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## ABSTRACT

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The following steps were employed in Coco-crisps processing: dehusking, deshelling, cutting of the meat into 0.6-0.7 mm thick slices, blanching in boiling water, cooking in light syrup and drying. The dried product contained 1.3% moisture, 3.1% protein, 33% fat, 35% sugar, 2.2% ash and 10.7% neutral detergent fiber (NDF). Coco-crisps was rated between 7-7.7 in all sensory attributes. It has an acceptability score of greater than six after six months of storage in either aluminum foil or polyethylene laminated bags. Results of consumer acceptability tests done in several locations revealed 71-83% of the respondents rating "like" the product. (Author)

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## STUDIES ON THE PROCESSING OF A DEHYDRATED FOOD PRODUCT FROM YOUNG COCONUT MEAT<sup>1</sup>

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COCO-CRISPS is a food product developed from young coconut endosperm. Called as such due to its crispiness, the product has these other features: it has a white color, has the pleasant coconut flavor, and does not leave any fibrous feeling aftertaste. Nine-month old nuts were found most suitable for Coco-crisps processing.

The following steps were employed in Coco-crisps processing: dehusking, deshelling, cutting of the meat into 0.6-0.7 mm thick slices, blanching in boiling water, cooking in light syrup, and drying. The dried product contained 1.3% moisture, 3.1% protein, 33% fat, 35% sugar, 2.2% ash, and 10.7% neutral detergent fiber (NDF). Coco-crisps was rated between 7-7.7 in all sensory attributes. It had an acceptability score of greater than six after six months of storage in either aluminum foil or polyethylene laminated bags. Results of consumer acceptability tests done in several locations revealed 71-83% of the respondents rating "like" the product.

### INTRODUCTION

The fluctuating prices of coconut oil in the world market have drastically affected the country's economy these past several years. If oil, therefore, will remain as the country's principal export product, the Philippine coconut industry might soon face instability, particularly since there is an increasing production of palm oil and other vegetable oils.

To contend with this not-so-pleasant scenario, diversification of the uses of coconut should be advocated. This means that aside from the production

of coconut oil, other non-traditional uses of the coconut should be looked into, and come up with novel products that could eventually be aimed at the world market.

With this premise, the researchers of this study started investigations on the processing of coconut endosperm (young coconut meat) into non-traditional food products.

Processed food products from young coconut meat could be arbitrarily classified into three groups: (1) young coconut meat or "buko" in syrup; (2) dehydrated "buko" in several traditional recipes; and (3) oven-toasted chips coated with salt or sugar.

Preservation of young coconut endosperm in sugar syrup was performed by several investigators (Damian, 1965; Manoto and Aspiras, 1970; and Valida, 1977). Various food preservatives and additives were used to improve the product quality. However, development of off-flavor and brown color of the product were the main drawbacks of "buko" in syrup.

In 1984, Raymundo reported on the processing of young coconut endosperm into dehydrated "buko." The process involved the preparation of "buko" meat into the desired size and shape, soaking them in buko water that contained sodium metabisulfate and preservatives, and subsequently drying the meat for 18 hours. The dehydrated product was reported to have remained white for at least seven months, and retained much of the original "buko" flavor. Pilot production of dehydrated buko was also conducted (Raymundo, 1985). Simultaneously, del Rosario (1984) also mentioned about dried buko rolled in powdered sugar before packaging.

The meat of mature nuts was also used in making coco-chips. Padilla and Labra (1977) reported a process that made use of the meat of 11-month old nuts. The meat was sliced and soaked in 2% brine solution for two hours, or in 50% sugar syrup for four minutes. After which, the material was dried and packed in cellophane foil and polyethylene bags. The finished product was rated "moderately acceptable" by a taste-panel.

<sup>1</sup>Based on the paper presented at the National Workshop on Coconut Meat and Oil Processing and Utilization held on December 12-13, 1985, Philippine Coconut Authority, Diliman, Quezon City. (Submitted for publication, November 19, 1986. Accepted, February 20, 1987).

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Another process of making coco-chips from 11-month old nuts was developed by Lontoc et al (1971). The meat was sliced into thin chips, cooked in syrup or salt, and oven-toasted at 90-100°C until golden brown. The product's moisture absorption characteristic and packaging requirement were studied (Marquez, 1977), in relation to its qualities. Presently, it is an export item (Gonzalez, 1983).

From an examination of the distinct characteristics of the mentioned products in relation to the physico-chemical properties of coconut meat at different stages of maturity, the following were observed: (1) the product is quite prone to rancidity, which was perhaps due to the high concentration of unsaturated fatty acids in the coconut meat especially at the "buko" stage (Padua-Resurrection and Banzon, 1979); (2) high fiber content and other changes of cell wall in the endosperm at maturity cause the fibrous feeling when eating dried coco chips, and possibly, the mild irritation aftertaste.

The succeeding report describes the development of Coco-crisps food product processed from young coconut endosperm. Coco-crisps is considered a new product in the sense that it possesses all together several important characteristics. It is white in color, has the pleasant coconut flavor without detectable rancidity for several months, and most especially, leaves no fibrous-feeling aftertaste. The product is also very crispy. Coco-crisps has a good potential for both domestic consumption and for export.

## MATERIALS AND METHODS

### Cultivars used

Coconut cultivars grown in the Visayas State College of Agriculture (ViSCA) experimental areas were used in the study. The varieties were: Baybay Tall, Tacunan, Catigan, and Coconiño.

Tagged nuts were harvested at seven, eight, nine, 10, and 11 months of maturity. The nuts were then dehusked and split into halves. The coconut water was collected, and its volume, total soluble solids, and pH, were determined. Subsequently, the coconut meat, minus the shell that is, was weighed. A vernier caliper was used to measure the endosperm's thickness at four locations in the middle portion of the nut.

### Coco-crisps processing and sensory evaluation

The meat of the aforementioned cultivars were processed into Coco-crisps following the procedure developed and standardized in this study (Fig. 1). The

processed samples were subjected to an eight-member taste panel who evaluated the product's sensory attributes, namely, color, flavor, sweetness, texture, mouthfeel (presence of "sapal" in the aftertaste), and overall acceptability.

A nine-point Hedonic scale (9-like extremely, 1-dislike extremely) was used in determining the acceptability scores. Crispiness and mouthfeel were rated following the intensity scale of 5-points. For crispiness, 5 corresponded to very crispy, down to 1-soft and gummy; whereas for the mouthfeel, 5-completely absent to 1-very noticeable.

### Storage studies

Coco-crisps processed from nine-month-old nuts of the Baybay Tall cultivar, were placed in two kinds of packaging material, namely, cellopolyethylene (CP), and aluminum foil/polyethylene (AP) laminate. The materials were stored at ambient condition and samples were taken after two, four, six and 12 months for sensory evaluation, and determination of moisture content and rancidity.

### Chemical analyses

Moisture, fat, protein, total sugar, and ash content were analyzed using the standard methods (A.O.A.C., 1975). Determination of neutral detergent fiber (NDF) and rancidity test were patterned after the methods described by Van Soest and Wine (1967), and Krishna-Murthy and Chandraskhasa (1974) respectively.

### Statistical analyses

Data from the sensory evaluation and chemical composition of the samples were subjected to an analysis of variance following the Split-Plot Design and Duncan's Multiple Range Test (DMRT), (Gomez and Gomez, 1984).

## RESULTS AND DISCUSSION

### Changes in chemical composition of the coconut meat during nut maturity

The changes in proximate composition of coconut meat during nut maturity of the four cultivars under study are shown in Table 1. Moisture and protein content decreased with maturity. No significant difference in the protein content among the cultivars was observed. The ash content which reflects the mineral content of the samples, however, significantly decreased with maturity except that of the Coconiño cultivar. Balleza and Sierra (1975) reported a similar trend in the other coconut cultivars.

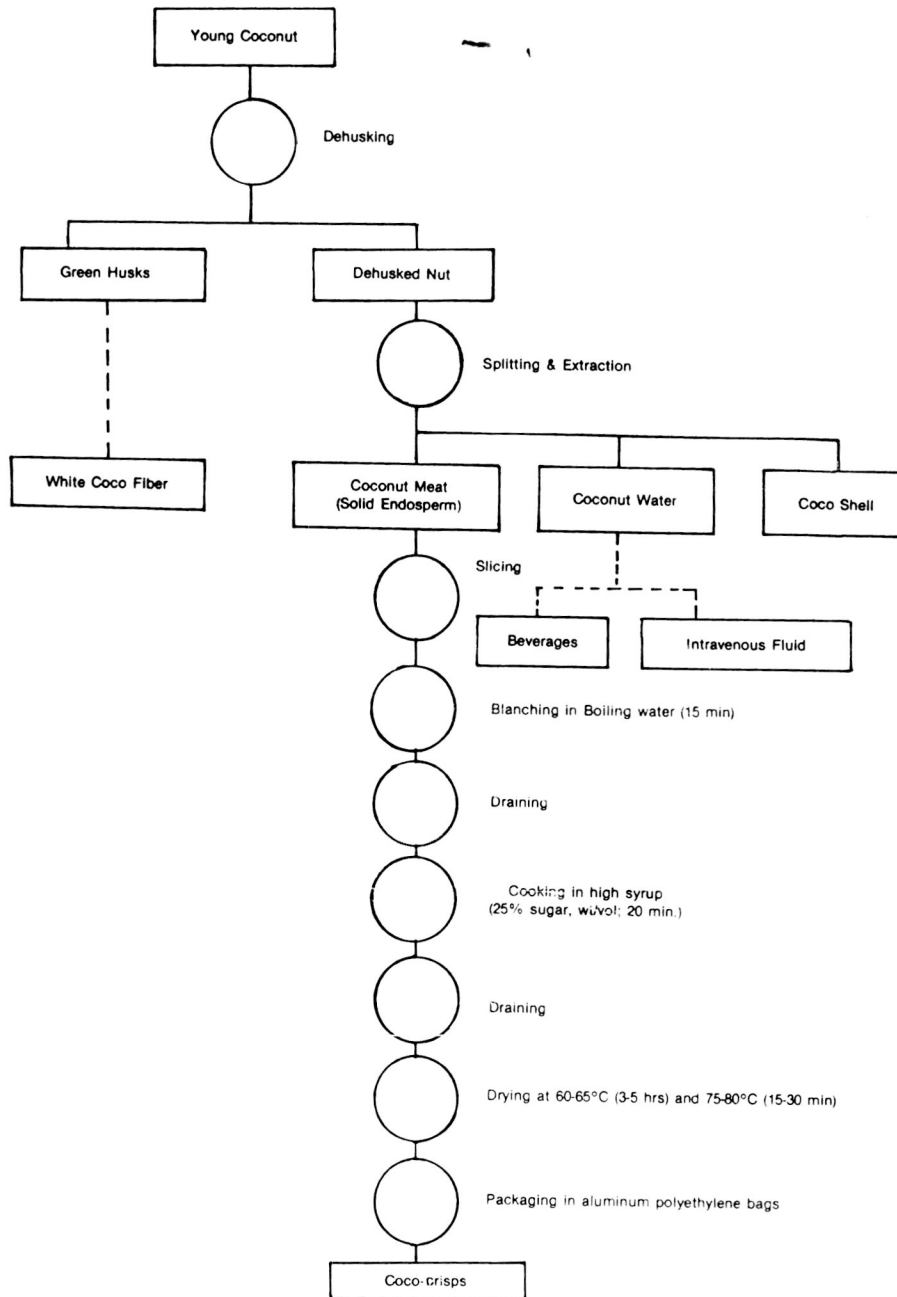


Figure 1. Flow chart of Coco-crisps production.

In contrast, an increase in NDF content with maturity was evident in all the varieties under study. Varietal differences in NDF content was noted with a significance of  $p \leq 0.05$ . The results are thus in agreement with the data reported on Laguna Tall Green, Laguna Tall Yellow, Ivory Coast variety, and hybrid (Manullang, 1981). A study on X-ray diffraction done by Manullang (1981) showed that the intensity of the X-ray diffraction diagram and relative crystallinity of cell wall in coconut meat increased with nut maturity. The crystal peak became distinct as the cell wall matured. Crystallinity of the cell wall could be

attributed to have been caused by the interaction between hemicellulose and  $\alpha$  cellulose fractions. Manullang's (1981) findings is thus a basis to speculate that the crystallinity of endosperm cell walls at maturity appeared to be the main factor contributory to the fibrous feeling when eating mature coconut meat.

Fat content of coconut meat of all cultivars increased rapidly up to 9-10 months of age. Varietal difference in fat content of the endosperm was significantly observed (Table 1). Padua-Resurrection and Banzon (1979) reported that the fatty acid composi-

**Table 1. Chemical composition of coconut endosperm from nuts of different ages and cultivars.<sup>1</sup>**

Cultivar Age of nuts (months)	Moisture (%)	Fat (%)	Protein (%)	Neutral detergent fiber (%)	Ash (%)
<b>Baybay Tall</b>					
7	82.4 a	31.1 e	6.5	—	5.7 a
8	69.4 b	39.3 d	6.2	11.5 d	3.7 b
9	52.3 c	58.8 b	6.0	14.5 c	2.0 c
10	46.1 d	62.8 a	6.0	17.0 b	2.3 c
11	45.8 d	56.2 c	5.2	19.8 a	2.1 d
<b>Catigan</b>					
7	67.7 a	45.6 d	8.2 ab	—	3.0 a
8	65.2 b	45.7 d	8.5 a	15.2 bcd	2.9 b
9	57.6 c	54.5 bc	6.7 cd	16.4 abc	2.4 c
10	45.3 d	56.2 ab	7.0 bc	17.0 ab	1.7 e
11	45.1 d	58.2 a	6.6 cd	17.4 a	2.0 d
<b>Coconiño</b>					
7	78.1 a	33.7 e	8.2 a	—	1.0
8	67.1 b	37.8 cd	7.7 abc	13.7 d	1.0
9	65.2 c	39.4 c	7.8 ab	16.2 bc	1.0
10	53.4 a	45.3 b	6.7 bcd	16.9 ab	1.0
11	50.7 e	47.6 a	6.6 bcd	18.3 a	1.1
<b>Tacunan</b>					
7	76.1 a	49.0 e	7.2	—	4.5 a
8	63.3 b	57.5 d	7.1	11.0 d	2.8 b
9	57.5 c	60.8 c	6.6	14.4 c	2.4 c
10	51.9 d	66.0 a	6.2	16.8 ab	2.1 d
11	46.2 c	65.5 ab	6.3	18.3 a	2.1 d

<sup>1</sup>Means within cultivar having the same letter and without letter are not significantly different at 5% level. DMRT.

tion of coconut oil extracted from nuts of different ages varies greatly. For instance, the oil yielded from a bunch of least mature nuts or "buko malauhog," had a very high percentage of oleic (ca. 30%) and linoleic (ca. 20%) acid. The unsaturated fatty acid content decreased rapidly as the nuts mature. Coconut oil extracted from nuts of the fifth bunch, as counted from the youngest bunch, contained less than 5% and 1%, of oleic and linoleic acid, respectively. Apparently, a high concentration of these unsaturated fatty acids at the early stage of nut development is the main cause of rapid rancidity of processed "buko."

#### Processing of coco-crisps

Several trial experiments were conducted to standardize the formulation and processing conditions for Coco-crisps. Aside from nut maturity, the thickness of the slices and the drying temperature

were found to have greatly affected the crispiness and whiteness of the product. Coco-crisps slices of 0.6-0.7 mm thick were rated most acceptable in terms of crispiness as compared to those with thickness of 0.8-1.0 mm or higher (data not shown). The desired sweetness of the product was achieved with a syrup of 25% (w/v) sugar concentrate. Sugar concentrations of 40% (w/v) or higher will require the sugar-coated slices to be rinsed with water before drying to prevent clumpiness. Hence, processing operations become difficult and laborious, and may even pose as a serious problem in large scale processing.

The sweetened coconut slices dried swiftly at 60-65°C in three to five hours, depending on loading density, air circulation, and relative humidity. The dried slices, however, turned crispy only when the drying temperature was raised to 80°C for 15-30 minutes during the last phase of the drying operation. Samples subjected directly and continuously to

a temperature of 80°C throughout the drying period produced creamy-colored Coco-crisps. This was attributed to the Maillard browning reaction.

### Effect of nut maturity on the eating quality of Coco-crisps

Data on changes in physico-chemical properties of coconut meat during maturity (Table 1) were used as basis in developing Coco-crisps. Coconut endosperm obtained from nuts of different stages of maturity, were processed into Coco-crisps following the scheme shown in Figure 1.

Results of sensory evaluation indicated that the color and sweetness of the product were highly acceptable regardless of variety and age of nuts (Table 2). All, except one of the samples, retained much of

the flavor of fresh coconut meat, and remained white in color. The samples taken from eight-month old nuts of the Baybay Tall variety were slightly grayish.

As would be expected from the changes in physico-chemical properties of coconut meat, nut maturity affected significantly ( $p \leq 0.01$ ) the texture and mouthfeel (presence of *sapal*) of Coco-crisps except for Catigan and Coconiño respectively. It was observed that for all varieties tested, the products prepared from seven-month-old nuts were soft and gummy. Likewise, the samples from eight-month-old nuts of Baybay Tall and Coconiño, were not crispy, and had acceptability scores for texture of 4.2 and 5.4, respectively (Table 2). Acceptability scores, however, were higher in samples from nine-month-old nuts. It is the product from 10-month-old nuts which was rated acceptable in terms of crispiness.

Table 2. Mean sensory scores of Coco-crisps processed from nuts of different ages and cultivars.<sup>1</sup>

Cultivar	Color <sup>4</sup>	Coconut flavor <sup>4</sup>	Sweetness	Texture		Mouthfeel or presence of sapal		Overall Acceptability <sup>4</sup>
				Scale <sup>2</sup>	Acceptability scores <sup>4</sup>	Scale <sup>3</sup>	Acceptability scores <sup>4</sup>	
Baybay Tall								
8	5.2 c	7.3	6.9	1.4 d	4.2 c	3.6 a	7.3 a	5.6 c
9	7.4 ab	6.7	7.7	3.3 abc	6.4 ab	3.2 ab	7.2 ab	7.0 a
10	7.5 a	7.3	7.5	4.0 a	7.5 a	2.4 abc	5.9 abc	6.6 ab
11	7.4 ab	6.9	7.2	3.9 ab	7.2 ab	2.0 c	5.0 c	5.7 c
Catigan								
8	7.0 d	7.5 a	7.9	4.0	7.1	3.8 a	7.7 a	6.8 b
9	8.2 a	6.7 ab	8.0	4.5	8.2	3.4 a	7.3 a	7.6 a
10	7.9 ab	6.7 ab	7.4	4.6	8.1	2.0 b	4.9 b	6.1 bc
11	7.8 abc	6.2 b	7.2	4.2	7.5	1.9 b	4.7 b	5.7 c
Coconiño								
8	7.2 c	7.2	7.4	2.2 c	5.4 d	3.4	7.5	4.9 d
9	8.1 a	7.4	7.6	4.0 ab	7.7 ab	3.2	7.4	7.6 a
10	8.0 ab	7.8	7.7	4.2 a	8.0 a	2.9	6.6	7.3 ab
11	7.6 abc	7.3	7.5	3.0 c	6.4 c	2.8	6.7	6.1 c
Tacunan								
8	7.3 b	7.2	7.4	3.2 c	6.4 c	3.7 a	7.6 a	6.9
9	7.1 bc	7.2	7.8	3.7 bc	7.1 bc	3.1 ab	7.3 ab	7.4
10	6.5 d	7.4	7.6	4.4 ab	8.0 ab	2.5 bc	6.0 bc	7.2
11	8.2 a	7.2	7.6	4.7 a	8.4 a	2.2 bc	6.1 bc	7.0

<sup>1</sup>Means within cultivar having the same letter and without letter are not significantly different at 5% level, DMRT.

<sup>2</sup>Texture Scale — 5 — very crispy — 4 moderately crispy — 3 slightly crispy — 2 not crispy — 1 soft and gummy.

<sup>3</sup>Mouthfeel or Presence of "Sapal" Scale — 5 completely absent — 4 not noticeable — 3 slightly noticeable — 2 moderately noticeable — 1 very noticeable.

<sup>4</sup>Acceptability scores/overall acceptability — 9 like extremely — 8 like very much — 7 like moderately — 6 like slightly — 5 neither like nor dislike — 4 dislike slightly — 3 dislike moderately — 2 dislike very much — 1 dislike extremely.

These findings are in contrast to the acceptability scores of dried buko in del Rosario's study. Del Rosario (1984) reported that dried buko processed from young coconut meat of seven to eight months of maturity was the most acceptable product, while those from eight to nine-month-old nuts were hard and gummy.

Coco-crisps prepared from nuts at the different stages of maturity of the Catigan and Tacunan varieties were crispy. The texture of the products prepared from eight, nine, 10, and 11 month-old nuts were rated from moderately crispy to very crispy. The highest score was given to the samples from nine-month-old nuts. It was noted that products from the Catigan and Tacunan varieties had the better texture. They were also easier to cut during processing. Hence, these two varieties are preferred.

The presence of *sapa* which reflects the mouthfeel when eating Coco-crisps is one of the most important qualities of the product. A significant difference ( $p \leq 0.01$ ) in acceptability scores for mouthfeel of the product processed from nuts of different maturities was observed among the cultivars, except in Coconiño. The presence of *sapa* was noticeable with the samples from 10 and 11-month-old nuts of all varieties under study. However, Coco-crisps developed from eight and nine-month-old nuts were rated slightly to not-noticeable with acceptability scores ranging from 7.2-7.7 (Table 2).

In terms of overall acceptability, the samples taken from nine-month-old nuts of the four varieties were given the highest scores (Table 2). Apparently, nine-month-old nuts give the best quality of Coco-crisps. At this stage of maturity, the thickness of coconut meat is approaching or equal to that of the mature nut and the weight is about 80-88% of the latter (Table 3).

Preliminary acceptability tests on Coco-crisps prepared from nine-month-old nuts of Baybay Tall variety were conducted in various locations in the Visayas region. The survey revealed a very encouraging result, with 73-81% of the respondents rating "like" the product.

### Nutrient content

Coco-crisps can be considered high energy food. Chemical composition (on dry weight basis) of Coco-crisps prepared from nine-month-old nuts of Baybay Tall cultivar is as follows: 1.3% moisture, 3.1% protein, 33% fat, 2.2% ash, 10.7% neutral detergent fiber, and 35% total sugars.

### Packaging materials and stability

Increase in moisture content of Coco-crisps was observed in the samples packed in both CP and AP

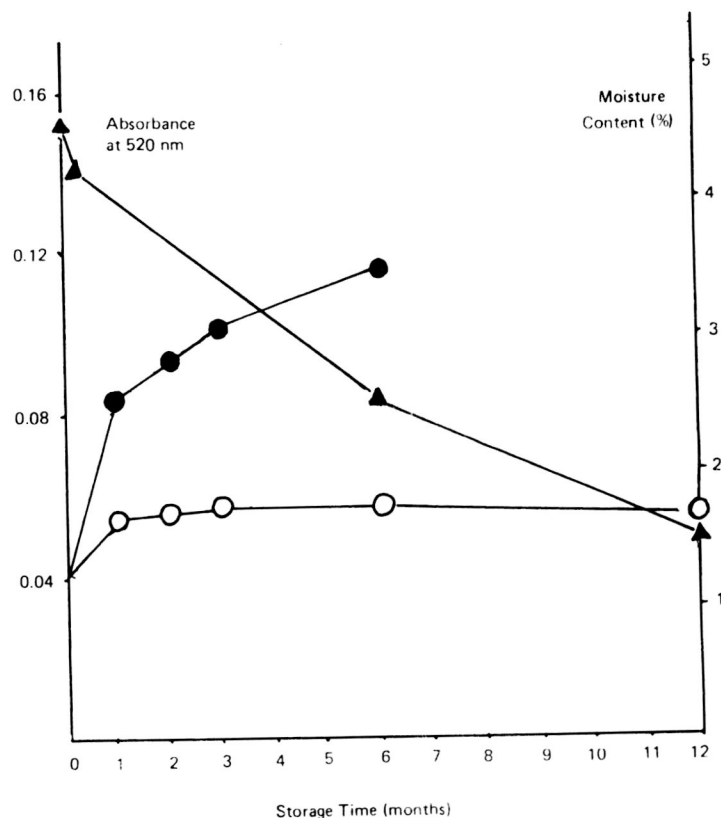


Figure 2. Changes in moisture content and color intensity of rancidity test of Coco-crisps during storage (moisture content of samples in AP bags ○—○, in CP bags ●—●; rancidity test of samples in AP bags ▲—▲).

bags, though the latter showed greater resistance to moisture uptake than the former (Fig. 2). The fast rate of moisture absorption of the samples placed in CP bags resulted to lower scores on odor, texture, mouthfeel, and overall acceptability after two months of storage (Table 4). A rancid odor due to oxidation was noticed by the panel after four months of storage. The change in odor of Coco-crisps went with the decrease in color intensity of the stored samples used in the rancidity test (Fig. 2).

On the other hand, AP bags effectively preserved the crispiness of the product. High scores on odor, mouthfeel, and overall acceptability of Coco-crisps in AP bags were obtained even after six months of storage. A sample stored for 12 months was still crispy, and described as moderately rancid. The AP bags were therefore found as the suitable packaging materials for Coco-crisps.

Lontoc et al. (1971) reported cello/aluminum foil/polyethylene bags as the most suitable packaging material for Coco-crisps. They claimed that the product packed in said material had a shelf life of about six months.

**Table 3. Some physical properties of nuts of different stages of maturity and cultivars.**

Cultivar	Coconut Meat <sup>1</sup>		Coconut Water <sup>1</sup>			
	Thickness at the middle portion of the nut (mm)	Weight with testa (g/nut)	Volume (ml/nut)	Total Soluble solid (°Brix)	Total Sugar (%)	pH
Baybay Tall						
7	3.5	296	1000	4.9	4.2	5.3
8	6.5	388	760	6.0	3.6	5.6
9	11.0	4.30	575	4.0	2.1	5.2
10	12.6	492	500	4.5	2.0	5.6
11	13.6	537	520	4.0	1.6	5.8
Catigan						
7	9.4	275	320	5.5	3.4	5.4
8	10.7	308	335	4.5	2.7	5.5
9	12.9	350	270	4.0	1.8	5.3
10	12.4	383	320	3.5	1.3	5.3
11	12.3	417	265	3.5	1.2	5.6
Coconiño						
7	4.0	108	213	6.0	5.1	5.4
8	6.5	142	161	5.0	3.8	5.4
9	6.5	138	207	4.5	3.5	5.5
10	8.2	150	135	3.5	2.5	5.6
11	9.1	167	166	3.0	2.0	5.8
Tacunan						
7	5.9	267	593	5.0	3.5	5.8
8	9.1	327	477	4.7	3.2	5.6
9	11.5	383	415	5.0	2.9	5.6
10	12.4	433	422	4.0	2.0	5.5
11	12.6	433	315	4.0	1.7	5.8

<sup>1</sup>Means of three nuts.**Table 4. Effect of storage on mean sensory scores<sup>1</sup> of Coco-crisps packed in different polyfilm bags.**

Storage time (months)	Packaging materials <sup>2</sup>	Color	Odor	Sweetness	Texture	Mouthfeel or presence of sapal	Overall Acceptability
0		7.6	7.2	6.9	7.7	7.0	7.5
2	CP	7.0	6.3	7.1	5.5	4.8	5.3
	AP	7.3	6.9	8.0	7.2	6.8	7.6
4	CP	7.3	6.1	5.7	3.8	4.8	4.3
	AP	7.5	7.1	7.5	7.8	7.0	7.6
6	CP	6.9	2.4	5.2	2.3	4.0	2.5
	AP	6.8	6.4	6.6	7.4	6.6	6.8
12	CP	—	—	—	—	—	—
	AP	6.6	4.7	6.9	7.6	5.5	5.6

<sup>1</sup>Hedonic Rating Scale of: 9 — like extremely; 8 — like very much; 7 — like moderately; 6 — like slightly; 5 — neither like nor dislike; 4 — dislike slightly; 3 — dislike moderately; 2 — dislike very much; 1 — dislike extremely.<sup>2</sup>CP — cellopolyethylene; AP — aluminum foil/polyethylene laminate.

## PROSPECTS AND RECOMMENDATIONS

In the processing of young coconut endosperm, the nuts should be harvested about two to three months before it reaches full maturity. Harvesting the nuts at this stage will result to a good quality Coco-crisps product. Moreover, there are some economic advantages going with this practice. For instance, since the coconut palm will no longer have to nutritionally support the nuts to full maturity, production per palm per year is enhanced.

Furthermore, the by-products from nine-month-old nuts which include coconut water and husk could be of high economic values. The green husk can be processed into white fiber for export as handicraft items. The coconut water can be used in making carbonated and non-carbonated beverages (Gonzales et al., 1983), and intravenous fluid (IV) to combat the diarrheal disease in the rural areas (Anzaldo et al., 1985). Interestingly, coconut water from nine-month-old nuts which are at the appropriate age of Coco-crisps processing, has a relatively high glucose content and is suitable for making into intravenous fluid. The IV fluid developed from the water of nine-month-old nuts can effectively substitute for the imported dextrose.

Integration of Coco-crisps processing with utilization of the by-products is therefore, highly recommended. Pilot production of Coco-crisps in cooperation with the food industry in both small and large scales, needs to be undertaken, to study the economic feasibility of the process, and the marketing strategies for the products.

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