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Preliminary Investigation of The Potential of Coconut Sugar Production Using Dwarf Varieties

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ABSTRACT

Coconut sugar is one of the high economic value products. The production of coconut sugar In Indonesia is about 300,000 tonnes/year. During the last few years, the supply of raw materials for the coconut sugar product has diminished due to stagnant production caused by the lack of coconut climbers collecting coconut sap. The scarcity of labor is caused by several factors, especially young tappers who are less interested in climbing tall coconut palms. To solve this problem, it is necessary to evaluate the potency of dwarf coconuts, with short trunk and fast fruiting. The objective of this study was the evaluation and selection of Dwarf coconut varieties that have high yield potential as a producer of sap and coconut sugar. The research was conducted in North Sulawesi Province by evaluating 9 Dwarf coconut varieties. The results of research on the production of coconut sap and sugar from 9 Dwarf coconut varieties with different plant ages, gave mixed results among coconut varieties. The length of tapping sap varied between 31.42 - 43.21 days/bunch, the volume of sap varied between 1.1 - 3.3 liters/tree/day, the pH of sap ranged between 6.49 - 7.86 and the Brix value varied between 14.01 - 17.64. The most important traits such as the sap yield and sugar production also varied from 14.54 to 18.95% among varieties, and between 0.16 to 0.42 kg/tree/day respectively. The Dwarf coconut varieties with the highest potential yield of sap and sugar are the Waingapu Red Dwarf (WRD), Salak Green Dwarf (SGD), and Nias Yellow Dwarf (NYD), with the potential sugar yield of 2.09 tons, 1.64 tons, and 1.56 tons/month/ha respectively. It is hoped that these Dwarf coconut varieties would be attractive for young tapers and could be introduced to farmers in several Provinces for tapping purposes for the production of coconut sugar.

Key words: *Dwarf coconut variety, short trunk, sap, brix, coconut sugar*

INTRODUCTION

Coconut palm, in addition to producing fruit that can be processed into various high economic value products, and used to produce sap (also called neera) by tapping inflorescences. Coconut sap contains a higher concentration of fructose and glucose with a lower concentration of sucrose compared with those of sugar palm and sugarcane juices (Asghar *et al.*, 2020). Coconut sap also contains higher amounts of vitamins (C, B1, B3, B4, and B10) as compared to sugar palm and sugarcane juices (Asghar *et*

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al., 2020). Hence, coconut sap could be a better potential source for the production of healthier sugar (Asghar *et al*., 2020).

According to Supomo (2007), each inflorescence can produce 2-4 liters of sap per palm per day. The results of an economic analysis showed that the coconut sap yields from coconut palms and made coconut sugar from them turned out to be more profitable for coconut farmers compared to coconuts being processed into copra or sold as fresh coconut.. Some evaluation reports (personal information) published says that income from palm sugar is 5-10 times higher than income from copra products. The main advantage of coconut sugar is that its glycemic index value is relatively low at 35-42, and it is a safe sweetener for diabetes (Trinidad *et al*., 2010). Coconut sugar also has sufficient nutrition compared to granulated sugar (cane sugar). The literature survey on coconut sap showed that there were about 30 developed products from coconut sap such as under suitable category; white crystalline sugar, fresh drinks, and jelly drinks and under a quite suitable category; syrup, candy, soy sauce, nectar, yakult, and yogurt and under not suitable category; kefir (Adiluhung *et al*., 2019) based on the priority recommendations for MSME (Medium and Small Micro Enterprise) in Banyumas District.

Coconut sugar which is known in the trade as Javanese or brown sugar is the result of processing coconut palm sap with a distinctive taste so that its use cannot be replaced by other types of sugar. Besides functioning as a sweetener, Javanese sugar also functions as a chocolate dye. Javanese sugar is produced from coconut sap which is then cooked by a family of farmers in a very simple way, then printed with bamboo molds, and then sold to small traders (baskets). From this basket Java sugar products are sold to collectors, then from, the collectors it is resold to dealers/suppliers who supply and sell directly to soy sauce factories in very large numbers (http://www.pidra-indonesia.org). The result of the effect of soaking tube with an anti inverse solution and concentration addition of sodium metabisulphite for naturally fermented coconut sap during 8 hours showed that the best parameter based on physicochemical properties were obtained by concentration addition of sodium metabisulphite 500 ppm and anti inverse concentration 3000 ppm (Pratama *et al*., 2015). Coconut sap sugar can be used as an alternative source for sugar because of its low glycemic index and since it possesses α – amylase inhibitory activity but is also used as a therapeutic agent in treating type II diabetes mellitus (Devi *et al*., 2015).

Nationally the production of coconut sugar is around 300,000 tons/year. The need for coconut sugar in Indonesia, especially for soy sauce raw materials, continues to increase every year by around 10%. In recent years, the supply of raw materials for coconut sugar for soy sauce products has decreased, due to stagnant production. This problem is due to the decreasing number of coconut sap that is caused by several factors, most significantly the less interest in climbing tall coconut trees by the youth. Climbing tall coconut trees is at high risk as falling from trees is quite evident. For this reason, it is necessary to find a solution so that coconut sugar production can be increased, and youth in rural and gender areas are interested in working in the area of tapping coconut sap. The use of coconut varieties that have short stem morphology is one solution to this problem. Coconut palms in the farmer's plantations are generally tall type coconut that has a high stem morphology.

The type of coconut that has a short stem morphology is the Dwarf coconut. The Indonesia Palma Crops Research Institute, IAARD has several dwarf coconut varieties collected as germplasm from several regions in

Indonesia, such as; Nias Yellow Dwarf (NYD), Raja Brown Dwarf (RBD), Salak Green Dwarf (SGD), Sagerat Orange Dwarf (SOD), Jombang Green Dwarf (JGD), Tebing Tinggi Dwarf (TTD) and Bali Yellow Dwarf (BYD). The difference in sap production is due to the differences in the variety and age of palms. According to Aristya *et al*. (2013) younger coconut palms have higher yields than older plants, in addition to the skills of tappers.

The objective of this study was to select and recommend Dwarf coconut varieties suitable for taping for coconut sugar production.

MATERIALS AND METHODS

The research was carried out in the Mapanget and Paniki Experimental Garden, IPCRI, North Sulawesi for six months starting in January-June 2016. The materials used in this study are productive trees from dwarf coconut varieties.

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The study used Single Block Design with 9 treatments and 20 sample palms for each coconut variety as a replication so that a total of 180 palms were used for the study along with KHINA-1 Hybrid coconut as the control (2 sample palms). The treatments tested were 9 dwarf coconut varieties consisting of:

1. Tebing Tinggi Dwarf (TTD)
2. Bali Yellow Dwarf (BYD)
3. Nias Yellow Dwarf (NYD)
4. Jombang Green Dwarf (JGD)
5. Nias Green Dwarf (NGD)
6. Waingapu Red Dwarf (WRD)
7. Raja Brown Dwarf (RBD)
8. Sagerat Orange Dwarf (SOD)
9. Salak Green Dwarf (SGD)
10. KHINA-1 hybrid as the control.

The observed variables consisted of:

1. Coconut stem height (m), measured from the bottom of the trunk to the old petiole of the crown of the leaf,
2. Inflorescence length (cm), measured from the base to the end of the bunch before starting the first tapping process,
3. Inflorescence of the circle (cm), measured in the middle of the inflorescence,
4. The production of sap per inflorescence/day, measured by the volume of sap per inflorescence per day (twice tapping),
5. Sap production per palm, measured by the volume of sap produced by each palm (for 6 months).
6. Sap sugar levels, measured using a refractometer.
7. The level of acidity (pH) of the sap.
8. Duration of tapping per bunch.
9. Number of bunches harvested for 6 months per tree (bunches).
10. Yield of coconut sugar produced (%).

MATERIALS AND METHODS

Palm ages, Stem length, and morphology of Bunch

The nine varieties of dwarf coconut with different ages were evaluated (Figure 1). The average duration of tapping of nine dwarf coconut varieties and one hybrid coconut as along with morphological characteristics are presented in Table 1.

The results in Table 1 shows that hybrid coconut of KHINA-1 (NYD x Tenga tall) has the highest duration of tapping (50 days). Of

Figure 1. Nine of dwarf coconut varieties in Mapanget Experimental Garden

No.	Varieties*)	Palms ages (years)	Average stem length (m)	Average Inflorescence length (cm)	Average Inflorescence circumference (cm)	Average days of tapping/ Inflorescence
1	WRD	17	5.43	63.26	26.32	43.21
2	SGD	15	4.93	50.32	21.66	31.42
3	NGD	38	10.33	54.25	21.08	42.00
4	NYD	39	9.61	56.00	22.27	37.70
5	JGD	38	9.43	48.92	22.79	36.33
6	SOD	30	7.20	57.44	17.19	36.13
7	RBD	36	8.66	61.22	19.64	34.90
8	TTD	37	8.24	50.20	23.53	33.90
9	BYD	10	4,06	51.09	21.53	32.21
10	KHINA-1 (Control)	38	11.90	64.13	26.75	50.00

Note: *) WRD (Waingapu Reda Dwarf), SGD (Salak Green Dwarf), NGD (Nias Green Dwarf), NYD (Nias Yellow Dwarf), JGD (Jombang Green Dwarf), SOD (Sagerat Orange Dwarf), RBD (Raja Brown Dwarf), TTD (Tebing Tinggi Dwarf), BYD (Bali Yellow Dwarf).

Table 1. The average length of tapping and the morphological characteristics of the inflorescence of nine dwarf coconut varieties and one hybrid

the nine dwarf coconut varieties, MRD has the highest duration of tapping (43.21 days) and the lowest was SGD with 31.42 days. The younger coconut palms have higher yields than older palms. It was observed that the circumference of the inflorescence, influences the duration of the tapping, as was seen in WRD and Khina 1 which have a larger inflorescence circumference than other varieties and have the highest duration of tapping. It was interested in observing that however, the length of the inflorescence does not affect the duration of the tapping.

In general, the production of one inflorescence of sap in the first week of tapping is below 500 ml/inflorescence/day which is then increasing in the second week, and become stable until the third week, and thereafter begins to fall in the fourth week onwards. But in the next / inflorescence, sap production in the first week on average was above 1,000 ml/inflorescence/ day and in the second week, it has reached above 2,000 ml/ Inflorescence/ day. The process of tapping sap in dwarf coconut variety can be seen in Figure 2.

The Sap and Coco sugar Production of Dwarf Varieties

The average volume of sap/tree/day and the production of sugar/palm/day are presented in Table 2. The number of palms of the nine dwarf coconut varieties is not uniform, because the palms conditions in the field are already quite high and some palms are considered to be quite risky to be tasted and there are limitations for tappers. From Table 2, it can be seen that the highest production of sap/palm/day and sugar/palm/day production are found in hybrid coconut (KHINA-1), While it was WRD among 9 dwarf coconut varieties showed the highest average production of sap /palm/day and the highest production of sugar /palm/day. The results of this observation are quite stable for four months of observation. Tulalo and Mawardi (2018) found that the coconut variety of WRD is

Figure 2. Tapping sap on dwarf coconut in Mapanget Experimental Garden

No.	Varieties	Number of palm sample (palms)	Average volume sap/ palm/day (ml)	Average production coco sugar/palm/day (kg)
1	BYD	20	1.56	0.29
2	SOD	7	1.36	0.23
3	RBD	5	1.33	0.22
4	WRD	10	2.60	0.45
5	TTD	7	1.48	0.27
6	JGD	6	1.28	0.23
7	SGD	11	2.07	0.35
8	NYD	4	1.91	0.33
9	NGD	2	1.48	0.30
10	KHINA-1	2	3.58	0.67

Table 2. Number of palms sample, sap volume/palm/day, sugar yield/palm/day, and average coco sugar/palm/day of nine Dwarf coconut varieties and hybrid KHINA-1 in Mapanget Experimental Garden

produced more sap compare to SGD, and RBD and the yield of sap are 1,007 ml, 741 ml, and 628 ml/ palm/day respectively. In India, on an average, a spadix can produce 1.5–3 liters of sap per day or 60–80 liters in 40–45 days (Hebbar *et al*., 2015). Although it was planned to use 20 sample palms for each coconut variety, but due to practical reasons between 2 to 20 palms were evaluated.

Compared to Hybrid coconut, the production of sap and coco sugar from nine dwarf coconut varieties is lower but seen from the condition of dwarf coconut palms with slower stem growth and faster first flowering of fruit bunches (2-3 years) compared to hybrid coconut (3-4 years) and tall coconut (5-7 years), shows the great potential of dwarf coconut to be developed in producing coconut sap and sugar. In addition, the number of dwarf coconut palms in one hectare of land is more than that of tall coconut and hybrid coconut because the spacing of Genjah coconut. The seed nuts needed for rejuvenation and development are easier to obtain because they do not go through an artificial pollination process such as hybrid coconut.

pH, Brix and Yield of Coco sugar

The damage to the sap is characterized by a decrease in pH due to a breakdown of sugar into organic acids by microbes, such as yeast (*Saccharomyces sp.*) and the bacterium *Acetobacter sp.* Sucrose is converted into glucose and fructose, then the fermentation process of glucose and fructose into ethanol and CO2 ends with the process of formation of acetic acid, the process of changing ethanol into acetic acid (Naufalin *et al.*, 2013).

The values of pH, Brix, and sugar yield during the period March-June 2016 are presented in Table 3. The pH of the sap is observed when the sap is lowered from the coconut palm in the morning and evening. The results of the observation of the pH of the sap from the nine varieties of Dwarf coconut and hybrid coconut which were evaluated were neutral, an average of 6.80 - 7.44. In general, it appears that the variation of sap in terms of acidity in the nine dwarf varieties is very small, illustrating that the pH of the sap is not affected by the variety. From the results of observations in the field, the pH of the sap is more likely to be influenced by the preservatives used as well as the weather during erosion, for example during very hot weather the sap of the pH tends to be lower than the weather that is not too hot. Based on PT. Unilever Palm Sugar Manufacturing SOP for coconut sap as raw material for making soy sauce, the expected pH of sap is 6-8. Karseno *et al*., 2018 reported that the browning intensity and antioxidant activity of sugars were increased with increasing pH of coconut neera and temperature. It was found that the effect of pH at 8 and temperature at 115°C shows the highest total phenolics (0.48%) and browning intensity (0.35) of sugar. The treatment also exhibited good antioxidant activity (DPPH scavenging activity) as high as 40%. This result also indicates that there is a significant correlation between browning intensity and the antioxidant activity of coconut sugar.

No.	Varieties	pH	Brix	Rendement
1	BYD	6.88	15.20	16.60
2	SOD	7.44	14.78	16.89
3	RBD	7.02	14.80	15.57
4	WRD	6.82	14.34	16.21
5	TTD	6.99	14.74	17.08
6	JGD	6.88	15.49	17.29
7	SGD	7.00	14.91	16.94
8	NYD	6.80	14.20	15.90
9	NGD	6.80	14.65	16.65
10	KHINA-1	7.30	15.45	17.64

Table 3. The average of pH, Brix and rendement coco sugar of nine Dwarf coconut varieties and hybrid KHINA in Mapanget Experimental Garden on period March - June 2016

The range of evaluated coconut brix value is 14.20-15.49 and the variety that has the highest brix value is GHJ which is 15.49. The sugar content of the nine sap from seven Dwarf coconut varieties in this study was almost the same as that was obtained by Xia *et al.* (2011) in his study, which was 14% in freshly tapped sap.

The extraction process is carried out twice a day, ie morning and evening, and from each palm two bunches could be tapped. The process of tapping and storing affects the freshness of the sap because the sugar in the sap is very easily fermented (Indahyanti *et al*., 2014). The yield range of coco sugar is among 15.57 - 17.29%, respectively and the average yield of JGD is 17.29%, TTD 17.08%, SGD 16.95%, SOD 16.89%, BYD 16.60 %, NGD 16.65%, WRD 16.21%, NYD 15.90% and RBD 15.57%. This data shows that to get as much as 1 kg of coconut sugar, it requires ±6 liters of palm sap.

The results of evaluations carried out on nine Dwarf coconut varieties showed all Dwarf coconut varieties evaluated could produce good quality sap and coconut sugar with varying production potential. All observations, obtained from the potential production of sugar /palm/ month and the potential sugar/month/hectare from Dwarf coconut planted with a spacing of 8 m x 8 m square planting system and hybrid coconut 9 m X 9 m is presented in Table 4. This evaluation shows that the nine Dwarf coconut varieties have the potential to be developed for the production of sap and coconut sugar, but of the nine varieties evaluated there are three high potential varieties with the highest sugar/hectare/month production potential, namely WRD coconut of 2,106 kg, evidenced by SGD 1,638 kg and 1,544 kg NYD. This is not only based on the production of sap and sugar but also based on palm morphology such as the number of flower bunches being tasted and visually more palms performance in the field.

Based on the experience delivered by the tappers, BYD and RBD varieties are less preferred by them due to the risk of tappers falling from the tree as the base of the fronds they support are loosely attached to the base of the stem.

No.	Varieties	Coco sugar/palm/day (kg)	Coco sugar/palm/ month (kg)	Potential coco sugar/ month/ha (kg)
1	BYD	0.46	13.37	2.106
2	SOD	0.3	8.85	1.404
3	RBD	0.33	10.01	1.544
4	WRD	0.23	6.94	1.076
5	TTD	0.23	7.02	1.076
6	JGD	0.23	7.02	1.029
7	SGD	0.27	8.17	1.263
8	NYD	0.29	8.6	1.357
9	NGD	0.35	10.54	1.638
10	KHINA-1	0.67	20.13	2.436

Table 4. Potential and sap production and coco sugar of nine dwarf varieties in Mapanget Experimental Garden

Figure 3. Processing Dwarf coconut sap to produce coco sugar

The process of cooking sap to produce coco sugar is shown in Figure 3. Coconut sap that has been spoiled or fermented when processed will produce coconut sugar with a texture that is difficult to converted to crystal sugar, resulting in loss for coconut sugar craftsmen (Febryanti *et al.,* 2014). To overcome this problem, it is necessary to provide preservatives in the sap container during tapping (Naufalin, *et al.*, 2012). Usually, the male member of the family does the tapping twice in day and the sap cooks to become coco sugar is done by the female member of the family.

CONCLUSIONS

1. The thickness of the inflorescence, influences the duration of the tapping, but not for the length of bunches.
2. The production of palm sap and coco sugar from nine dwarf coconut varieties with different old palms, shown mixed results among coconut varieties. The length of tapping varies between 31.42 - 43.21 days / bunch, the volume of sap is between 1.1 - 3.3 liters / tree / day, the sap of pH is 6.49 - 7.86, Brix 14.01 - 17.64, sugar yield of 14.54 - 18.95%, and coco sugar production between 0.16 - 0.42 kg / palm / day.
3. Waingapu Red Dwarf (WRD), Salak Green Dwarf (SGD), and Nias Yellow Dwarf (NYD) were identified as the high potential varieties with the highest sugar/hectare/month with the potential yield of 2.09 tons, 1.64 tons, and 1.56 tons/month/ha respectively.

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REFERENCES

Andiluhung A., Mela E., Widjonarko G. & Sitoresmi I. (2019). Products of coconut nira to develop medium and small micro enterprise in Banyumas Regency. *Agrin Journal, 23(2)*, 85-102.

Aristya V. E., Prajitno D., Supriyatna & Taryono. (2013). Kajian aspek budidaya dan identifikasi keragaman morfologi tanaman kelapa (Cocos nucifera, L) di Kabupaten Kebumen. Jurnal.ugm.ac.id/jbp/article.

Asghar M. T., Yusof Y. A., Mokhtar M. N., Ya'acob M. E., Ghazali H. M., Chang L. S., & Manaf Y. N. (2020). Coconut (*Cocos nucifera* L.) sap as a potential source of sugar: Antioxidant and nutritional properties. *Food Sci Nutr., 8(4)*, 1777–1787.

Devi N. S., Prasad T. H., Ramesh K. & Merugu R. (2015). Antioxidant properties of coconut sap and its sugars. *International Journal of Pharmtech Research, 8(1),* 160-162.

Febriyanti R., Susanto W. H. & Nugrahini N. I. P. (2014). Karakteristik sirup jahe nira kelapa terfermentasi delapan jam (Kajian Jenis dan Konsentrasi Sari Jahe). *Jurnal Pangan dan Agroindustri, 3(3),* 1026-1031.

Hebbar K. B., Arivalagan M., Manikantan M. R., Mathew A. C,. Thamban C., Thomas G. V. & Chowdappa P. (2015). Coconut inflorescence sap and its value addition as sugar – collection techniques, yield, properties, and market perspective. *Current Science, 109(8),* 1-7.

Indahyanti E., Kamulyan B. & Ismuyanto B. (2014). Optimasi konsentrasi garam bisulfit pada pengendalian kualitas nira kelapa. *Jurnal Penelitian Saintek, 19(1),* 1-8.

Karseno, Erminawati, Yanto T., Setyowati & Haryati P. (2018). Effect of pH and temperature on browning intensity of coconut sugar and its antioxidant activity. *Food Research, 2(1),* 32-38.

Naufalin R., Yanto T. & Binardjo A. G. (2012). Penambahan konsentrasi Ca(OH)2 dan bahan pengawet alami untuk peningkatan kualitas nira kelapa. *Jurnal Pembangunan Pedesaan, 12(2),* 86- 96.

Naufalin R., Yanto T. & Sulistyaningrum A. (2013). Pengaruh jenis dan konsentrasi pengawet alami terhadap mutu gula kelapa. *Jurnal Teknologi Pertanian, 14(3),* 165-174.

Pratama F,. Susanto W. H. & Purwantiningrum I. (2015). Making coconut sugar from natural fermented sap. *Jurnal Pangan and Agroindustri, 3(4),* 1272-1282.

Supomo. (2007). Meningkatkan kesejahteraan pengrajin gula kelapa di Wilayah Kabupaten Purbalingga. *Jurnal Ekonomi Pembangunan 12,* 149-162.

Trinidad T. P., Mallillin A. C., Sagum R. S., Encabo R. R. (2010). Glycemic index of commonly consumed carbohydrate foods in the Philippines. *Journal of Functional Foods 2,* 271-274.

Meity T. A. & Mawardi S. (2018). Potential sap and coconut sugar production of three accession Dwarf coconut. *Jurnal Littri, 24(2),* 87-92.

Xia Q., Li R., Zhao S., Chen W., Chen H., Xin B., Huang Y. & Tang M. (2011). Chemical Composition Changes of Post-Harvest Coconut Inflorescence Sap During Natural Fermentation. *African Journal of Biotechnology, 10(66),* 14999-15005.