Annals of Agri-Bio Research **26** (1) : 85-89, 2021

Analysis of Proximate and Mechanical Characteristics of Nata de Coco of Three Types Coconut Fermentation Media

ANDASURYANI, ANWAR KASIM AND VIONI DEROSYA*

Department of Agroindustrial Technology, Faculty of Agricultural Technology, Andalas University, Kampus Unand Limau Manis 25613 (Padang), Indonesia
(e-mail : vderosya@ae.unand.ac.id; Contact : +62 85263872463)

(Received : July 17, 2020; Accepted : September 10, 2020)

ABSTRACT

In order to produce nata optimally, it is required a suitable media fermentation for *Acetobacter xylinum*. The media should supply sugar as carbon resources, nitrogen through urea or ZA addition, vitamins and mineral, citric acid or acetic acid for acidic environment. Nata de coco was generally produced using coconut water. On the other hand, coconut milk and skim were alternatives for fermentation media. The objectives of this study were to determine nutrition content of coconut water, milk, and skim as fermentation media and also mechanical characteristic of nata de coco from those three media. Proximate analysis was water, ash, protein, fiber, fat, saccharose and carbohydrate (by difference), while mechanical characteristics were water holding capacity, tensile strength, elongation to break and Young's modulus. From proximate analysis, it showed that coconut milk and skim were possible for nata de coco fermentation but they had less condition compared to coconut water. Further, nata de coco from milk and skim had lower value of mechanical characteristic (tensile strength, Young's modulus, elongation to break and water holding capacity) compared to those from coconut water.

Key words : Skim coconut milk, mechanical characteristics, nata de coco, proximate analysis

INTRODUCTION

Fruit is the important part of coconut (*Cocos nucifera* L.) and has a high economic value. It consists of edible parts which are endosperm (white meat) and water (aqueous part inside fruit) covered by hard shell part (Velasco *et al.*, 2014). As explained by Angeles *et al.* (2018), coconut endosperm is the main product of coconut that includes liquid and solid or meat and its by-product. Coconut meat in Indonesia, based on Ngampeerapong and Chavasit (2019), contains 52.55% moisture, 3.31% protein, 27.69% fat and 0.99% ash.

Further, coconut meat is the basic material to produce coconut milk, coconut oil and VCO (Virgin Coconut Oil). Coconut milk is extracted by grating and pressing or squuezing coconut meat. Coconut milk then will be used in cuisine or continued to obtain coconut oil and virgin coconut oil (VCO) as stated by Patil and Benjakul (2018).

Another product by processing coconut meat is colpra obtained from sun-drying or using low temperature drying. Boemeke *et al.* (2015) explained that copra was pressed to extract coconut oil followed by bleached and deodorized. Coconut oil consists of more than 95% fat, while scraped coconut has 34% of oil and coconut milk has 24%.

Oil can be extracted from fresh and mature kernel of coconut, named, VCO. Mansor *et al.* (2012) described that VCO could be extracted mechanically or naturally by using heat or not (as long no alteration or transformation occurred). VCO is another processed product of coconut milk that largely utilized as healthy product and cosmetic. During production process, coconut milk would be separated into cream, skim and precipitate. Then, cream of coconut milk is processed into high oil content VCO, while its skim becomes a waste in spite of its high protein content. Skim coconut milk is coconut milk with less than 3.75% of fat content as explained by the Codex Standard for Aqueous Coconut Products. Separating coconut cream, low fat coconut milk and insoluble protein can be also conducted by centrifugation as explained by Khuenpet *et al.* (2016).

Coconut water is consumed as beverages and has a potential for rehydration and sport drink with well-balanced sugar content and isotonic mineral (Prades *et al.*, 2012). As explained by Rao and Najam (2016), coconut water composition is varying depending on fruit maturity level.

Nata de coco is bacterial cellulose from the fermentation *Acetobacter aceti* subspecies xylinum in acidic sugary medium. Nata de coco is traditionally consumed as desserts, while there is also development of new recipes for using nata de coco in various dishes and food product. Despite using only for culinary, nata de coco as bacterial cellulose has a great potency for medicine and pharmacy as stated by Nugroho and Aji (2015). Suitable media is a requirement for growing and living of *Acetobacter xylinum* in nata production. Fermentation media supply important components such as sugar as carbon resources, nitrogen by adding ZA or urea, mineral and vitamins for supporting bacteria growth, and citric acid or acetic acid for acid environment in order to optimize nata production. Thus, coconut water is largely used as main media for nata de coco production (Pa'e *et al.*, 2014). However, Andasuryani *et al.* (2017) explained that coconut milk and coconut skim could be alternatives for nata de coco media. Thus, this study was conducted to obtain information about proximate components of three fermentation media (coconut water, milk and skim) and mechanical characteristics of nata de coco from those three different media.

MATERIALS AND METHODS

Mature coconut fruit obtained from local market in Padang was extracted to get water, milk and skim. For fermentation, sugar, urea, glacial acetic acid (Merk) and *Acetobacter xylinum* were purchased from PT. Cocomas Nata de Coco Factory. The endosperm of coconut was shredded and compressed to get coconut milk. Fresh coconut milk and skim were obtained after 2 h precipitation and directly used for fermentation, while coconut water was put in storage for three days in order to increase its acidity and yield. Further, distilled water was added to fresh coconut milk to obtain similar fat content to coconut water. The proximate analysis (water, fiber, ash, fats, proteins and carbohydrate by difference) of coconut water, coconut milk and skim was determined. The moisture and ash were computed using weight difference method. Fiber content was determined from the loss in weight of the crucible and its content on ignition. Carbohydrate was analyzed by summing of the percentage of moisture, ash, protein either extracts and fiber was subtracted from 100. The nitrogen value as protein precursor from a substance was analyzed by micro Kjeldahl method as described by Nielsen (2014) involving sample digestions, neutraliaztion followed by distillation, and titration. All the proximate values were reported in percentage based on AOAC.

The mineral concentrations of Zn, Cu, Mn, Fe, Al, Na, Mg, Ca and K of coconut water, coconut milk and skim were conducted using Atomic Absorption Spectrophotometric Method (SNI 6989.4 : 2009). The results were obtained while using a working standard of 1000 ppm for each of the species.

Mechanical properties of nata from three different media were conducted. The tensile strength and elongation at break were measured by Com95T Test System (Comten Industries, Florida) and calculated (Chang and Chen, 2016) as :

$$\text{Tensile strength (kPa)} = F/A$$

$$\text{Elongation at break (\%)} = 100 \times \Delta L/L$$

Where, F and A represented the maximum force (N) to break samples and area (m^2) of sample, while ΔL and L represented the elongation (mm) and original length (50 mm) of sample. Then, Young's Modulus was defined by comparing tensile strength to elongation to break of samples.

RESULTS AND DISCUSSION

In this research, proximate and mineral of coconut water, skim and milk were observed, while mechanical properties were observed nata from coconut water, skim and milk. The suitability of skim and milk for nata production was checked through proximate and mineral given in Table 1 and mechanical properties of nata from coconut water, skim and milk are given in Table 2.

During nata de coco making process, it was required fermentation media with nutrition and mineral for a proper growth of *Acetobacter xylinum.* Moreover, an adequate amount of sugar is preferable for fermentation media. Thus, proximate analysis was conducted to get information about nutrition. Proximate analysis explained the quantity of water, ash, protein, fiber, fat, saccharose, total solid, and carbohydrate (by difference), while micro nutrient (mineral) analysis was also conducted

Table 1. Proximate and mineral components of three different nata de coco media

Characteristics	WCN	CMN	SMN
Chemical components			
Water (%)	96.77	87.51	99.64
Ash (%)	0.45	0.34	0.36
Protein (%)	0.024	0.543	0.051
Fiber (%)	3.23	12.41	2.73
Fat (%)	0.45	6.98	1.15
Saccharose (%)	0.45	0.15	0.15
Carbohydrate (by difference) (%)	2.43	5.28	1.26
Mineral			
Mo (mg/l)	0.031	0.031	0.016
Zn (mg/l)	0.035	0.044	0.018
Cu (mg/l)	0.488	0.048	0.071
Mn (mg/l)	0.224	0.020	0.041
Fe (mg/l)	0.610	0.134	0.207
Al (mg/l)	0.238	0.083	0.107
Mg (mg/l)	1.176	1.382	1.941
Ca (mg/l)	1.180	1.420	1.640
K (mg/l)	2.250	2.396	2.167

on coconut water, skim and milk to obtain information about those contents as shown in Table 1.

Water content is an important analysis since water becomes the main component in food product. Mansor *et al.* (2012) stated that water content could cause oxidation and rancidity in food product with fat content. It can be found in this study as shown in Table 1 that coconut water had 96.77% of water content which was nearly to Othaman *et al.* (2014) study who reported that water content of coconut water was 95.97%. On the other hand, 87.51% of water content was detected in coconut milk which was higher than Widjajaseputra and Widyastuti (2017) who analyzed 54, 52 and 49.58% of water content. In coconut skim, 99.64% of water content was observed. The higher water component in this study might be related to water addition during coconut milk extraction.

Ash remained inorganic compound after organic combustion as per Nielsen (2014). The results were 0.45% for coconut water which was highest compared to those of coconut milk (0.34%) and skim (0.36%). In similar studies, Prades *et al.* (2012) and Andasuryani *et al.* (2017) noted that ash of coconut water was 0.43 and 0.47%. Further, Widjajaseputra and Widyastuti (2017) reported that ash component in coconut milk was 0.55%. Higher ash content meant high component of inorganic components such as mineral (Nielsen, 2014). Thus, coconut water with the highest ash content had the highest inorganic compound among these three media which was 6.232 mg/l, while coconut milk was 5.558 mg/l and skim was 6.208 mg/l.

The major component of a cell is protein that consists of mainly nitrogen, hydrogen, carbon, oxygen and sulfur (Nielsen, 2014). From proximate analysis shown in Table 1, it can be calculated that protein in coconut water was 0.024%, while Prades *et al.* (2012) and Andasuryani *et al.* (2017) found 0.25 and 0.51% of protein in their coconut water. Further, coconut milk had 0.543% protein which was lower compared to those of Widjajaseputra and Widyastuti (2017) which was 4.33% and it was 2.14-2.97 as noted by Tetrapak (2019). Lower protein content of coconut water, milk and skim in this study is the result of coconut variety and growth environment.

Coconut milk was enriched with albumin, globulin, prolamin and glutein as explained by Alyaqoubi *et al.* (2015). Protein in coconut milk was highest from those three fermentation media. Patil and Benjakul (2018) observed protein in coconut milk at differennt stages of maturity was between 2.90-3.35%.

Fiber was analyzed from those three fermentation media. As the result, coconut milk had the highest crude fiber content (12.41%). It might be related to the result of fiber component on coconut flesh. Then, it was 3.23% of fiber found on coconut water and 2.73% on skim as shown in Table 1.

There were 0.45, 6.98 and 1.15% of fat for coconut water, coconut milk and skim. Higher fat content on coconut milk compared to those in coconut water and skim was related to utilization of coconut flesh in producing coconut milk. Othaman *et al.* (2014) and Andasuryani *et al.* (2017) reported that coconut water contained 0.06 and 0.15% of fat, while Widjajaseputra and Widyastuti (2017) found that coconut milk had 24% of fat.

Based on Nielsen (2014), carbohydrate was an important component in food as major source of energy, affected texture properties and as dietary fiber that is related to physiological process. This study also studied carbohydrate (by difference) on three different media that coconut milk had 5.28% carbohydrate (by difference), while coconut milk and skim contained 2.43 and 1.26% of carbohydrate (by difference). Sucrose calculated in coconut milk (0.15%) and skim (0.15%) was lower than those in milk (0.45%). Sucrose compound in

Table 2. Mechanical characteristics of nata de coco

S. No.	Parameters	WCN	CMN	SMN
1.	Water content (%)	95.92 ±0.03	95.80±0.05	96.20±0.13
2.	Water holding capacity (%)	61.08±6.77	55.67±7.67	53.33±2.59
3.	Tensile strength (MPa)	57.32±5.46	25.10±5.2	27.12±5.40
4.	Elongation break (%)	4.17±1.36	3.20±0.59	2.75±0.35
5.	Young's modulus (MPa)	1374.58	784.38	986.18

coconut water was main component as explained by Prades *et al.* (2012).

The mechanical characteristics of nata de coco from three fermentation media are shown in Table 2 including water content, water holding capacity, tensile strength, elongation to break and Young's Modulus. Nata from these three different media were named as water coconut nata (WCN), coconut milk nata (CMN), and skim milk nata (SMN). The results are the average of three replications with standard deviation. Water content of WCN, CMN and SMN was more than 90% which was in agreement with that of Pa'e *et al.* (2014) who reported 98-99% water content of nata de coco. Tensile strength was observed to obtain information related to the amount of force exerted on sample. It was found that WCN had the highest tensile strength and Young's modulus which were 57.32±5.46 MPa and 1374.58 MPa followed by SMN with tensile strength was 27.12±5.40 MPa and Young's modulus was 986.18 MPa. Then, CMN indicated the smallest for tensile strength and Young's modulus which was 25.10±5.2 MPa and 784.38 MPa. Rigidity level of nata de coco was defined from Young's modulus where the higher Young's modulus meant the more rigid bacterial cellulose. Tensile strength was related to SEM structure since a larger surface area as the result of intertwined string covering pores weakened the samples (P=F/A) (Pa'e *et al.*, 2014). Andasuryani *et al.* (2017) reported that cellulose ribbon of nata de coco WCN, SMN and CMN was 0.45 to 1.19, 0.92 to 1.20 and 0.47 to 1.23 μm.

In elongation to break tests, WCN had the highest amount (4.17±1.36%), followed by CMN (3.20±0.59%) and SMN (2.75±0.35%). Elongation to break was inversed to tensile strength and Young's modulus where the lower elongation to break meant the higher tensile strength and Young's modulus (Pa'e *et al.,* 2014). Next, water holding capacity (WHC) observed that WCN gained the highest amount of WHC which was 61.08±6.77%, CMN was 55.67±7.67% and SMN was 53.33±2.59%. However, Gayathry (2015) found that WHC of nata de coco from coconut water was 87.14%.

CONCLUSION

It can be concluded from this study that coconut milk and skim which are by-products from VCO industry can develop as nata de coco with similar function and characteristic to nata de coco from coonut water. However, fermentation media from coconut water still has the highest value of mechanical characteristics compared to those from milk and skim coconut milk.

REFERENCES

Alyaqoubi, S., Abdullah, A., Samudi, M., Abdullah, N., Addai, Z. R. and Musa, K. H. (2015). Study of antioxident activity and physico-chemical properties of coconut milk (pati santan) in Malaysia. *J. Chem. and Pharmaceuthical Res.* **7** : 967-973.

Andasuryani, Kasim, A., Rahmi, I. D. and Derosya, V. (2017). Characteristics of nata de coco of three types coconut fermentation media. *Res J. Pharmaceutical Bio. Chem. Sci.* **8** : 658-664.

Angeles, J. G. C., Lado, J. P., Pascual, E. D., Cueto, C. A., Laurena, A. C. and Laude, R. P. (2018). Towards the understanding of important coconut endosperm phenotypes : Is there an epigenetic control. *Agronomy* **8** : 225. doi:10.3390/agronomy8100225.

Boemeke, L., Marcadenti, A., Busnello, F. M. and Gottschall, C. B. A. (2015). Effects of coconut oil on human health. *J. Endocrine Metabolic Diseases* **5** : 84-87.

Chang, W. and Chen, H. (2016). Physical properties of bacterial cellulose composites for wound dressings. *Food Hydrocolloids* **5** : 75-83.

Gayathry, G. (2015). Production of Nata de Coco – A natural dietary fibre product from mature coconut water using *Gluconacetobacter xylinum* (sju-1). *Int. J. Food Fermentation Technol.* **5** : 231-235.

Khuenpet, K., Jittanit, W., Hongha, N. and

Pairojkul, S. (2016). UHT skim coconut milk production and its quality. *SHS Web of Conferences 23*. Published by EDP Sciences.

Mansor, T. S. T., Che-Man, Y. B., Shuhaimi, M., Abdul-Afiq, M. J. and Ku-Nurul, F. K. M. (2012). Physico-chemical properties of virgin coconut oil extracted from different processing methods. *Int. Food Res. J.* **19** : 837-845.

Ngampeerapong, C. and Chavasit, V. (2019). Nutritional and bioactives compounds in coconut meat of different sources : Thailand, Indonesia and Vietnam. *CMU J. Nat. Sci.* **18**. doi.org/10.12982/CMUJNS.2019.0037.

Nielsen, S. S. (2014). *Food Analysis, 3rd edn.* Springer, New York.

Nugroho, D. A. and Aji, P. (2015). Characterization of nata de coco produced by fermentation of immobilized *Acetobacter xylinum. Agric. and Agric. Sci. Procedia* **3** : 278-282.

Othaman, M. A., Sharifudin, S. A., Mansor, A., Kahar, A. A. and Long, K. (2014). Coconut water vinegar : New alternative with improved processing technique. *J. Eng. Sci. Technol.* **9** : 293-302.

Pa'e, N., Hamid, N. I. A., Khairuddin, N., Zahan, K. A., Seng, K. F., Siddique, B. M. and Muhamad, I. I. (2014). Effect of different drying methods on the morphology, crystallinity, swelling ability and tensile properties of nata de coco. *Sains Malaysiana* **43** : 767-773.

Patil, U. and Benjakul, S. (2018). Coconut milk and coconut oil : Their manufacture associated with protein functionality. *J. Food Sci.* Doi : 10.1111/1750-3841.14223.

Prades, A., Dornier, M., Diop, N. and Pain, J. P. (2012). Coconut water uses, composition and properties : A review. *Fruits* **67** : 87-107.

Rao, S. S. and Najam, R. (2016). Coconut water of different maturity stages ameliorates inflammatory process in model of inflammation. *J. Intercult. Ethnopharmacology* **5** : 244-249.

Tetrapak (2019). *Coconut Handbook*. Tetrapak : Switzerland ISBN: 9789177739487.

Velasco, C. E. O., González, M. C. and Beltrán, J. A. G. (2014). Ultraviolet-C light inactivation of *Escherichia coli* and *Salmonella typhimurium* in coconut (*Cocos nucifera* L.) milk. *Innov. Food Sci. Emerging Technol.* **26** : 199-204.

Widjajaseputra, A. I. and Widyastuti, T. E. W. (2017). Potential of coconut milk and mung bean extract combination as foam stabilizer in non-dairy ice cream. *Int. Food Res. J.* **24** :1199-1203.