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Fermentation Products from Coconuts*

by

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INTRODUCTION

Fermentation may be defined as "the decomposition produced in an organic material by the action of living organisms like fungi and bacteria." The most commonly known fermentation process may be that of alcohol production, but fermentation really encompasses the whole range of microbial actions on organic substances under any given set of environmental or cultural conditions.

Therefore, to associate fermentation with the coconut is to envisage the utilization of the different parts of the coconut in ways which may heretofore have not been seriously considered. This paper, however, shall only be limited to the study of the coconut fruit.

THE SAP

A natural fermentation product of the coconut is the *tuba* (sap) which is an exudate from the bud when incised near the tip. This liquid is high in sugar so that wild yeasts in the atmosphere gravitate towards this bud and consequently contaminate the collected sap. Since the initial yeast content is very low, the fermentation rate of the tuba would also be correspondingly low. Furthermore, from among the many more species of organisms in the atmosphere there is a specie which converts ethyl alcohol to acetic acid. Thus tuba has to be distilled within 48 hours of collection so that it will not turn to vinegar. Both fermentation steps mentioned are without human intervention beyond sap collection. If desired, the fermentation may be stopped within the first step (before the sugars completely run out and before a significant fraction of the alcohol has been converted by other species to acetic acid) and bottled for a longer shelf-life. This method, however, is not practiced locally.

Sap collection limits fruit production because the fruit is literally nipped off from the bud. If the bud were allowed to flower and mature, the fermentability of the fruit becomes entirely different. Its microbial susceptibility varies according to the section of the fruit attacked.

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THE HUSK

The primary economic value of the husk is in its long fibers, recovered by mechanical decortication. During the process some of the fibers break and go with the coir dust. To maximize fiber recovery, the husk is soaked in water for some time to increase fiber resilience as well as minimize flying coir dusts. Because of the voluminous amount of coir dusts generated, there is a need to isolate and identify an organism which can degrade coir dust and biologically release the fibers. But so far there has not been much success along this line. The ligneous materials in the husk inhibit microbial activity. This view is substantiated by the fact that coir dust mounds that have been left for months under the sun and rain have remained undegraded. At the moment it seems our hopes for lignin hydrolysis lie on the genetic splicing of bacterial genes to extend its capability to synthesize some "lignilolytic" enzymes.

THE MEAT

A large portion of the coconut meat is dried as copra and milled or exported as such, or, processed to desiccated coconut. A small percentage is directly used for household needs.

The meat itself when almost totally free of oil has been found to be highly enzymically (biologically) hydrolyzable. The hydrolysate has been consequently fermented to alcohol. But the initial objective was for the eventual possibility of partially hydrolyzing fresh coconut meat to facilitate the recovery of the oil at room temperature. The hydrolysate will just dissolve in the inherent water content so that simple demulsification and liquid-liquid separation of the oil from the water may be achieved without using heat or high pressure.

At the moment the residue *(sapal)* from fresh coconut milk extraction is used largely for stock feed. For such purposes the quality of the sapal may be improved by partial microbial hydrolysis to initially break the large cellulosic molecule into better metabolizeable smaller molecular fractions.

THE ENDOSPERM WATER

The coconut water is the part most amenable to fermentation. This part of the coconut has been used, even if only to an almost insignificant degree, for the production of vinegar and *nata de coco.* For both products the water is used as a vehicle for fermentation because of the nutrients inherent in it (Table 1) but the actual products – acetic acid and dextran (nata) – are both generated from the sugar added to the coconut water prior to fermentation.

Table 1. Vitamins and Amino Acids Present in Coconut Water

Ascorbic	13.23 mg/l
Nicotinic acid	0.64 mg/l
Pantothenic acid	0.52 mg/l
Riboflavin	0.01 mg/l
Folic acid	0.003 mg/l
Glumatic acid	14.50%
Arginine	12.75%
Leucine	4.18%
Lysine	4.51%
Proline	4.12%
Aspartic acid	3.60%
Tyrosine	2.83%
Alamine	2.41%
Histidine	2.05%
Phenylalanine	1.23%
Serine	0.91%
Cystine	1.17%

Even without any addition of sugar, the coconut water is still a good substrate for microbial cultivation such as single cell protein (SCP) production. Its availability and supply makes SCP production a very viable proposition. But since the Filipinos are not yet fully educated on the use of SCP as a nutritional supplement, then SCP might be exploited to meet part of the enormous demand for animal feeds.

TETRACYCLINES

Another fermentation product which has a high demand in the feeds industry are the tetracyclines and derivatives metabolized by *Streptomyces aureofaciens* and related species. Unfortunately, the production of tetracyclines is not possible in coconut water because the amino acid or serine, seems to be too high and is therefore inhibiting the metabolism of the compound and its derivatives. However, this does not necessarily mean that Streptomyces will not grow in coconut water.

There is undoubtedly a host of fermentation products that can be generated through the utilization of coconut water because it is certainly a rich substrate for microbial growth. But since it has not yet been extensively used, the nutritious coconut water is an economic burden to the coconut processors and an environmental burden to the bordering communities.

FERMENTATION AND WASTEWATER TREATMENT

Viewed from a different angle, because of the high organic content of coconut water, its discharge to the rivers will impose adverse effects on the aquatic life therein. It should therefore be treated before it can be discharged into any river.

An organic loading in wastewaters would logically be treated by biological means and the process.can only be either aerobic or anaerobic. When the organic load is of the order of 30,000 ± 5,000 ppm as that of coconut water, treatment is likely to be costly. This cost could be reduced if some revenues could be recovered from the operation itself, e.g., if the treatment is aerobic, instead of just producing biological sludge which does not carry any economic value as yet, then the treatment may be controlled so as to produce only one specie – a pure culture – so that the biomass produced may be utilized as in feeds production.

Fungal Culture

Simulated coconut mill waste (coconut water diluted with processed waters) was treated using it for fungal culture. Except for standard housekeeping cleanliness, no sterilization was made. The organism used was *Geotrichum candidum* and the culture was aerobic open system. The instantaneous biomass concentration was about 3000 mg/1. and the BOD reduction was observed as tabulated below.

Table 2. BOD Reduction in Aerated Fungal Culture (Continuous Culture of Geotrichum Candidum)

		Detention time (in hours)		
Detention time		10	8	6
pH 6.08:	Influent BOD	6420	5200	4800
	Effluent "	3810	2960	3800
	BOD red^n	40.7%	43%	21%
pH 8.0 :	Influent BOD	4210	3800	7200
	Effluent "	1810	1680	4610
	BOD red^n	57%	56%	36%

Anaerobic Fermentation

The coconut water by itself (separated from the processed waters) with its high organic load should be amenable to anaerobic digestion. This design results in the generation of gases one of which is methane.

Summary of the possible reactions involved in anaerobic digestion from acetic acid:

$$CH_3COOH \longrightarrow CO_2 + CH_4$$

From formic acid:

$$4HCOOH \longrightarrow CH_4 + 3CO_2 + 2H_2O$$

From a higher fatty acid:

$$2\,C_4H_9COOH + CO_2 + 2H_2O \longrightarrow CH_4 + 2\,CH_{\#}COOH + 2CH_3CH_2COOH$$

For early initiation and maximization of methane production, a methane starter from the National Institute of Science and Technology (NIST) was used as the inoculum. The four-liter culture carried batch for five days gave a profile of the BOD reduction and gas production as tabulated below:

Table 3. BOD Reduction in Anaerobic Digestion of Coconut Water

	Day					Overall BOD Redn, %
pH 6.8	0	2	3	4	5	
BOD, ppm x 10^3	33.0	23.7	19.7	15.3	7.7	77
Gas prod'n liters			4.7	4.1	4.0	
% CH_4 (by vol)			30.3	23.0	27.7	
pH 7.0						
BOD, ppm x 10^3	29.0	23.3	20.7	15.7	10.6	63
Gas prod'n. liters			4.65	4.6	4.4	
% CH_4 (by vol)			32.3	19.0	16.0	

Biomethanation

Biomethanation involves the anaerobic fermentation of carbon dioxide, carbon monoxide and hydrogen in reactions as follows:

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$$

$$CO + 3H_2 \longrightarrow CH_4 + H_2O$$

Usually, and as may also be seen in Table 3, the methane content of the gas generated decreases with time so that unless the carbon dioxide portion is removed from the gas stream, the CH_4 becomes less and less available for use as the gas stream reduces in combustibility. Scrubbing will remove the CO_2 from the gas stream and will free the CH_4 for use. However, because there is so much more CO_2 than CH_4, the operation will result in the drastic reduction in the volume of the gas and the CO_2 will just be lost to the scrubbing liquid. If the scrubbing is made by recycling the gas stream into the system, the CO_2 will then be available for the microorganisms to convert to CH_4. Summarily, biomethanation is just an additional step in the same direction as the anaerobic digestion earlier mentioned. Such efforts resulted in the reduction of the CO_2 content in the gas stream by its conversion to CH_4 which also redounds in the increase of the heating value of the gas stream by about 12–15 percent than that of the conventional biogas digester systems. Additional information may be gathered from the accompanying graphs.

Table 4. BOD Reduction in Biomethanation of Coconut Water

	Day					Overall BOD
pH 6.8	0	2	3	4	5	Redn %
BOD, ppm x 10^3	36.8	26.8	16.5	10.8	8.6	76.6%
Gas prod'n. liters			9.5	5.5	0.3	
% CH_4 (by vol)			64.9	68.9	71.5	
pH 7.0						
BOD, ppm x 10^3	36.3	26.2	20.7	13.7	8.5 :	76.6%
Gas prod'n. liter			8.0	5.3	1.5	
% CH_4 (by vol)			64.7	67.7	70.9	

The foregoing has about covered the current and prospective fermentables of the coconut fruit and related materials. There is no doubt other fermentation products will be generated from the coconut in the future. With gene splicing and the vast possibilities from biotechnology, it may just be a matter of time.