Observations on kopyor coconut (*Cocos nucifera* var. Kopyor) characteristics during distribution

Yora Faramitha[1*], *Firda* Dimawarnita[1], *Masna Maya* Sinta[1], *Rizka Tamania* Saptari[1], *Imron* Riyadi[1], and Sumaryono[1]

[1]Indonesian Oil Palm Research Institute-Bogor Unit, Jl, Taman Kencana No.1, Bogor 16128, West Java, Indonesia

Abstract. Kopyor coconut (*Cocos nucifera* var. Kopyor), a native Indonesian coconut, differs from common coconuts because it has brittle flesh (endosperm) due to a natural genetic mutation. Kopyor coconut seedlings have been successfully cultivated from the tissue culture technique, which can produce kopyor above 99%. Nowadays, the demand for kopyor continues to increase. The cultivation of kopyor is centralized in several locations in Indonesia. Hence, the time of kopyor distribution to consumers is crucial in the kopyor business. This study evaluated changes in the characteristics of whole fruit and peeled kopyor coconuts during distribution. The observations included quality attributes (appearance, aroma, texture, and taste), physical observations (pH and water content), and microbial observations using the total plate count method. Whole kopyor showed better quality attributes than peeled kopyor. Peeled kopyor coconut flesh began to change color to yellowish-white, mushy, and had a rancid smell and a sour taste in the second week, while whole fruit kopyor in the fourth week. In conclusion, the distribution of peeled kopyor should be carried out in less than two weeks, or even sooner, while whole fruit kopyor can be distributed for up to two weeks without altering the characteristic taste of kopyor.

1 Introduction

Cocos nucifera L. var. Kopyor is a native Indonesian coconut natural mutant known for its unique characteristics. It has delicate flesh that easily separates from the coconut shell and offers a rich and more delicious taste than common coconuts. Kopyor coconut lacks the a-D galactosidase gene, a recessive gene expressed when in a homozygous condition [1]. The nutritional content of kopyor coconut is high, particularly its high lauric acid content, which ranges from 31-51% of total lipid [2, 3]. Lauric acid is a medium-chain fatty acid (MCFA) with numerous health benefits, such as antibacterial, antifungal, and anticancer properties and cholesterol reduction [4].

* Corresponding author: yora.faramitha@gmail.com

Naturally, kopyor coconut is obtained through crossbreeding heterozygous coconuts carrying the kopyor coconut trait. This method can obtain less than 25% kopyor coconut [5]. Conventionally, kopyor coconut seedlings cannot be grown directly from kopyor coconut embryo because the endosperm is separated from its shell, making it unable to support the embryo for normal seedling growth [5]. Another way is by embryo rescue in *in vitro* culture. This method can obtain seedlings that produce 99% kopyor fruits [6-8]. The embryo culture of kopyor coconut seedlings has been commercially produced by the Indonesian Research Institute for Biotechnology and Bioindustry since the 2000s (now Indonesian Oil Palm Research Institute- Bogor Unit).

Kopyor coconut plantations were initially concentrated in Pati, Sumenep, Jember, and Lampung [9], now expanding to several regions, such as Bogor (West Java) and Batang (Central Java). Although the production center of kopyor coconut has developed, they have yet to reach many consumers. The distribution of kopyor coconuts to many areas is important in the kopyor coconut business. Currently, kopyor coconut is primarily used as an ingredient in beverages of processed food products, with the largest consumers generally located in big cities. Kopyor coconuts are commonly distributed in frozen flesh or as whole fruit. Considering consumer demand and the ease of consuming the fruit, kopyor coconuts are often sent in peeled form. As kopyor coconut is categorized as perishable food that is easily spoiled, the distribution time of kopyor coconut becomes crucial to prevent fruit loss due to spoilage. According to FAO [10], global data 2016 showed that around 20% of fruits and vegetables were lost due to spoilage from post-harvest to distribution. Therefore, this research aimed to evaluate the quality of kopyor coconut during distribution.

2 Materials and methods

2.1 Materials

Kopyor coconuts aged 11 months were harvested from a kopyor coconut plantation owned by the Indonesian Oil Palm Research Institute (IOPRI) in Bogor, West Java. The kopyor coconuts used were green kopyor coconuts from the ‘genjah’ type. There were two types of kopyor coconuts prepared for the distribution: whole fruit and peeled kopyor coconuts (Fig. 1). Kopyor coconuts were packed in a plastic bag sack during the distribution, in one plastic bag sack consisting of 30 kopyor coconuts.

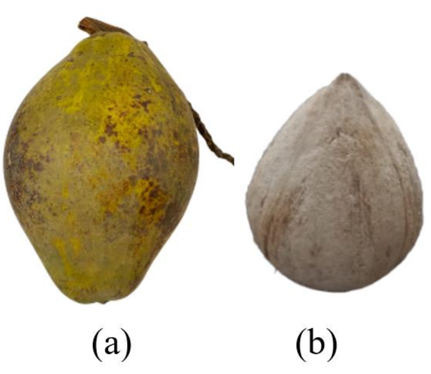

Fig. 1. Whole fruit (a) and peeled (b) kopyor coconuts.

2.2 Analysis

Descriptive analysis, physical analysis, and microbial analysis were conducted to evaluate the quality of kopyor coconuts during the distribution. The main parameter was the changes in the kopyor flesh of whole fruit and peeled kopyor coconuts. The data were measured and collected at weeks 0, 2, and 4.

In the descriptive analysis, panelists assessed the quality attributes of kopyor flesh including its appearance, texture, aroma, and taste. The appearance represented the color of the flesh, while the texture was concerned more with forms of the flesh. The aroma was assessed to determine whether it had a coconut or rancid aroma. The taste was assessed by eating the coconut flesh, except for the coconut with a rancid smell.

In physical analysis, the pH and water content of coconut flesh became the parameters to be evaluated. In pH measurement, 10 g of flesh kopyor was added with 20 mL of distilled water and stirred roughly with a glass spatula into a slurry. The pH of the coconut slurry was measured by a pH Meter (Thermo Scientific Orion Star A215 benchtop pH/conductivity meter). In water content measurement, 10 g of flesh kopyor was dried in an Oven at 105°C for 3 hours or until the dried sample's weight was constant. Water content was measured by using the following formula :

$$water\ content\ (\%) = \frac{weight\ of\ wet\ sample - weight\ of\ dry\ sample}{weight\ of\ wet\ sample}\ x\ 100\% \quad (1)$$

Microbial analysis was done by using the total plate count method. A 10 g of flesh coconut was put in a jar bottle containing 0.85% of sterile NaCl. The sample was shaken at 24°C for 15 minutes in a shaker incubator. A 1 mL liquid sample was transferred to a glass test tube and diluted with 9 mL of 0.85% sterile NaCl. The sample was homogenously vortexed and 10^{-1} dilution was obtained. The dilution was continued until getting 10^{-4} dilution. 0.1 ml of sample from each dilution was taken using a micropipette and then poured into sterile agar media in a petri dish and incubated at room temperature for two days. The number of bacterial colonies from the sample was calculated using the following formula :

$$cfu\ /mL\ = \sum colony\ in\ petri\ dish\ x\ \frac{1}{dilution\ factor} \quad (2)$$

3 Result and discussion

The flesh of whole fruit and peeled kopyor coconuts at weeks 0, 2, and 4 is presented in Fig. 2, while the descriptive observation of their quality attributes was summarized in Table 1. At week 0, whole fruit and peeled kopyor had a brittle white flesh with a typical coconut aroma. When the fleshes were eaten, both had a soft texture and tasted like savory coconut milk and sweet. These characteristics represented kopyor coconut with good quality.

Fig. 2. Observation of kopyor coconut during week-0, week-2, and week-4. (a) Wholefruit kopyor coconut (b) Peeled kopyor coconut.

Table 1. Descriptive observation of whole fruit and peeled kopyor coconut during distribution.

Quality attributes	**Whole fruit kopyor coconut**			**Peeled kopyor coconut**		
	Week-0	**Week-2**	**Week-4**	**Week-0**	**Week-2**	**Week-4**
Appearance	white	white	yellowish white	white	dull white	Brownish yellow
Aroma	Coconut aroma	Coconut aroma	Rancid smell	Coconut aroma	Rancid smell	Rancid smell
Texture	soft	soft	mushy	soft	Mushy and watery	mushy
Taste	savory coconut milk and sweet	Slightly savory coconut milk and sweet	-	Savory coconut milk and sweet	-	-

At two weeks of distribution, differences in quality attributes were observed between whole fruit and peeled kopyor coconut. The flesh of the whole fruit kopyor was still white with a coconut aroma and soft texture. The taste of savory coconut milk and the sweetness of kopyor became less, but it was still good. In contrast, the flesh of peeled kopyor started to change to a dull white color with a mushy, watery texture and a rancid smell. These changes indicated that peeled kopyor was not proper for consumption.

At four weeks of distribution, whole fruit and peeled kopyor had poor quality attributes. The flesh of the whole fruit kopyor was yellowish-white with a mushy texture and rancid smell. The flesh of peeled kopyor was even worse, and it had a brownish-yellow color with a mushy texture and a pungent, rancid smell. Therefore, both of them were rejected and should be destroyed. In conclusion, based on their quality attributes, whole fruit kopyor coconut had a longer shelf life when distributed than peeled kopyor.

The difference in flesh quality between whole fruit and peeled kopyor shows that coconut fiber is essential in maintaining flesh quality. Coconut fiber, as the thick fibrous outer layer of coconut, has solid and strong structure [11]. According to Bello et al. [12], coconut fiber or coir reaches 54% of the total weight of coconut fruit. These properties of coconut fiber protect the inside part of the coconut from bumps, reducing the deterioration potency of the coconut. Besides, the natural fiber of coconut is difficult to rot, making it resistant to microorganisms [13]. In peeled kopyor coconut, the coconut fiber had been removed, so the protection was only from the coconut shell, which was thin and easily broken. This factor may affect the quick deterioration of the flesh in peeled kopyor coconut compared to the whole fruit kopyor coconut.

pH of the flesh of whole fruit and peeled kopyor are presented in Table 2. In general, the pH of peeled kopyor was slightly lower than whole fruit kopyor during distribution. The pH values of whole fruit kopyor were in the range of 6.04 – 6.43, while the pH values of peeled kopyor were in the range of 5.32-5.96. pH values of peeled kopyor at 2nd and 4th week decreased compared to its pH at 0 week.

The water content of whole fruit and peeled kopyor showed different trends (Table 3). The water content of whole fruit had risen from 80% at 0 week to 83.47% at 2nd week and 85.95% at 4th week. On the other hand, the water content of peeled kopyor tended to decrease, from 84.66% at 0 week to 79.36% at 2nd week. An increase in water content occurred at week 4 (81.80%). However, this value was still lower than at 0 week.

Table 2. pH of whole fruit and peeled kopyor coconut during distribution.

Type of Kopyor	**pH**		
	week-0	**week-2**	**week-4**
Whole fruit kopyor	6.04±0.2	6.43±0.14	6.10±0.18
Peeled kopyor	5.96±0.12	5.32±0.07	5.68±0.21

Table 3. Water content of whole fruit and peeled kopyor coconut during distribution.

Type of Kopyor	**Water content**		
	week-0	**week-2**	**week-4**
Whole fruit kopyor	80.00±1.58	83.47±0.48	85.95±1.58
Peeled kopyor	84.66±2.97	79.36±0.89	81.80±2.71

Table 4. Total viable count of microorganism of whole fruit and peeled kopyor coconut during distribution.

Type of kopyor	**TPC (CFU/mL)**		
	Week-0	**Week-2**	**Week-4**
Whole fruit kopyor coconut	<10	< 10	1.7 x 10^5
Peeled kopyor coconut	<10	1.9 x 10^3	TNTC

Table 4 shows the total viable count of microorganism of flesh between whole fruit and peeled kopyor coconut at 0, 2nd, and 4th week of distribution. No microorganism was observed in both types of kopyor coconut when they were freshly prepared and ready to be sent (0 week). However, the peeled kopyor coconut began to show sign of contamination at the 2nd week (1.9 x 10^3 CFU/mL) and escalated became unquantifiable by the 4th week. On the other hand, the whole fruit of kopyor coconuts showed better quality in which no microorganism was observed at 2nd week (<10). The microorganism began to appear after the 2nd week and increase by 4th week (1.7 x 10^5).

This research shows that the deterioration in the quality of kopyor coconut flesh could relate to changes in pH and water content, and mainly due to microbial spoilage. The typical pH of coconuts is acidic. Asaad et al. [14] also reported that the pH values of some varieties of 5–6-month-old coconut in Malaysia (tall, dwarf, and hybrid) were around 5.25-5.48. In this study, the pH values of kopyor coconut flesh tended to decrease as the longer the storage and distribution time. Research conducted by Aswan et al. [15] on Bido coconut water indicates that the age of harvested fruit determines pH of coconut water. Solangi & Iqbal [16] research results showed that the pH of 6-7-month-old coconut flesh was around 5 while the pH of 11-12-month-old coconut flesh was around 4. Changes in pH values in a food indicate a deterioration in the quality of that food. The pH decrease in acidic conditions below the typical pH value of food could influence food's water-holding capacity and softness, changing the food texture [17]. Therefore, in the 4^{th} week of distribution, kopyor coconut flesh, which had a decreased pH, was mushy and watery.

The changes in quality attributes of kopyor coconuts to be undesirable and unacceptable for consumption are also strongly related to microbial spoilage. Kopyor coconuts, like other common fruits, contain vitamins, minerals, dietary fibers, and other nutrients, which are favourable energy sources for microbial growth [18, 19]. Besides, the pH of coconut falls within a range suitable for the growth of neutrophilic microbes [20]. Kopyor coconuts are also categorized as perishable foods since they have high water content, and water promotes microbial growth [18]. Therefore, the state of the kopyor coconuts is ideal for microorganisms to grow and extremely escalate, thus later changing the sensory characteristics of kopyor coconuts.

In this research of the kopyor coconut case, the causes of microbial spoilage might be highly due to outer part damage and fruit ripening. According to [21], fruit cuticle or exocarp protects fruit flesh from bacterial contamination. On peeled kopyor coconuts, the coconut fiber, as the outer part of the coconut, had been removed. Therefore, the peeled kopyor coconuts were more easily spoiled than whole fruit kopyor coconuts. Fruit ripening also becomes a major factor that causes microbial spoilage in both kopyor coconuts, mainly at the 4^{th} week of distribution. The age of harvested kopyor coconuts was 11 months, which was the mature time of kopyor coconuts. The biochemical of fruit naturally changes as the fruit ripens, thus changing the fruit texture to be softer and higher in nutrients, which make it easily invaded by microorganism [22].

This study suggests that whole fruit kopyor coconuts can be transported for up to 2 weeks, while peeled kopyor coconuts should be transported for less than two weeks. Whole fruit kopyor coconut is still protected by coconut fibre, which effectively extends the distribution time to 2 weeks. In whole fruit kopyor coconut, the flesh is protected by two layers: coconut fibre and coconut shell, whereas peeled coconut kopyor is only protected by the coconut shell. Research conducted by Prasetiyo et al. [23] shows that kopyor coconut fibre has the highest proportion based on its fresh weight, ranging from 39-50%, while the proportion of kopyor coconut shell is only 14-17%. Coconut fibers act as a natural barrier that makes it difficult for microorganisms to spoil the coconut flesh. In future research, it would be best to conduct observations at closer intervals to determine precisely when the kopyor coconuts start to spoil and be sensory undesirable.

4 Conclusion

Whole fruit kopyor coconut can be distributed in 2 weeks, whereas for peeled coconut kopyor should be less than 2 weeks. Coconut kopyor spoilage during distribution is caused by microbial contamination, which is indicated by the appearance in TPC, aroma, texture, taste, and color changes.

References

1. C.V. Mujer, D.A. Ramirez, E.M.T. Mendoza, Phytochem **23**, 6 (1984)
2. M.Y. Antu, I. Maskromo, B. Rindengan, Perspektif, Rev.Pen. Tan. Industri **19**, 2 (2020)
3. Y. Srivastava, A.D. Semwal, A. Majumdar, Cogent Food Agric. **2**, 1 (2016)
4. S. Sandhya, J. Talukdar, D. Bhaishya, Int. J. Adv. Res. **4**, 7 (2016)
5. H. Novarianto, I. Maskromo, D. Dinarti, Sudarsono, Cord **30**, 2 (2014)
6. S. Tahardi S, K. Warga-Dalem, Menara Perkebunan **50**, 5 (1982)
7. Sisunandar, *Produksi bibit kelapa kopyor true-to-type melalui teknik kultur embryo,* in Prosiding Seminar Nasional XI Pendidikan Biologi FKIP UNS, June 2014, Surakarta, Indonesia (2014)
8. Sumaryono, I. Riyadi, Menara Perkebunan **84**, 1 (2016)
9. I. Maskromo, H. Novarianto, Sukendah, D. Sukma, Sudarsono, Buletin Palma **15**, 2 (2014)
10. Food and Agriculture Organization, The state of food and Agriculture: moving forward on food loss and waste reduction (FAO, Rome, 2019)
11. J. Ahmad, A. Majdi, A. Al-Fakih, A.F. Deifalla, F. Althoey, M.H. El Ouni, M.A. El-Shorbagy, Materials **15**, 3601 (2022)
12. S.A. Bello, J.O. Agunsoye, J.A. Adebisi, F.O. Kolawole, S.B. Hassan, Kathmandu University J. Eng. Sci. Technol. **12**, 1 (2016)
13. P. Nasution, S.P. Fitri, and Semin, Berkala Perikanan Terumbuk **42**, 2 (2014)
14. A.N. Asaad, F. Jailani, S.R. Ab. Mutalib, Sci. Res. J. **19**, 1 (2022)
15. M. Aswan, S. Bahri, A. R. Ibrahim, *Karakterisasi kandungan kimia endosperm dan air kelapa Bido pada tingkat umur buah yang berbeda,* in Prosiding Seminar Nasional Agribisnis, 7 Dec 2021, Ternate, Indonesia (2021)
16. A.H. Solangi & M.Z. Iqbal, Pak. J. Bot. **43**, 1 (2011)
17. A. Andre´s-Bello, V. Barreto-Palacios, P. Garcı ´a-Segovia, J. Martı ´nez-Monzo´, Food Eng. Rev. **5**, 158-170 (2013)
18. P. Zhao, J.P. Ndayambaje, X Liu, X. Xia, Food. Rev. Int. **38**, 1 (2022)
19. S. H. Hamad, Factors Affecting the Growth of Microorganisms in Food. *In* Progress in Food Preservation (John Wiley & Sons, New Jersey, 2012)
20. Q. Jin, M.F. Kirk, Front. Environ. Sci. **6**, 21 (2018)
21. L.B. Martin & J.K. Rose, J. Exp. Bot. **65**, 16 (2013)
22. G. Gundewadi, V.R. Reddy, B.B. Bhimappa, J. Hill. Agric. **9**, 1 (2018)
23. M.E.R.B. Prasetyo, I. Riyadi & Sumaryono, Menara Perkebunan **90**, 1 (2020)