Tobasa TOCANTINS BABAÇU S/A

COCO DE BABAÇU

A RIQUEZA DE UM BRASIL DESCONHECIDO

Eng. Edmond Aziz Baruque Filho

TOBASA - Tocantins Babaçu S/A

- 1996 -

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• Introdução

O coco de babaçu é oriundo de uma palmeira nativa da região norte do Brasil, ocupando elevadas extensões de terras com coberturas florestais, sendo um recurso renovável de imenso potencial energético e de produtos químicos. No entanto, estas ricas florestas naturais vêm sendo exploradas de forma predatória, devido a uma série de fatores amplamente conhecidos, ao longo dos últimos anos.

A implantação de grandes projetos agro-pecuários na Amazônia Brasileira, mormente no Estado do Tocantins, vem contribuindo decisivamente para uma dramática queda de produção da safra anual de coco, pois estes referidos projetos não contemplam a aplicação de experiências de manejo florestal sustentado em escala comercial, como, também, não consolidam um mercado diferenciado para os produtos advindos da exploração extrativista do coco de babaçu baseado em práticas sustentáveis, de forma que a devastação indiscriminada das palmeiras de babaçu já é uma realidade preocupante, tornando-se incompatível com os objetivos do desenvolvimento sustentável.

Além desses indicadores agro-florestais, o babaçu apresenta elevada importância ecológica, social e política como produto extrativo, envolvendo uma infinidade de famílias nos Estados do Tocantins, Maranhão e Piauí. Sua importância social é ainda maior porque a exploração do produto ocorre no período de entre-safra das principais culturas regionais, concorrendo para a manutenção dessas famílias e contribuindo para conter o êxodo rural. Ademais, o babaçu exerce um papel fundamental na manutenção da fertilidade do solo – imprescindível para a sustentabilidade dos sistemas agro-pecuários.

Vale considerar que o aproveitamento integral do coco de babaçu no Brasil insere-se como instrumento estratégico do moderno conceito mundial de preservação da BIODIVERSIDADE, com conseqüências reais e imediatas para o País no contexto macroeconômico de sua matriz bioenergética e auto-sustentável. Esta atividade agro-industrial já é realizada, com tecnologia própria e em escala industrial, pela TOBASA. O projeto – genuíno e pioneiro em sua essência tecnológica a nível mundial – constitui o único complexo energético do gênero existente no País, produzindo óleo, farinhas amiláceas, álcool, subprodutos proteicos e carvão "in natura".

Finalmente, o aproveitamento integral do coco de babaçu com aplicação de tecnologia mais atual e moderna no processamento industrial dos produtos químicos gerados – como a tecnologia de ativação do carvão "in natura" – , reveste-se de significante valor para o desenvolvimento econômico e social da região de influência da TOBASA, constituindo uma biomassa alternativa, economicamente competitiva e fonte renovável de matéria-prima para produção, em larga escala, de energia, alimentos, álcool combustível, produtos químicos e, principalmente, carvão ativado que se destina, dentre outras importantes aplicações, para fins industriais, alimentícios e de tratamento de poluição ambiental.

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•Impactos esperados do projeto à região onde será desenvolvido o projeto

As expectativas que se descortinam à região onde será desenvolvido o projeto são especialmente promissoras. Não é demais lembrar que a TOBASA vem exercendo, desde o início de suas operações industriais, um relevante papel no desenvolvimento econômico e social em sua área geo-econômica de atuação, mormente nos diversos municípios que compõem as florestas nativas de babaçu, onde centenas de trabalhadores rurais encontram-se envolvidos com as práticas de cata e manuseio do coco. Na falta de outras alternativas econômicas em certas áreas, o babaçu possui o importante papel de mantenedor de subsistência econômica dessas centenas de famílias rurais.

O domínio da tecnologia de ativação do carvão de babaçu permitirá à Empresa implantar unidades de porte industrial que capacitem-na a operar em escalas comerciais de produção. Pode-se antever a magnitude dos impactos sociais, econômicos e ambientais à região de influência da TOBASA; geração de novos e mais bem remunerados empregos rurais para a cata e manuseio do coco, maior incremento da circulação de recursos financeiros no interior de novas áreas florestais e, fundamentalmente, aumento significativo do volume de palmeiras nativas a serem conservadas e preservadas.

É de se ressaltar que, tendo em vista a melhor remuneração que poderá ser atribuída à aquisição do coco de babaçu, certamente o abate indiscriminado e predatório das palmeiras de babaçu será significativamente contido, em função do interesse econômico dos proprietários de terras da região. É notoriamente conhecida a prática de manejo sustentável destas florestas nativas, que permite, tecnicamente, consorciar-se os grandes projetos agro-pecuários com o raleamento racional das palmeiras de babaçu, que, conseqüentemente, aumentam cerca de duas a três vezes a sua produtividade agrícola.

Um outro importante segmento da comunidade local que será amplamente beneficiado com o presente projeto e seu desdobramento será a população indígena das aldeias Mariazinha e São José. O envolvimento se concretizará a partir do fornecimento de coco de babaçu para os testes operacionais na unidade piloto, que, inclusive, demonstrará a outros segmentos da sociedade regional a vantagem econômica de se conservar, em bases racionais, as palmeiras nativas de babaçu. Portanto, pode-se afirmar que esta será uma "experiência piloto" de exploração extrativista do coco associada ao conceito de sustentabilidade econômica e ambiental.

Finalmente, é oportuno salientar que, além dos indicadores técnicos, sociais, agro-florestais e econômicos apresentados no presente projeto, favoráveis à implantação da tecnologia de ativação do carvão de babaçu, o melhor aproveitamento agro-industrial do coco ensejará, como consequência direta e pela valorização econômica do fruto, a preservação e a utilização racional das florestas nativas de babaçu. Sob a concepção internacional que ora rege os conceitos de conservação e de integridade da BIODIVERSIDADE em suas mais variadas vertentes, o projeto contribui, decisivamente, para a defesa do ecossistema vegetal, para o incentivo ao desenvolvimento sustentável e para a imprescindível preservação do meio ambiente de importante área territorial da Amazônia Brasileira.

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March 17, 1997

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Dear Edmond:

On behalf of the program committee for the 19th Symposium on Biotechnology for Fuels and Chemicals, I would like to congratulate you for being selected to present your paper during this conference.

In the enclosed preliminary agenda, the day, session and title of your oral presentation are listed as:

Date:	Wednesday, May 7
Time:	11:35 a.m.
Session:	Session 5—Specialty Chemicals with Emphasis on Environmentally Benign Products and Processes
Title of Paper:	"Ethanol from Babassu Coconut Starch: Technical and Economical Aspects"

The general session rooms are set up with an overhead projector, 35mm slide projector, laser pointer and microphone. We ask that you limit your presentation to the scheduled **20 minutes**, including any time you may want for questions.

You are encouraged to publish your presentation in the proceedings of the 19th Symposium on Biotechnology for Fuels and Chemicals. A copy of the Humana Press guidelines for the proceedings document is also enclosed. There is a 20 page limit to your paper. We ask that you submit an original and three copies of your paper to Liz Willson, at NREL, 1617 Cole Blvd, Golden, CO 80401, preferably before or the first day of the conference.

There will be a continental breakfast and orientation for speakers at 7:30 a.m. We invite you to attend this orientation breakfast. In addition, a speaker preparation room will be available each day during the symposium for your use.

We look forward to your participation in the 19th Symposium on Biotechnology for Fuels and Chemicals Contact me if you need any additional information.

Sincerely,

Joan Ross

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Ethanol from babassu coconut starch: technical and economical aspects

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Ethanol from babassu coconut starch: technical and economical aspects

ABSTRACT

Babassu coconut is the fruit of a Brazilian native palm (*Orbignya phalerata* Mart.) which is found in the north of the country over a very large area (about 15 millions hectares). It is a source of fuels and chemicals, mainly lauric oil, starch for ethanol production and charcoal. The interest on babassu coconut as an energetic source started in the seventies, but practically all the projects in this field were discontinued. The only exception is the project conducted by Tobasa, currently in operation, and its success can be credited to the utilization of an integrated industrialization approach. This work describes a pioneering industrial scale experience in ethanol production from the amylaceous flour obtained by mechanical processing of the babassu mesocarp. Technical aspects related to enzymatic and fermentation processes as well as overall economical aspects are discussed. When produced on a small size industrial plant (5,000 L/day), babassu ethanol has a final cost of about 218 US$ per cubic meter. The impact of raw materials, production & processing (enzymes, steam, energy etc.) on the final product cost is also presented. Babassu coconut ethanol can be produced at low cost in comparison with traditional starchy raw materials or sugar-cane. The net profitability of ethanol production is about 40% for babassu coconut and just 10% for sugar-cane. If the estimated renewable babassu resources were entirely industrially used, one billion liters of ethanol per year could be produced, which would roughly correspond to 8% of the current Brazilian ethanol production.

Key words: babassu coconut, amylaceous flour, ethanol, alcohol production

INTRODUCTION

Native babassu palm (*Orbignya phalerata* Mart.) is an important source of fuels and chemicals and is available over large areas in the north and northeast of Brazil, corresponding to about 15 millions ha (*1*). The babassu palm exploitation is still carried out on an extrativist basis, but it has a relevant social and economical role, assuring the subsistence of about 300,000 families (*2*).

Data concerning babassu coconut productivity are controversial but a conservative value of 2.5 metric ton/ha.year may be taken as a representative average of the regions where these fruits are currently exploited. Considering that only 33% of these native palms are productive, the potential productivity can be estimated as 12.4×10^6 metric ton of coconut/year.

Babassu coconut consists of three layers: a fibrous external (epicarp), a fibrous-amylaceous intermediate (mesocarp) and a woody internal (endocarp) where the kernels are enclosed. Figure 1 illustrates the babassu coconut fruit form. The average weight contents of babassu coconut are: 12% epicarp, 23% mesocarp, 58% endocarp and 7% kernels. Traditionally, the exploitation of babassu coconuts is oriented for oil production from kernels, wasting about 93% of the fruit biomass (*3*). If an integral industrial utilization is performed, a significant production of fuels and chemicals will be obtained as indicated in Table 1, which illustrates the potential of that biomass. It can be observed that the potential for ethanol production is very high, reaching 1 billion liters/year, corresponding to 8% of the current ethanol production in Brazil. The integral coconut utilization, which is a new concept of babassu fruit processing, is based on the complete separation of its basic components (epicarp, mesocarp, endocarp and kernels). After this industrial operation, several interesting products can be obtained by diverse processing routes, as illustrated in Figure 2. The project implanted by Tobasa at its industrial site located at Tocantinopolis, Tocantins

State, Brazil, has an integrated infrastructure from the coconut harvest, transportation and storage until the industrial processing. Mechanical processing of the coconut fruit involves dehusking (which separates epicarp and mesocarp) and cutting of the fruits, leading to the continuous separation of the kernels and endocarp pieces. In the current project stage, only some of the products shown in Figure 2 are industrially produced, they are: lauric oil and animal feedstock, both obtained from the kernel pressing operation; primary fuel for steam generation (fibrous epicarp); charcoal from the endocarp and amylaceous flour and ethanol from the mesocarp. The production of more sofisticated products (shown in Figure 2) will require the development of technology and high investiment costs.

This work describes an industrial process for ethanol production, developed by Tobasa. This development was motivated by the significant starch content found in the coconut mesocarp (about 68%, when a manual dehusking processing is used) and the relatively low mesocarp cost. Technical results are presented and an economical evaluation is performed based on an industrial scale experience.

INDUSTRIAL PROCESS CHARACTERISTICS

Babassu starch characteristics: as previously mentioned, fruits are dehusked in an industrial machine and the following fractions are obtained: dehusked fruits, fibers (epicarp) and amylaceous flour (mesocarp). When the mechanical process is used the percentage of starch in the flour is about 50% (w/w) and its fiber content is around 10% (w/w). A more detailled composition of industrial babassu amylaceous flour is presented in Table 2. This flour has a brownwish color due to tanins. The gelatinization temperature of the starch granules is in the range of 63 to 73 ^{o}C and the Brabender viscosity curves are very similar to those of corn starch. The babassu starch physico-chemical properties are close to those of other common cereal starches and very different to the properties of starches from roots and tubercles (cassava, potato etc) as remarked by Rosenthal and Espindola (*4*). Due to its significant amylose content, babassu starch presents a high autoretrogradation trend, thus, cooking and liquefaction steps are crucial for the saccharification process, requiring a strict control of cooking and cooling processes temperatures (*5*).

Process flowshet: Figure 3 summarizes Tobasa's process for ethanol production from babassu amylaceous flour (*6*). First the milled flour is mixed with room temperature water in a 3,000-L capacity stirred tank, in a batch process. The resulting slurry has a solid content of 20% w/v. This slurry is suplemented with calcium hydroxide in order to assure a necessary amount of calcium for enzyme activity and to adjust the solution pH to 6.0. Some amount of bactericide is also added to prevent contamination. This slurry is pumped to a buffer tank where 33% of the amount of commercial alfa-amylase (Termamyl 120 L, Novo Nordisk) required for liquefaction process is added. This tank assures the continuous operation of the gelatinization step, which is carried out in a specially designed jet-cooker for babassu starch processing using saturated steam. The gelatinezed starch is continuously fed to a flash-tank, which promotes an abrupt pressure loss, reducing the liquid temperature to 85-90 ^{o}C. The enzyme alfa-amylase (67% of the total amount required) is added to this tank content in an intermitent way. To complete the liquefaction process, an additional 6,000-L tank in series with the flash-tank is necessary. This tank has an internal refrigerating coil and an external heating jacket to keep the adequate liquefaction temperature. Partial starch saccharification is conducted in a 6,000-L stirred tank, where an intermitent addition of the commercial enzyme glucoamylase (AMG 200 L, Novo Nordisk) is performed. This tank has heating and refrigerating devices in order to maintain the liquid temperature in the range of 55 to 60 ^{o}C. The operation pH value (4.5 to 4.8) is controlled by the addition of commercial chloridric acid. The desired degree of dextrinization is achieved in a downstream 10,000-L stirred tank. The content of this tank is continuosly pumped througth heat exchangers to reduce the liquid temperature to 30 °C, which is used in the fermentation step. This latter process step is performed in a batch and conventional way, by using six 100,000-L capacity fermenters, which are open vessels, mecanically agitated and coil refrigerated. Finally the product is fermented by *Sacharomyces cerevisae* and is continuosly fed to a bubble cap tray distillation column.

BABASSU ETHANOL QUALITY

The characteristics of babassu ethanol are similar to those of other cereal alcohols, presenting a density of 0.95 g/mL, total acidity of 0.8% (w/v) and a very pleasant smell. Table 3 compares babassu alcohol produced by Tobasa with other cereal and sugar-cane alcohols found in the Brazilian market, in terms of minor components. These cromatografic results indicate that babassu alcohol has non detectable levels of propanol and isobutylalcohol, in contrast with sugar-cane alcohols that present very high levels of these components. However, it presents higher amounts of ethyl acetate and acetaldehyde when compared with commercial cereal alcohols, due to the fact that the distillation step at Tobasa industrial plant is not yet completely optimized. Improvements on babassu alcohol quality are expected in a near future.

ECONOMIC ASPECTS OF BABASSU ETHANOL PRODUCTION

Figure 4 shows the contribution of itemized costs on the final product cost. Raw material is the major contribution for alcohol production cost, followed by enzymes, manpower, electricity, chemicals, steam and mechanical maintenance. Steam generation costs are quite insignificant due to epicarp utilization as solid fuel for boilers. This is a favorable aspect for the net energy balance of the industrial plant, as remarked by Menezes (7).

The results obtained in Tobasa's industrial plant enable us to compare production costs and profitabilities for ethanol production from babassu starch, conventional amylaceous raw materials and sugar-cane. Table 4 summarizes technical and economical data, concerning raw material market prices and its starch content, ethanol yield (based on an starch-ethanol conversion of 60% for all the amylaceous materials), conversion costs, processing costs (considered 30% of the ethanol price for amylaceous raw materials and 24% for sugar-cane), final production costs and profitabilities.

Data from Table 4 show that ethanol production from conventional amylaceous raw materials do not present economical viability, as indicated by the negative profitability values obtained for rice, cassava, corn and sorghum. The high profitability of ethanol production from babassu coconut is essentially linked to the pronounced starch content of its mesocarp and the relatively low price alloted for this coconut fraction. Obviously if the coconut fruit was purchased only for ethanol production, the profitability would become negative as for the other starchy raw materials. Thus, only the integral utilization of the fruit allows a profitable production of alcohol. It is important to note that babassu coconut is also a source of oleaginous, proteics and carbonaceous materials as well as fibrous material (epicarp), which, used as a primary fuel, has a major contribution for the process energy balance.

Sugar-cane is considered the most competitive source for ethanol production, mainly due to its low raw material and processing costs in comparison with conventional starchy raw materials. However, as shown in Table 4, when these costs are compared with those of babassu mesocarp, a new picture is established, as conversion costs of sugar-cane and babassu coconut are 66% and 30% of the alcohol price, respectively. This advantage overcomes the higher processing costs of babassu coconut. Thus, the final ethanol production cost is US$ 326 per cubic meter for sugar-cane and US$ 218 per cubic meter for babassu coconut ethanol, resulting in profitabilty values of US$ 36/m^3 and US$ 145/m^3, respectively.

CONCLUSIONS

The production process of ethanol from babassu coconut mesocarp was developed and implanted on a small industrial scale (5,000 L ethanol/day). This process, constituted of physico-chemical, enzymatic and fermentation steps, reaches an ethanol yield of 60%, which is similar to those obtained in conventional plants processing other amylaceous materials. For babassu mesocarp this yield correponds to 290 L of alcohol per metric ton of amylaceous flour.

Alcohol production from amylaceous raw materials seldom presents economical viability, due to starchy flour costs, which nowadays have increased their market prices. The production of ethanol from babassu coconut starch will be economical viable if and only if an integral fruit processing approach is adopted. Babassu ethanol can be produced at a final cost of US$ 218 per cubic meter, which is a low value in comparison with ethanol produced from other starchy raw materials and even sugar-cane. Furthermore, it can be produced with a profitability which is significantly higher than that currently presented by the sugar-cane alcohol.

The results presented in this work indicate that a rational and intensive utilization of babassu coconut can be economically performed on an industrial scale. Furthermore, babassu palms are an important native and renewable forest resource, which assures fuel and chemicals production without developing new agricultural frontiers and avoiding the substitution of traditional food crops by sugar-cane or other energetic crops.

Aknowledgements: This work was partially supported by Conselho Nacional de Desenvolvimento Cientifico e Tecnologico (CNPq), Brazil.

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Table 1. Estimated production potential of babassu coconut and its derivated products

Product	product/ha.year	total product/year
Coconut (ton)	2.5	12.4×10^6
Alcohol (L)	200	1.0×10^9
Charcoal (ton)	0.36	1.8×10^6
Oil (ton)	0.10	0.5×10^6
Gas (m^3)	435	2.2×10^9
Epicarp (ton)	0.30	1.5×10^6

Table 2. Average composition of babassu mesocarp (industrial amylaceous flour)

Components	Weight distribution (%)
Moisture	14.0
Starch	50.0
Protein	2.3
Fibers	10.0
Lipids	2.8
Soluble carbohydrates	1.3
Pentosanes	3.4
Ash	1.3
Other components	14.8

Table 3. Minor components of commercial and babassu coconut alcohols

Alcohol type	propanol (mg/L)	isobutyl alcohol (mg/L)	methanol (mg/L)	acetaldehyde (mg/L)	ethyl acetate (mg/L)
Babassu coconut (Tobasa)	nd	nd	84	51	226
Cereal (Trade mark A)[a]	nd	nd	51	23	10
Cereal (Trade mark B)[b]	20	nd	25	14	80
Sugar-cane (Trade mark B)	640	270	5	52	913
Sugar-cane (Trade mark C)[c]	110	32	8	110	1350

[a, b, c] correspond to samples of commercial Brazilian alcohols (by ethical reasons true trade marks were preserved)
Components determination was performed by gas cromatography using the following conditions: FID detector, column temperature (75 °C), detector temperature (150 °C), stainless steel column-PAC 3334 and injection volume (5 μl).

Table 4. Ethanol production from amylaceous raw materials, babassu coconut and sugar-cane: an economical comparative evaluation

Parameter	Rice	Cassava	Corn	Sorghum	Babassu mesocarp	Sugar-cane
FOB price (US$/metric ton)[a]	85	30	120	100	32	19
Starch content (w/w %)	35	15	65	63	50	-
Ethanol yield (L/metric ton)	208	90	400	370	290	80
Conversion cost (US$/$m^3$)[c]	408	330	300	270	109	238
Conversion cost/ethanol price (%)[b]	112	91	83	74	30	66
Processing cost (US$/$m^3$)[d]	109	109	109	109	109	87
Processing cost/ethanol price (%)[b]	30	30	30	30	30	24
Final production cost (US$/$m^3$)[e]	515	439	410	377	218	326
Final prod. cost/ethanol price (%)[b]	142	121	113	104	60	90
Profitability (US$/$m^3$)[f]	-152	-76	-47	-15	145	36
Profitability/ethanol price (%)[b]	-42	-21	-13	-4	40	10

[a] raw materials prices based on current market prices of April, 1996

[b] ethanol established governement price (free taxes): US$ 362.68/m^3 (April, 1996)

[c] the conversion cost is the result of the division of FOB price per ethanol yield

[d] the processing cost was estimated as 30% (starchy materials) and 24% (sugar-cane) of the ethanol price based on Tobasa's experience

[e] the final production cost is the sum of conversion and processing costs

[f] the profitability value is the difference between the ethanol price and the final production cost

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LIST OF FIGURES

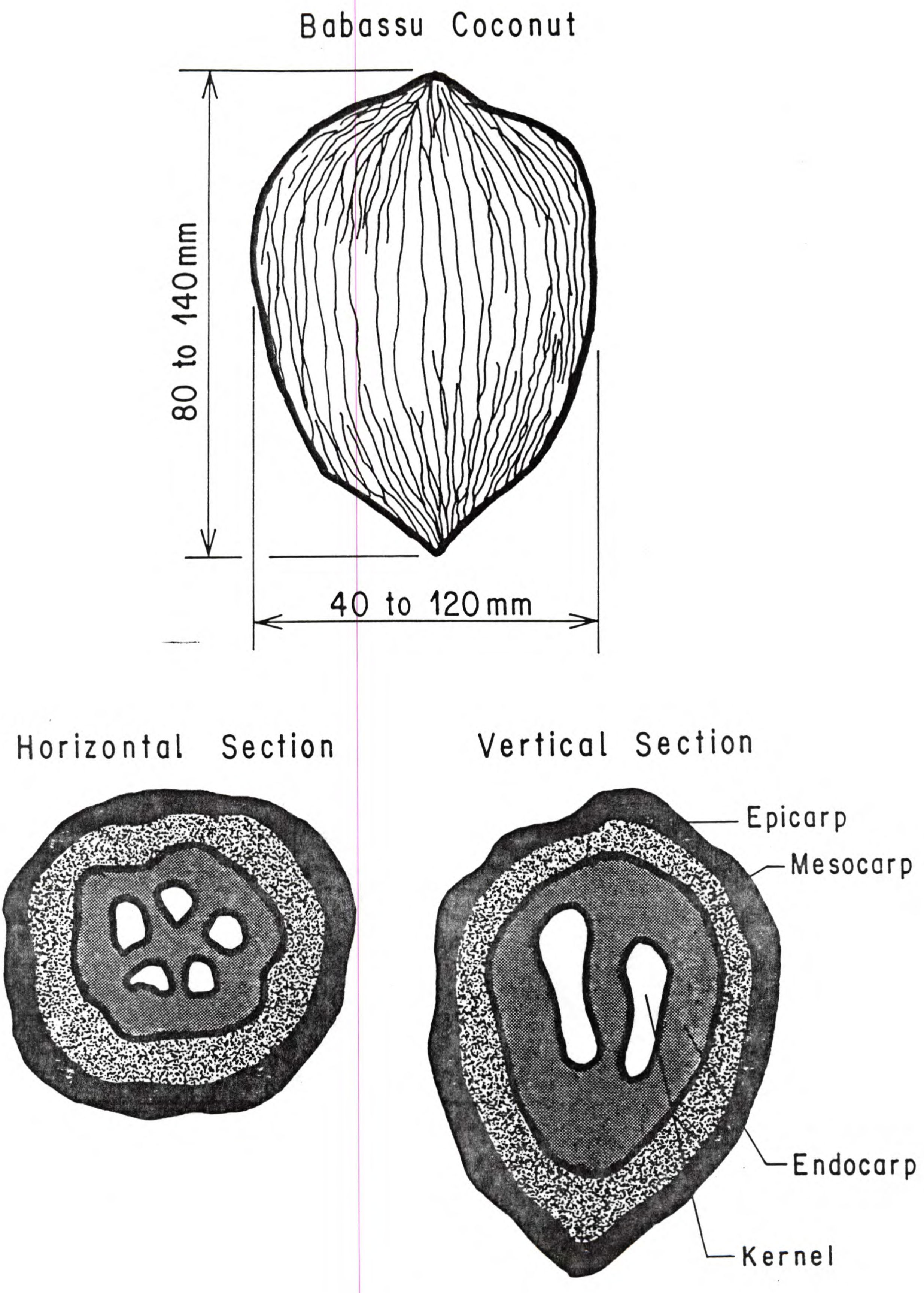

Figure 1. Babassu coconut: dimensions and internal views of the fruit

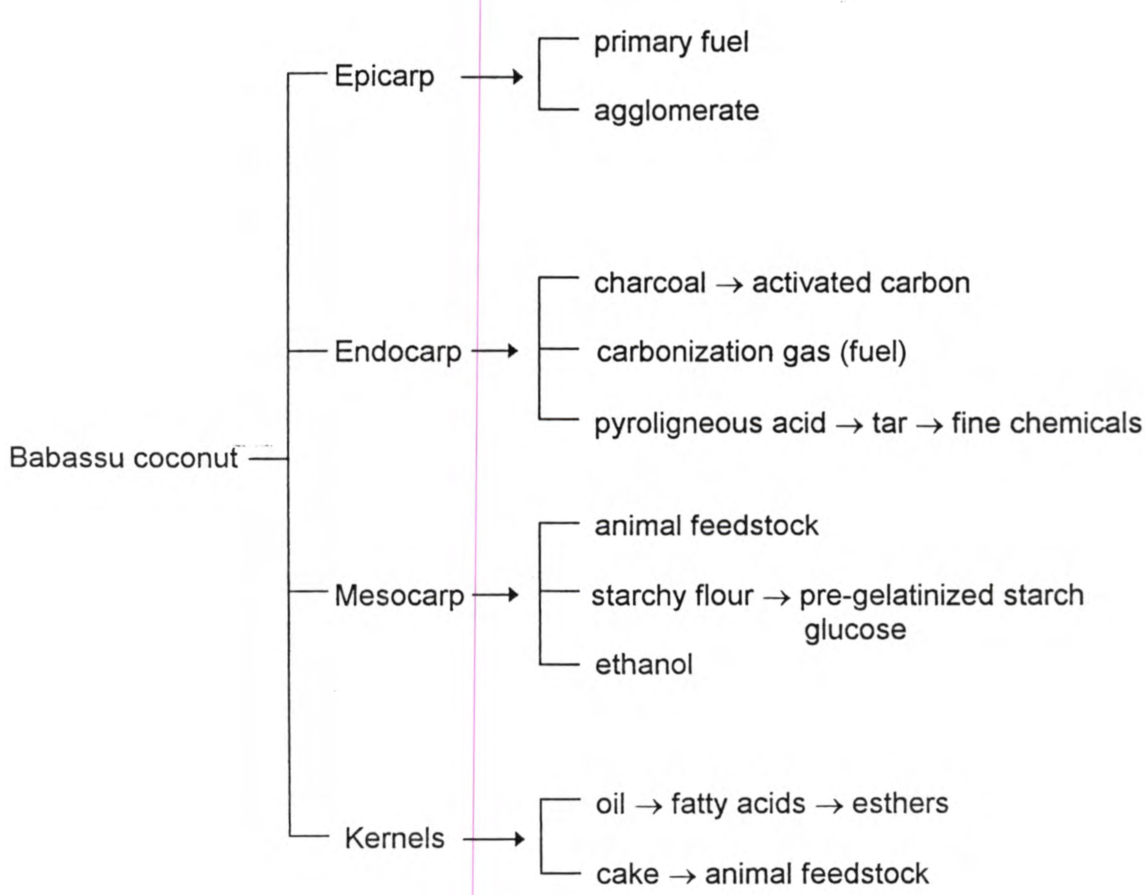

Figure 2. Potential products obtained from the industrial processing of babassu coconut

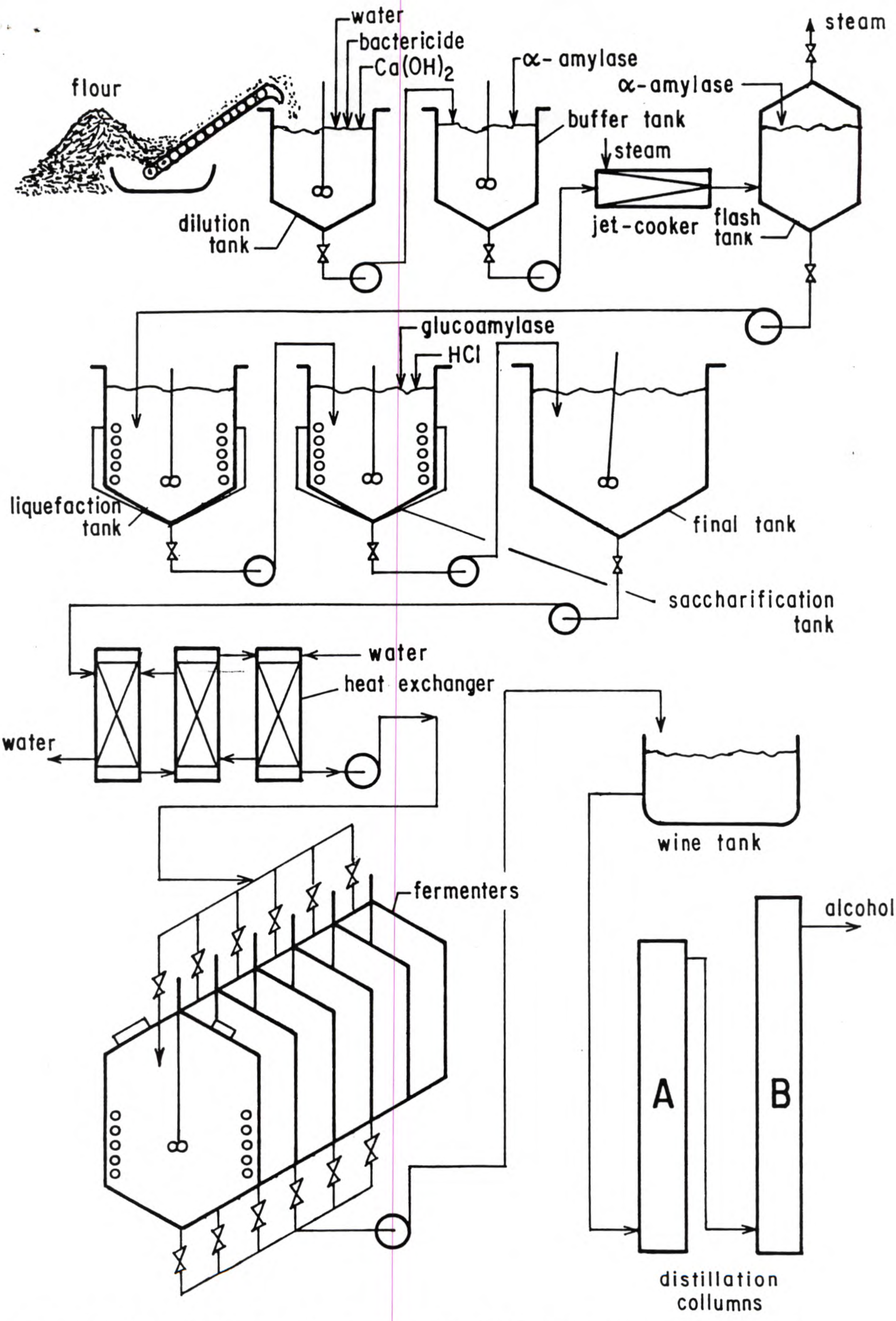

Figure 3. Tobasa's flowsheet for alcohol production from babassu amylaceous flour

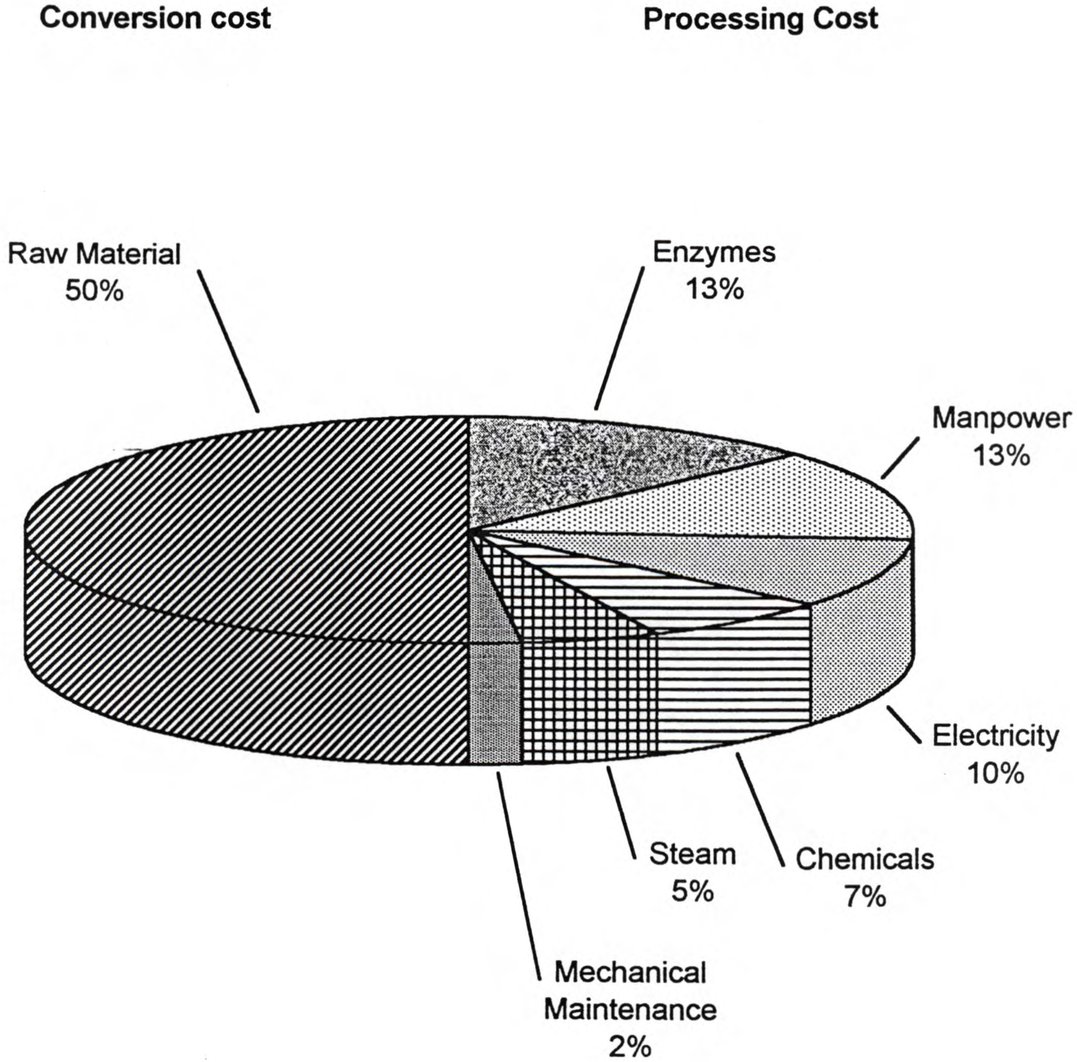

Figure 4. Contribution of production on the final babassu coconut alcohol cost