalent in pith.

These alternatives are already industrialized employing woods, or other cellulose residues with the similar composition of the bagasse. For example, the present production of torula yeast through hydrolisis of the wood in the U.S.S.R. reaches the sum pf 2×10^6 metric ton of dry product per year.

Other technological alternatives to obtain protein from bagasse are under experiment at pilot plant.

A process developed at Louisiana State University makes, after chemical prehydrolisis of bagasse, a microbial fermentation with Cellulomonas in order to obtain a single cell protein.

Some scientific institutions study the hydrolysis of bagasse through cellulolitic bacteria for its fermentation afterwards and others search for the direct fermentation of bagasse through fungi that reproduce directly in one process.

The cost of production of hydrolytic molasses or single cell protein will depend much on the local conditions of the place in which the process is carried out and how the bagasse is obtained, as a surplus or substituted by petroleum.

Also the cost of production of one metric ton of carbohydrates from bagasse through chemical hydrolysis will depend on the same local factors, the capacity of the sugar mill if it is from surplus bagasse or obtained through the substitution with oil. This value is set in a range of 27 to 45 pesos per metric ton of carbohydrates taking into account the extreme situations.

F. The pith as a source of animal feed

Additionally, in the industrialization of bagasse for the production of boards, pulps or paper, pith is obtained as a by-product, which must be separated from the fiber. The pith as a waste cannot be ignored due to its low cost and its relative nutritive quality.

In Cuba the commercial application of the pith as a source of fodder is mainly concentrated in its use as a mixture with final molasses and urea in the diets for ruminants. The typical composition of the formula is shown in Table 8.

In order to improve the conservation of the mixture it is recommended to lower the humidity of the pith to a maximum of 15% before the mixing with the molasses.

It is necessary to indicate that the pith as well as the bagasse have the inconvenience when used directly in their natural form, of very low digestibility values that reaches only 14 and 8% respectively, however, the research works which today are being accomplished in Cuba, indicate that it is possible to improve, in a significant manner, these values through chemical and/or thermical treatments. With these treatments is possible to reach digestibility values of 60%, which means that, potentially, the bagasse or the pith, can supply up to 70% of the energy in diets for ruminants.

It should be said that the thermical treatment of bagasse or pith at moderate pressures (6-12 ata) with its afterward neutralization of the free organic acids through H_3N, offers a product with 1 - 1,5% of nitrogen fixed and a high disgestibility. For the studied conditions, on the base of surplus bagasse or pith, one metric ton of the product will cost 12-16 dollars.

V. USES OF THE FINAL MOLASSES

The final molasses (blackstrap molasses) constitute the residue of final product obtained in the centrifuge when the sugar crystals are separated from the low grade massecuites.

The blackstrap molasses are mainly formed by soluble sugar and organic elements accumulated as the result of the crystalization of the sucrose. It is not possible to recover more sucrose from them and therefore, it is taken out of the mill as a by-product.

The standard composition of the final molasses are within the values shown in Table 9.

The molasses are by-products of the sugar cane most widely used at present as a source of animal feed, mainly due to its high content of as similable carbohydrates.

Traditionally, the tropical countries that produce sugar have been important exporters of final molasses to more developed countries which have used them mostly for the preparation of fodder or for direct use.

The real cost of production of this product is minimum. It deals with storage, punping, and transportation, with an average of 2 to 3 dollars per metric ton. However, the value of the molasses is calculated according to its price at the world market.

The most stable price which it appears to have had the sugar cane molasses ranges between 46 and 52 dollars per metric ton (52% of total sugar) FOB Cuba. Its price has depended more upon the conditions of the market of animal fodder than on the changes of the prices of the raw sugar.

Really, in a developing country the value of use of molasses should not be fixed according to the price in the market, but because of their potential use. When we examine this, it is evident that, the less advantageous use for any of these countries is the export.

The sugar cane molasses have been widely used to produce alcohol, alcoholic beverages, torula yeast, beaker yeast, citric acid, L-lysine and others.

A. Torula Yeast

This product is a source of protein and vitamins that had been widely used in the preparation of mixed feed for the animals.

The production of torula yeast present a great interest for the developing countries that have sugar cane molasses due to the ever more serious situation of the lack of protein and the increase in the prices of the traditional protein concentrates.

The torula yeast is not commercialized and the producing countries use it for internal consumption.

The production of yeast has not great technological difficulties; the equipments are the standarts of the fermentation industry: fermenters, separators, pumps and tanks. The effluents may be treated by means of conventional methods.

The most influenceing factor in the cost of production of the product is the price of the final molasses. The investment cost of a plant with a capacity of 12,000 ton/year is about 9 million dollars, with a cost of production of 170 dollars/metric ton of yeast if we consider the molasses at 5,0 dollars per ton.

In Cuba it is being developed a vast investment program that includes the construction of ten new plants for the production of torula yeast from molasses.

This program will allow an average production of 150,000 ton per year in 1979.

B. Production of ethyl alcohol from molasses

This methods constitutes one of the oldest form of the use of molasses. Its technology of fermentation is widely known and its required equipments are conventional not being necessary to go deeper in this point.

The most commun use of this product is in the preparation of beverages not being replaced for this purpose by sinthetic alcohol.

The increase of oil prices in the last years compels to consider the possibility of alcohol, obtained through fermentation, from the molasses as a substitute of great possibilities for the traditional fuels obtained in the petrochemical industry.

This alternative creates very favorable perspectives for the countries that produce sugar cane in order to reduce the expenses as a result of the import of crude oils or refined products.

The investment for the installation of an alcohol distillery with a capacity of 100,000 liters per day at 100º G.L. ranges between 4,0 - 5,0 million dollars, and the cost of production of one liter of alcohol considering the molasses a 4,0 U.S. dollars per ton, would be 4 cents(dollars).

The production of alcohol through fermentation allows to obtain yeast by a process of recovery before the distillation. At the same time the use of the distillery waste for the production of single cell protein have been successfully tested in Cuba. In this way, it is possible to increase the economic efficiency of the alcohol industry and to offer cheap sources of protein of high biological value.

C. Citric acid from final molasses

It is widely use in the food industry, in beverages as acidulants, to enhance the flavor and as preserver in canned products.

Traditionally, this product is obtained through the fermentation of carbohydrates, basically cane and beet molasses. There are two methods for,its production: the superficial fermentation, practically obsolete and the submerged fermentation used in the industries of recent construction. The process of production is under patent.

For a plant of 5,000 tons of citric acid per year, the value of the investment is calculated at 9 million dollars and the cost of production ranges between 450-500 dollars per ton. The price of the product in the world market reaches up to 1,200 dollars per metric ton.

D. L-Lysine

The L-lysine is one of the most important aminoacids, employed in the enrichment of cereal used for human consumption. It is also widely used as a supplement in the diet of chickens and swines and in the pharmaceutical industry.

This product is consumed mainly by the producing countries, such as Japan, U.S.A., France and United Kingdom, Japan control 90% of the world production.

The L-Lysine may be produced synthetically, with the disadvantage that it form racemic mixtures, and living organism only metabolize the L form of the aminoacid.

The production through fermentation, although it only produces the form L, which is biologically active, has the inconvenience of the subs- trate to be used and the complexity and strict control of the process.

The value of the investment for a plant of 5 000 ton per year is of 24 million dollars and its production cost is about 1,800 dollars per metric ton.

The price of the product in the world market is higher than 8,000 dollars per metric ton.

VI. THE FILTER CAKE

The filter cake is the residue obtained from the purification of the cane juice during the manufacture of sugar. This material is obtained in the form of a earthy cake with a humidity of 75-80%.

The composition of this by-product varies widely according to the type of soil, cane variety, method of harvest, technological process, etc.

Within the condition prevailing in a normal harvesting season the components present in the filter cake will be in the relation shown in Table 10.

In the classical clarification process with heat and lime 30% of the raw protein of the juices is floculated and joint the filter cake.

Traditional the use of the filter cake have been as fertilizer due mainly to its P_2O_5 content.

Various experiences carried out in Cuba demonstrate that the filter cake could be used as a supplement in the diet of the milking cows as a substitute of the final molasses.

The aminoacids composition of the protein contained in the filter cake is shown in Table 11.

Considering its high carbohydrate content the filter cake can be fermented "in situ" to increase its nutritive value. A process bow under research the filter cake is slightly diluted, and fermented under vigorous aeration during 4 hours. After the fermentation the material is neutralized with NH_3 and mixed with molasses. By this process is possible to obtain from 1 metric ton of dry filter cake 70 kg of yeast rich in vitamins and protein. The protein obtained by this way is 40-60% cheaper than any other type.

As a reference is possible to obtain 10 metric ton of this product (dry base) for every 1000 tons of sugar cane processed in a sugar factory.

Table 1. Sugar cane by-products. Relative production

By-product	Place	% of the sugar cane Natural	Dry base
Cane tops and leaves	Field	9 - 13	2,0 - 3,0
Bagasse	Factory	23 - 27	11 - 13
Black-strap molasses	Factory	2,6 - 3,0	2,3 - 2,7
Filter cake	Factory	3,0 - 3,8	0,8 - 1,0

Table 2. Composition of cane tops and Napier grass

	Dry matter %	Protein %	Fibre %	Wax %	Ash %	Carbohidrates %
Fresh cane tops	20 - 25	5,4	34,5	1,0	5,9	53,2
Napier (Pennisetum purpureum)	18 - 20	6,9	32,1	2,1	11,1	47,8

Table 3. Composition of a typical cuban cane top meal

	%
Dry matter	6,17
Raw protein	4,11
Digestible protein	3,09
Fat	0,94
Fibre	29,7
Ash	4,57

Table 4. Aminoacids content of the cane tops proteins
(Means values)

	%
L-lysine	4,31
Histidine	0,96
Arginine	2,23
Asparagine	8,12
Threonine	3,63
Serine	4,18
Glutamic acid	8,50
Proline	1,42
Glycine	3,92
Alanine	4,82
Valine	6,50
Methionine	1,02
Isoleucine	3,61
Leucine	6,59
Thyroxine	1,48
Phenylalanine	3,34

Table 5. Aminoacid composition of the protein extracted from sugar cane juice

	%
Aspartic acid	7,02
Threonine	3,78
Serine	4,60
Glutamic acid	6,97
Proline	4,01
Glycine	6,96
Alanine	6,95
Valine	5,09
Methionine	1,06
Isoleucine	3,37
Thyroxine	2,14
Leucine	6,28
Phenylalanine	2,75
Histidine	3,65
Triptophane	0,97
Lysine	7,78
Arginine	12,81

Table 6. Mean composition of the cuban bagasse

Component	Fresh base %	Dry base %
Humidity	50,0 - 47,0	0
Total dry matter	50,0 - 53,0	100,0
Sucrose	2,0 - 3,5	4,0 - 7,0
Holo-cellulose	32,5 - 36,0	65,0 - 68,0
α-cellulose	18,0 - 20,6	36,0 - 39,0
Lignine	8,5 - 10,0	17,0 - 19,0
Pentosanes	10,5 - 12,7	21,0 - 24,0
Ash	0,7 - 1,3	1,5 - 2,5

Table 7. Chemical composition of the fibre and pith of the bagasse

Component	Fibre %	Pith %
Sucrose	3,0 - 5,5	4,5 - 8,0
Holo-cellulose	65,0 - 67,5	64,0 - 67,5
α-cellulose	37,0 - 40,0	37,0 - 35,5
Pentosanes	22,0 - 25,0	23,0 - 25,0
Lignine	17,5 - 19,0	16,0 - 18,7
Ash	0,5 - 0,8	2,3 - 3,1

Table 8. Typical composition of the mixture of pith and molasses

Compound	% by weight
Final molasses	67 - 70
Urea	3 - 5
Pith (15% humidity)	25 - 30

Table 9. Composition of the cuban cane final molasses

Dry matter	83 - 85	%
Sucrose	34 - 36	%
Reducing matters	25 - 28	%
Total ash	9 - 13	%
P_2O_5	0,12 - 0,20	%
CaO	0,7 - 1,2	%
R_2O_3	0,1 - 0,4	%
Na_2O	0,18 - 2,0	%
K_2O	3 - 5	%
MgO	0,3 - 0,6	%
$SO_3^{=}$	0,8 - 2,0	%
SiO_2	0,1 - 0,8	%
Mn	10 - 18	ppm
Cu	5 - 12	ppm
Total nitrogen	0,4 - 0,6	%
Raw protein	2,5 - 3,7	%
Biotine	1,1 - 2,9	microg/g

Table 10. Mean composition of filter cake in Cuba

Component		Content % dry base
Raw protein		12 - 16
Bencene extract		10 - 14
Ash	P_2O_5	3,0 - 5,0
	CaO	2,0 - 3,5
Total sugars		10 - 14
Pith		18 - 25
Others		25 - 35

Table 11. Aminoacid content of the filter cake protein

	%
Aspartic acid	4,4
Threonine	2,8
Serine	3,4
Glutamic acid	3,7
Proline	2,7
Glycine	7,2
Alanine	5,8
Valine	3,5
Methionine	0,5
Isoleucine	2,1
Leucine	3,6
Thyroxine	0,6
Phenylalanine	1,3
Tryptophane	1,2
Histidine	2,2
Lysine	2,1
Arginine	2,9

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