

# Descriptive sensory evaluation of virgin coconut oil and refined, bleached and deodorized coconut oil

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## Abstract

Descriptive sensory analysis was conducted to describe and differentiate Philippine virgin coconut oil (VCO) and refined, bleached and deodorized (RBD) coconut oil samples. A total of 14 terms were generated by 11 trained panelists to describe the coconut oil samples. Samples were significantly different ( $P < 0.05$ ) in all attributes except for turbidity, saltiness and margarine flavor. The RBD was distinctly yellow, slightly salty, had no perceptible aromas and flavors. All VCO samples were nearly colorless, had slightly detectable acid aroma, sweet and salty tastes, and perceptible nutty aroma and flavor. Cooked coconut with sweet taste terms (*cocojam* and *latik*) were generally associated with VCO samples which were heated while rancid attributes describe the nonheated sample. *Cocojam* and *latik* attributes highly correlated ( $R^2 = 0.93$ ) using principal component analysis, thus maybe considered redundant terms. Acid and rancid aromas were likewise highly correlated ( $R^2 = 0.90$ ) as the acidic notes perceived may contribute to the overall rancid characteristics of the coconut oil samples.

*Keywords:* Sensory profile; Virgin coconut oil; Refined; Bleached and deodorized coconut oil

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## 1. Introduction

The Philippines is the world's major supplier of coconut oil delivering 57.1% of the total exported trade (Hamm & Hamilton, 2000). In 2004, a total of 227, 243 MT of refined, bleached and deodorized (RBD) coconut oil was exported, mainly to North and South America (Bureau of Export Trade and Promotions (BETP), 2004). Coconut oil belongs to a group of vegetable oils abundant in lauric acid (Hui, 1996). German and Dillard (2004) cited the virtues of lauric acid of having antiviral, antibacterial, anticaries, antiplaque and antiprotozoal functions. Nolasco, Balboa, Serame, and Lim-Sylianico (1994) found that coconut oil, trilaurin and tripalmitin inhibited the promotion stage of carcinogenesis. A study by de Roos, Schouten, and Katan (2001) showed that consumption of solid fat rich in lauric acids resulted in a more favorable serum lipid profile in healthy men and women than with solid fat containing

*trans* fatty acids. Dayrit (1997) enumerated the medicinal values of coconut oil itself while Lim-Sylianico et al. (1991) reported that the antigenotoxic activity of dietary coconut oil surpassed that of dietary soybean oil.

An emerging product of importance from coconut, both in the local and foreign market, is the virgin coconut oil (VCO) (Corpuz, 2004). The Philippine National Standards or PNS (Bureau of Product Standards (BPS), 2004) defines VCO as the oil obtained from the fresh, mature kernel of the coconut by mechanical or natural means, with or without the use of heat, without undergoing chemical refining, bleaching or deodorizing, and which does not lead to the alteration of the nature of the oil. Aside from lauric acid, VCO contains a considerable amount of short-chain fatty acids such as capric, caproic and caprylic which were also investigated to have antimicrobial and antiviral effects (Bergsson, Arnfinnsson, Karlsson, Steingri'Msson, & Thormar, 1998; German & Dillard, 2004; Van Immerseel et al., 2004). VCO has been claimed to have numerous beneficial health effects (Delmo, 2004; Villariba, 2003, 2004). Nevin and Rajamohan (2004) reported that VCO

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lowered total cholesterol, triglycerides, phospholipids, LDL, and VLDL cholesterol levels and increased HDL cholesterol in serum and tissues. They also found out that the polyphenol fraction of VCO was capable of preventing in vitro LDL oxidation with reduced carbonyl formation.

The PNS (BPS, 2004) describes VCO as colorless, with natural coconut scent and free from rancid flavor and odors. The sensory profile of VCO needs to be defined to fully differentiate it from RBD and qualify existing VCO products in the market. Descriptive sensory analysis is useful in the determination of a detailed specification of the sensory attributes of a single product or a comparison among several products. It can indicate how one product differs from another in terms of sensory attributes. (Lawless & Heymann, 1999).

No existing scientific records or data are available to completely characterize Philippine VCO and differentiate it from the RBD or “copra” coconut oil. The information on the sensory profile of VCO could facilitate other useful studies that would help draw a picture of what makes the VCO unique from the RBD coconut oil.

The sensory profile can also lead to classification of VCO samples into different grades (e.g. extra, ordinary) just like what is currently being done in virgin olive oils (International Olive Oil Council (IOOC), 1996). This will add value to products which are of high quality and thus make the market competitive with corresponding economic implications. Moreover, sensory evaluation can authenticate the processes claimed by the different manufacturers. There are several types of processes being applied to produce VCO (Bawalan, 2002). The profile may also eliminate fraudulent or erroneously labeled samples. This study will help revise the Philippine National Standards on VCO, thus ultimately protect the Philippine VCO industry.

The objective of this study was to describe the sensory characteristics of Philippine VCO samples and differentiate it from RBD coconut oil. Specifically, it aimed to compare the sensory profile of VCO samples from different processes, as well as with that of RBD samples.

## 2. Materials and methods

### 2.1. Samples

Samples including four commercial VCO and one RBD coconut oil sample were subjected to descriptive sensory analysis. The RBD sample was purchased from a local grocery store and the VCO samples were provided by various local manufacturers. VCO samples used were produced using fermentation (F), fermentation with heat (FH1 and FH2), and centrifugation with heat (CH) processes.

The RBD sample was locally manufactured and one of the leading commercial brands of RBD coconut oil. Only one commercial RBD sample was utilized as the process for this type of coconut oil has long been established and standardized in the Philippines and was assumed to represent the general description for such types of oil.

Sample F was manufactured using fermented coconut milk and coconut water. After fermentation, the collected oil was aged for several weeks before packaging. Sample FH1 was also prepared by fermenting coconut milk and coconut water but the resulting oil was heated without the aging process. Manufacturers of sample FH2 applied the same fermentation treatments used in FH1. The separated oil was likewise heated but was aged for several weeks prior to packaging. Producers of sample CH primarily used centrifugation to separate the oil from coconut milk, and vacuum evaporation to dry the oil.

Samples evaluated were according to the manufacturer's specifications. Samples differ in manufacturing date, packaging type and size but were obtained within the same week. The stability properties of the oil samples were not known and were not controlled in the study. All samples were stored at room temperature ( $30 \pm 2^\circ\text{C}$ ) at a cool, dry and dark place.

### 2.2. Experimental design

A randomized complete block design was used in this study. A total of 5 samples with 5 replicates were evaluated by the panelists.

### 2.3. Sensory evaluation

#### 2.3.1. Panelists

A total of 11 trained panelists (9 female and 2 males) ages 21 to 58-year old, participated in the tests. The panelists were recruited on the basis of their previous experience in descriptive sensory analysis, interest, availability and consumption of coconut oil at least once a week. All panelists were staff and students of the College of Home Economics, University of the Philippines Diliman, Quezon City.

#### 2.3.2. Training

The panelists were trained and samples were evaluated using the generic descriptive method (Lawless & Heymann, 1999), a combination of quantitative descriptive method (Tragon Corp., Redwood City, CA, USA and Spectrum™ Analysis Method (Sensory Spectrum Inc., Chatam, NJ, USA). A total of 18 h was spent for training and evaluation of 5 replicates of the samples.

During the 1st day of training each panelist received coconut oil samples and generated perceivable product attributes in RBD and VCO samples. Panelists identified appearance, aroma, taste and flavor attributes to be used in describing the oil samples. The panel decided whether descriptors were redundant and should be removed from the list or if there were terms that should be added. The final list of terms was written and the panelists defined each attribute (Table 1). Panelists also identified possible reference standards from which the rating of the generated attributes will be based on.

Table 1  
Definitions of attributes used by the trained panel to describe virgin and refined, bleached and deodorized coconut oils

Attribute	Definition
<i>Appearance</i>	
Yellow color	The intensity of yellow color from colorless to dark yellow
Turbidity	The appearance associated with turbidity of the oil samples
<i>Aroma</i>	
Acid	The aroma associated with acetic acid solutions
Cocojam	The aroma associated with sweetish burnt/roasted coconut
Latik	The aroma associated with cooked sweet coagulated coconut milk
Nutty	The aroma associated with the 2nd layer of fresh coconut kernel with testa
Rancid	The aroma associated with old stored oil
<i>Taste</i>	
Sweet	Taste on the tongue associated with sucrose solutions
Salty	Taste on the tongue associated with sodium chloride solutions
<i>Flavor</i>	
Cocojam	The flavor associated with sweetish burnt/roasted coconut
Latik	The flavor associated with cooked sweet coagulated coconut milk
Margarine	The flavor associated with margarine
Nutty	The flavor associated with the 2nd layer of fresh coconut kernel with testa
Rancid	The flavor associated with old stored oil

On the 2nd day of training, panelists reviewed the attribute terms and definition of each term. The identified references were presented to each panelist. Each panelist rated the intensity of the references from 0 to 150 for each attribute (Table 2). The

whole panel was calibrated by obtaining the mean rating. Panelists whose rating was not within the  $\pm 10$  points of the mean rating were asked to re-evaluate the references and adjust their rating until a consensus was reached. Panelists were considered calibrated if the standard deviation of the scores is within 10 points of the mean rating. The consensus mean intensity rating was assigned as the attribute intensity rating for that specific reference standard.

On the 3rd day of training, the panelists finalized the descriptors, and defined each term and reference standards to be used in rating the samples. Techniques of evaluation of the oil samples were also finalized. A VCO sample was presented as a warm-up sample to be used as the initial sample during training and evaluation sessions (Plemmons & Resurreccion, 1998). The mean rating for the VCO warm-up sample was obtained. The panel was again calibrated by asking those panelists whose rating was not within the  $\pm 10$  points to re-evaluate the references and adjust their rating until a consensus was reached. After

calibration all 5 samples were presented to the panelists for evaluation. The panelists rated the samples using paper ballots with 150 mm line scale. On the last day of training, calibration of the panelists continued with a VCO warm-up sample and the 5 coconut oil samples.

#### 2.4. Sample evaluation

A total of 15 ml samples were presented in 6 in test tubes (Pyrex, USA) with screw cap, coded with 3 digit random numbers, and maintained at room temperature ( $30 \pm 2$  °C). Samples consisting of 4 VCO and 1 RBD samples were presented to the panelists in a balanced random and monadic order. Samples were presented with a glass of warm water, spit cup for expectoration, paper napkin and palate cleansers (white bread and apple slices) on a white plastic tray. Panelists evaluated 5 samples per d using a paper ballot with 150 mm line scale in individual booths illuminated with artificial daylight.

#### 2.5. Statistical analysis

Means and standard deviations were calculated to analyse sample attributes and panel performance. One-way ANOVA ( $P < 0.5$ ) across all attributes was used to analyse performance of the individual panelists. General linear model ( $P < 0.05$ ) was used to analyse the differences among the samples. Duncan's multiple range test (DMRT) was applied to determine sample differences. Principal component analyses (PCA) were executed on the correlation matrices generated by using the mean values per replicate across generated attributes of the coconut oil samples. PCA was performed to group attributes into principal components to determine redundancies that are present in the attribute list. Furthermore, the factor analysis routine was accomplished to determine what variables loaded on what factors and thus the patterns of correlation. The principal components were Varimax rotated. All statistical analyses were done using SAS Enterprise Guide Version 2.0 (S.A.S. Institute, 2002).

### 3. Results and discussion

#### 3.1. Sensory profile

Data from only 8 panelists were considered after eliminating those who cannot discriminate according to one-way ANOVA ( $P < 0.5$ ). Results indicate that samples significantly differ in most of the attributes except for turbidity, saltiness and margarine flavor. Table 3 presents the mean descriptive ratings of significant attributes in VCO and RBD coconut oil samples.

##### 3.1.1. Color

Evaluation of the samples reveals that RBD significantly differ in color having a distinct yellow color while all VCO samples were almost colorless. Ratings on color

Table 2

Standard reference intensity ratings used in the descriptive sensory analysis of virgin and refined, bleached and deodorized coconut oils

Attribute	Reference standards	Intensity <sup>a</sup>
<i>Appearance</i>		
Yellow color	Distilled water (Inom, Quezon City, Phils.)	0
	Yellow food color (McCormick, Sysu, Q.C. Phils.) solutions:	
	0.1 ml/l	50
Turbidity	0.25 ml/l	150
	Distilled water (Inom, Quezon City, Phils.)	0
	Cornstarch (Liwayway Mktg., Quezon City, Phils.) solutions:	
	0.005 g/100 ml	70
	0.01 g/100 ml	150
<i>Aroma</i>		
Acid	Glacial acetic acid solutions:	
	1.0 ml/l	30
	5.0 ml/l	65
	10.0 ml/l	150
<i>Cocojam</i>	<i>Cocojam (Ludy's, Pasay City, Phils.)</i>	75
<i>Latik</i>	Homemade <i>latik</i> <sup>b</sup>	110
Nutty	Second layer fresh coconut kernel with testa cubes	45
Rancid	Rancid coconut oil (Carica, Quezon Province, Phils.)	90
<i>Taste</i>		
Sweet	Sucrose solutions:	
	2 g/100 ml	20
	5 g/100 ml	50
Salty	Sodium chloride solutions:	
	0.2 g/100 ml	25
	0.35 g/100 ml	50
<i>Flavor</i>		
<i>Cocojam</i>	<i>Cocojam (Ludys, Pasay City, Phils.)</i>	60
<i>Latik</i>	Homemade <i>latik</i> <sup>b</sup>	75
Margarine	Margarine (Butterfresh, Pasig City, Phils.)	40
Nutty	Second layer fresh coconut kernel with testa cubes	45
Rancid	Rancid coconut oil (Carica, Quezon Province, Phils.)	60

<sup>a</sup>Intensity ratings are based on 150 mm unstructured line scales.<sup>b</sup>In total, 2.8 kg coconut milk was boiled for 2 h and 10 min in an aluminum pan until it coagulated and turned brown.

demonstrated that the application of heat may affect the color of the samples. RBD underwent severe mechanical, chemical and heat treatment (Belitz & Grosch, 1987; PCARRD-DOST, 1993). FH samples received the highest color scores among the VCO samples.

### 3.1.2. Aroma

The RBD sample had no perceptible aroma while the VCO samples were described to have an acid, *cocojam*, *latik*, nutty and rancid aromas which differed among samples. The differences in the aroma ratings among VCO samples may be attributed to the processes applied. CH had the lowest acid aroma rating amongst all VCO samples while F, FH1 and FH2 were described to have slightly perceptible acid aroma. The acid aroma may be attributed to the acetic acid produced during the fermentation process.

Samples produced using fermentation and heat treatment (FH1 and FH2) and centrifugation with heat (CH), were rated to have significantly detectable *cocojam* and *latik* aroma. *Cocojam* is the aroma associated with that of

roasted coconut with slight sweet sensation while *latik* refers to cooked coconut with perceived sweet sensation. These descriptors are both associated with heating, thus ratings for these attributes were significantly ( $P < 0.05$ ) higher in heated samples (FH1, FH2 and CH) than nonheated heated samples (F).

On the other hand, the F sample was described to have more of the rancid aroma. Since no heat was applied to this sample, it is expected that the initial moisture content and microflora of the sample may be high which may facilitate hydrolytic rancidity. Hydrolytic rancidity often referred as "soapy rancidity" is a problem mainly encountered in lauric products and caused by a combination of moisture and microorganisms (Allen & Hamilton, 1983). The lipases released by the microorganisms catalyse the action of moisture to hydrolyse the triglycerides (Freeland-Graves & Peckham, 1996). Hydrolysis liberates the free fatty acids from the parent oil and thus releasing the free fatty acids that are responsible for the rancid aroma.

Another possible explanation of the rancid aroma in the nonheated VCO sample was that the microorganisms

present in the sample degraded the oil to methyl ketones. Methyl ketones provide undesirable odors noted as “perfume rancidity” (Belitz & Grosch, 1987). The presence

of moisture aggravated the release of free C<sub>8</sub>–C<sub>12</sub> fatty acids and their partial degradation to methyl ketones (Belitz & Grosch, 1987).

Table 3  
Mean<sup>a</sup> descriptive scores of virgin and refined, bleached and deodorized coconut oils

Attributes	FH 1	FH 2	F	CH	RBD
<i>Appearance</i>					
Color	11.45 ± 1.32 <sup>b</sup>	9.02 ± 1.12 <sup>bc</sup>	7.95 ± 0.95 <sup>bc</sup>	4.82 ± 0.89 <sup>c</sup>	53.68 ± 3.66 <sup>a</sup>
<i>Aroma</i>					
Acid aroma	13.66 ± 1.25 <sup>a</sup>	15.28 ± 1.06 <sup>a</sup>	15.82 ± 1.30 <sup>a</sup>	10.12 ± 1.21 <sup>b</sup>	3.30 ± 0.76 <sup>c</sup>
Cocojam aroma	24.20 ± 1.77 <sup>a</sup>	23.62 ± 1.55 <sup>a</sup>	16.32 ± 1.30 <sup>b</sup>	21.70 ± 1.74 <sup>a</sup>	3.48 ± 0.91 <sup>c</sup>
Latik aroma	37.95 ± 3.45 <sup>a</sup>	28.35 ± 1.66 <sup>b</sup>	19.40 ± 1.39 <sup>c</sup>	30.15 ± 1.81 <sup>+</sup>	4.75 ± 1.05 <sup>d</sup>
Nutty aroma	20.62 ± 2.84 <sup>a</sup>	18.05 ± 1.48 <sup>ab</sup>	15.25 ± 1.14 <sup>b</sup>	16.85 ± 1.50 <sup>ab</sup>	4.18 ± 0.87 <sup>c</sup>
Rancid aroma	28.78 ± 2.68 <sup>b</sup>	35.70 ± 3.18 <sup>a</sup>	40.35 ± 2.57 <sup>a</sup>	22.48 ± 1.75 <sup>b</sup>	4.25 ± 0.83 <sup>c</sup>
<i>Taste</i>					
Sweet	16.20 ± 1.05 <sup>a</sup>	15.10 ± 0.94 <sup>a</sup>	14.10 ± 1.06 <sup>a</sup>	16.28 ± 0.97 <sup>a</sup>	7.82 ± 1.09 <sup>b</sup>
<i>Flavor</i>					
Cocojam flavor	21.58 ± 1.67 <sup>a</sup>	20.42 ± 1.18 <sup>a</sup>	16.50 ± 1.47 <sup>b</sup>	21.22 ± 1.40 <sup>a</sup>	7.05 ± 1.03 <sup>c</sup>
Latik flavor	28.32 ± 1.93 <sup>a</sup>	23.38 ± 1.40 <sup>bc</sup>	19.58 ± 1.57 <sup>c</sup>	25.60 ± 1.73 <sup>ab</sup>	10.85 ± 1.55 <sup>d</sup>
Nutty flavor	18.88 ± 2.17 <sup>a</sup>	16.28 ± 1.09 <sup>a</sup>	16.50 ± 1.34 <sup>a</sup>	18.88 ± 1.21 <sup>a</sup>	10.40 ± 1.74 <sup>b</sup>
Rancid flavor	23.70 ± 1.62 <sup>c</sup>	28.50 ± 1.77 <sup>b</sup>	33.12 ± 1.89 <sup>a</sup>	18.80 ± 1.28 <sup>d</sup>	9.30 ± 0.90 <sup>c</sup>

<sup>a</sup>Means within the same row not followed by the same letter are significantly different ( $P < 0.05$ ) as determined by DMRT.

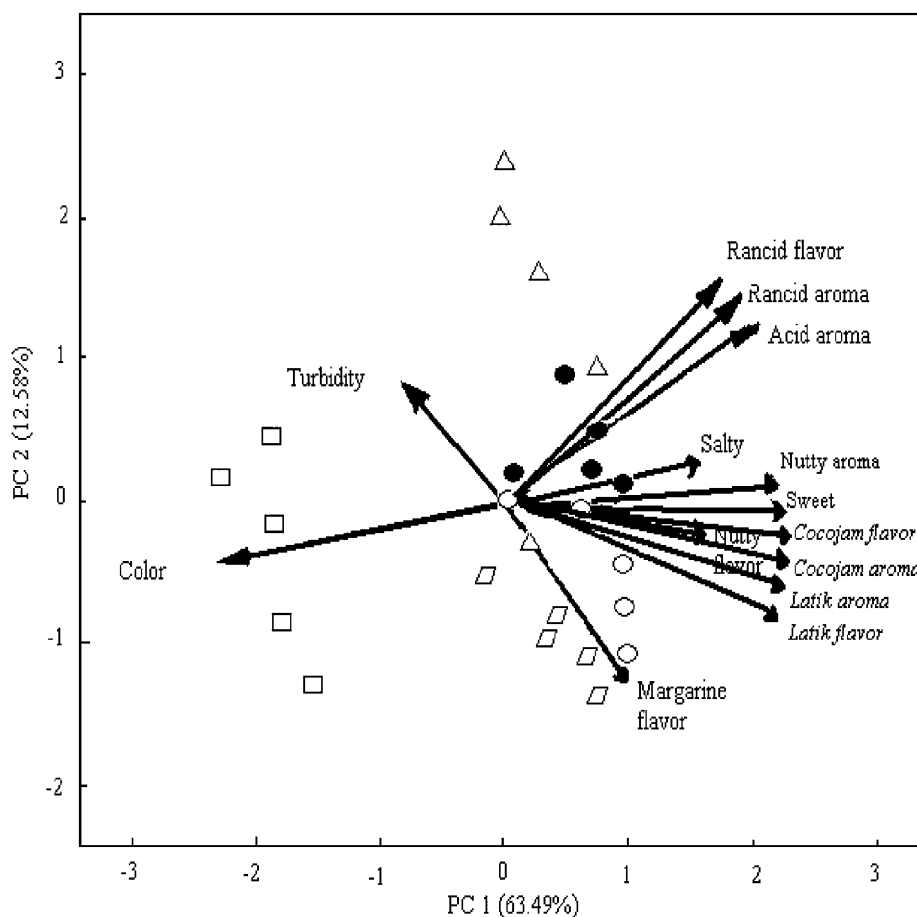


Fig. 1. Principal component analysis (PC 1 and 2) of the mean ratings by replicates of the coconut oil samples for 14 attributes. The attribute vectors and the 5 coconut oil samples with their codes, that is, RBD (□), F(△), FH1 (○), FH2 (●), and CH(◇) are plotted.

### 3.1.3. Taste and flavor

RBD had a slight salty taste with no perceivable flavor while all VCO samples had detectable sweet taste and nutty flavor. Heat treated samples (FH1, FH2 and CH) were found to have significantly ( $P < 0.05$ ) more intense *cocojam* and *latik* flavor than that of F. Inversely, the F sample was distinctly more rancid than FH1, FH2 and CH. These results logically follow the observations made in the corresponding aroma attributes.

### 3.2. Correlation and redundancy of terms

PCA was done for the mean ratings per replicate of each coconut oil sample across the 14 attributes. The first 2 PCs had Eigenvalues greater than 1 and accounted for 76.07% of the total variability (63.49% and 12.58%, respectively) as presented in Fig. 1. The 2 significant PCs were subjected to Varimax rotation to bring them into closer alignment with the original variables. Table 4 shows the Varimax rotated factor loadings and loadings with an absolute value greater than 0.70 represent a strong influence.

It can be deduced from the PCA plot and factor loadings that PC1 is heavily influenced by the coconut with sweet aromatics characteristics. On the other hand, PC2 is almost entirely related to the color, rancid and acid attributes. From the PCA plot the VCO samples are divided into the two significant principal components. The heated samples concentrated on PC1 while the nonheated samples on PC2 specifically for rancid and acid attributes. The RBD sample was mainly differentiated by its color attribute.

The correlation matrix showed that some attributes with related definitions in the lexicon were highly correlated: *cocojam* and *latik* aromas and flavors ( $R^2 = 0.93$ ); nutty and *cocojam* attributes ( $R^2 = 0.75-0.85$ ); nutty and *latik* attributes ( $R^2 = 0.74-0.86$ ); and acid and rancid aromas ( $R^2 = 0.90$ ).

Table 4  
Varimax rotated principal component factor loadings<sup>a</sup> for the sensory attributes of virgin coconut oil and refined, bleached and deodorized coconut oil samples

Sensory attributes	PC1	PC2
Color	-0.601	<b>-0.754</b>
Turbidity	-0.270	-0.136
Acidity	0.325	<b>0.866</b>
Cocojam aroma	<b>0.837</b>	0.465
Latik aroma	<b>0.937</b>	0.276
Nutty aroma	<b>0.743</b>	0.525
Rancid aroma	0.205	<b>0.949</b>
Sweet	0.725	0.564
Salty	0.322	0.411
Cocojam flavor	<b>0.842</b>	0.396
Latik flavor	<b>0.908</b>	0.291
Margarine flavor	0.541	-0.048
Nutty flavor	<b>0.708</b>	0.407
Rancid flavor	0.116	<b>0.944</b>

<sup>a</sup>Loadings with an absolute value greater than 0.70 are shown in bold type.

Owing to the linearity of the definition and ratings for *cocojam* and *latik* attributes the statistical results revealed that these terms were redundant and may be consolidated to simplify the sensory profile of the coconut oil samples. On the other hand, the high correlation between nutty, and both the *cocojam* and *latik* attributes may be ascribed to the coconut notes that were detected in the samples.

Acid and rancid aromas' high correlation indicates that the acidic note perceived by the panelists may be the similar notes observed when evaluating the rancid aroma. This may reflect that the acid aroma is a contributing factor in the rancid aroma perceived in the samples. It can be noted from Table 3 that the acid mean ratings generated for all samples were only slightly perceptible. However, panelists were able to significantly detect the overall rancid aroma characteristics specifically in fermented samples.

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