

Physico-Chemical Properties of Refined Oil Based on Maturity Level and Drying Time of Nutmeg Mace (*Myristica Fragrans Houtt*)

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Abstract

This research aims to study and determine the level of full maturity and the appropriate and best drying time for nutmeg mace so that a high yield of mace oil is produced with physico-chemical properties that meet Buenther's criteria. Ripe nutmeg will produce good quality nutmeg and mace when used as spices for export. Apart from that, old nutmeg mace can still be used for its essential oil because the oil content is still quite high. To get nutmeg oil from the fruit when it is young, you can also get mace which has a high level of oil content. The water content in mace is quite high so it is easy for mold to grow and will affect the oil yield and possibly also the physico-chemical properties of the oil. This research is a factorial experiment using a Completely Randomized Design (CRD) consisting of two factors. Factor A, namely the maturity level of mace, consists of two levels, namely full young and old mace. Factor B is the drying time of mace with four levels, namely 0, 8, 16 and 24 hours. Each treatment was repeated three times. The oven drying temperature was 40° C and distillation was carried out for 20 hours. The results of the research for each level of mace maturity gave significant differences to the yield, specific gravity, refractive index, optical rotation and acid number of the refined oil, while the length of drying of the mace gave a real difference to the physico-chemical properties of the mace oil. The best results obtained were young mace which was dried for 24 hours with the following characteristics, full water content of 6.77%, mace oil yield of 12.8889 ml/100 grams of material, specific gravity of mace oil 0.9255; full oil refractive index 1.4871; The optical rotation of the oil is (+) 6.3433 and the acid number of mace oil is 2.29.

Keywords— Nutmeg Mace (*Myristica Fragrans Houtt*), Oil Content, Physico-Chemical, Yield, Drying

Introduction

Nutmeg is usually picked when the fruit is ripe so that good quality nutmeg and nutmeg seeds will be produced when used as spices for export. Apart from that, the nutmeg fruit can still be used for its essential oil because the oil content is still quite high. Nutmeg plant (*Myristica fragrans Houtt*) generally done well Indonesia and in other countries. Nutmeg production is intended to be used as a source of essential oil. Nutmeg mace is classified as an agricultural product that is easily damaged due to the high water content of the material, therefore it requires drying treatment before being distilled to extract its essential oil. The drying treatment on nutmeg mace will affect the yield and physico-chemical properties of refined nutmeg mace oil where the

drying temperature is too high or drying too fast will result in the loss of most of the nutmeg mace oil from the material, while the drying time for nutmeg mace is less will result in Nutmeg mace is easily damaged because the water content of nutmeg mace is still high enough to allow mold to grow.

Literature Review

This Research Department Laboratory was carried out at the Faculty of Agricultural Technology, Faculty of Agriculture, the Basic Laboratory of the Agricultural Chemistry Section and the Laboratory of Sam Ratulangi University, Manado

The materials used in this research were nutmeg mace nutmeg (*Myristica fragrans* Houtt.) originating from Karegesan village, Kauditan sub-district, Minahasa regency, and the chemicals for analysis were aquades, silica gel, 95% ethanol, acetone, diethylether, chloroform, KOH 0.1 N, phenolphthalein (PP) solution.

The tools used are ovens, thermometers, measuring cups, scales, distillation equipment, stoves, knives, gauze (asbestos), funnels, bottles of essential oils, plastic containers, and tools for analysis, namely Abbe refractometer, polarimeter, pycnometer, dropper pipette, measuring pipette, excisator, suction paper, water bath, stative, magnetic stirrer, burette, and Erlenmeyer.

Research Method

This research is a factorial experiment using a Completely Randomized Design (CRD) consisting of two factors. From Factor A, namely the treatment of nutmeg mace maturity levels with two levels: white (young) nutmeg mace, called

A₁

Nutmeg mace which is red (dark), is called A₂ Factor B, namely the drying time for nutmeg mace with four levels: Drying time 0 hours, called B₁

Drying time 8 hours, called B₂

Drying time is 16 hours, called B₃

The drying time is 24 hours, called B₄

In this experiment, each treatment was repeated three times. The data obtained was analyzed by means of variance and continued with the Least Significant Difference Test (LSD).

Work procedures

This research was carried out in two work stages, namely:

1. Sorting and Drying. Nutmeg mace is separated from the nutmeg seeds, then selected based on the level of maturity, namely nutmeg mace which is white (young) and nutmeg mace which is red (dark). Weigh each sample as much as 1500 grams of nutmeg mace before being subjected to drying treatment. The drying treatment was carried out in an oven at a constant temperature of 40°C with four consecutive levels, namely 0, 8, 16 and 24 hours.
2. Refining Nutmeg Mace Oil. Before the nutmeg mace resulting from the experiment was distilled, the water content of each treatment was analyzed. This nutmeg mace distillation uses a water distillation method and during distillation the steam temperature is maintained at 100°C. Nutmeg mace results 20 hours. Oil made during light-tight refining is stored in a hot bottle (dark colored bottle) and isolated from air and then ready to be analyzed for its physical and chemical properties.

Observed Variables

Nutmeg mace after being treated is analyzed for water content, then after distillation, the oil is analyzed for physical and chemical properties consisting of specific gravity, refractive index, optics and acid number as well as oil yield (yield).

Results and Discussion**Fuli Water Content**

Analysis of the water content of mace resulting from treatment by oven heating was obtained as shown in:

Nutmeg mace Water Content Table %

Level Maturity Nutmeg mace	Long Drying nutmeg mace	TEST			
		I	II	III	Average
The young nutmeg mace	0	59.20	60.17	58.84	59.4033
	8	18,84	15,57	20,04	18,1500
	16	11,81	9,73	10,42	10,6533
	24	7,80	5,89	6,62	6,7700
The old nutmeg mace	0	54,60	57,97	56,14	56,2367
	8	23,94	24,78	21,60	23,4400
	16	12,37	10,86	11,61	11,6133
	24	7,54	6,75	8,29	7,5267

The water content of nutmeg mace greatly determines the resistance of nutmeg mace to damage due to rot. Therefore, nutmeg mace needs to be dried at a safe moisture content of less than 12% (Nollet *et al* 2023). From the research results, it turns out that when drying both "the young nutmeg mace" and "the old nutmeg mace", the water content can be achieved after a drying time of 16 hours.

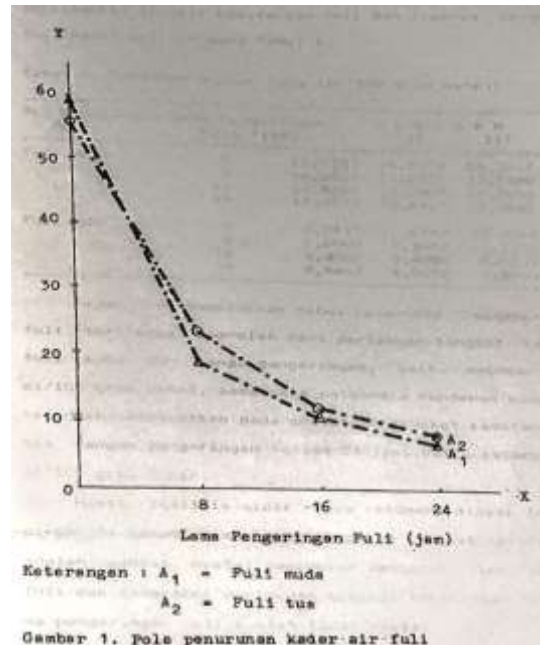
For nutmeg mace which is used as a source of essential oil, the water content really determines the amount of essential oil produced from distillation (Torres, *et al* 2022). If nutmeg mace is ready to be directly distilled at the production site, then perhaps the wet state (without drying) is more suitable because it will produce a higher yield of nutmeg mace oil compared to dried nutmeg mace.

In the production capacity of essential oil refineries, large quantities are required to be sufficient, therefore it is generally dried first and then collected and when there is sufficient production capacity, the nutmeg mace is ready to be refined.

Drying is a processing method using heat which aims to extend the shelf life of food (Sharangi *et al* 2018). Likewise, Nutmeg mace is required during storage purposes drying as a preservation measure before further processing. To export nutmeg mace oil, it should be dried first until the water content meets export standards, and if nutmeg mace is used as a source of essential oil, the drying time will greatly influence the yield and physico-chemical properties of mace oil (Radzimierska *et al* 2021).

The results of the water content analysis show that "the young nutmeg mace", with drying

treatment at a temperature of 40°C for 16 hours and above and "the old nutmeg mace", with the same drying time have met the stipulated water content requirements, namely below 12 %. Meanwhile, the other treatments, namely "the old nutmeg mace" and "the young nutmeg mace", which were dried for 8 hours without drying, had a water content above 12% so that the nutmeg mace rotted due to the activity of microorganisms.



Nutmeg Mace Oil Render

Nutmeg mace oil yield is taken based on the maturity level of the nutmeg mace and the drying time

Nutmeg mace oil yield (ml/100 grams of material)

TEST					
Level Damn bro nutmeg mace	Long Dryer bro nutmeg mace (O'clock)	I	III	III	Average
The young nutmeg mace	0	11.93 33	14.81 33	15.26 67	14.00 44
	18	14,83 33	13,23 33	12,74 00	13,60 22
	16	14,82 67	13,36 00	10,54 00	12,90 89
	24	13,93 33	13,46 67	11,26 67	12,88 89
The old nutmeg mace	0	8,846 7	10,04 67	10,46 87	9,793 4
	8	8,600 0	9,200 0	9,320 0	9,040 0
	16	8,800 0	8,400 0	8,920 0	8,706 7
	24	8,466 7	8,000 0	7,600 0	8,022 2

Shows that the average. The highest nutmeg mace oil yield was obtained from the "young

nutmeg mace" maturity level treatment and without drying, namely 14.0044 ml/100 grams of material, while the lowest average nutmeg mace oil yield was obtained from the "old nutmeg mace" maturity level treatment. " with drying for 24 hours, which is 8.0222 ml/100 grams of material.

The results of the analysis of variance in nutmeg mace oil yield (1 appendix 3) show that the influence of the maturity level of Nutmeg mace is very real, while the effect of long drying of Nutmeg mace and the interaction between treatments of Nutmeg mace maturity level and Nutmeg mace drying time was not significant.

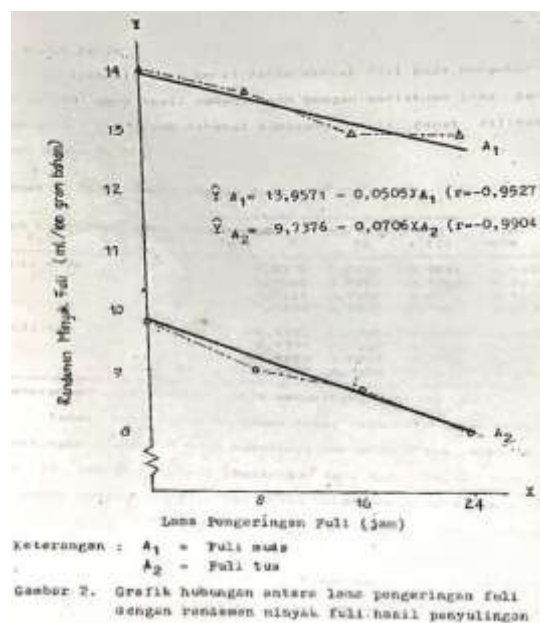
Nutmeg mace maturity level on the amount of nutmeg mace oil yield Table: BNT Test for Maturity Level of Nutmeg Mace against Yield

Mace nutmeg oil

Nutmeg Mace Maturity Level	Average	Notation*)
The young nutmeg mace	13,35111	a
The old nutmeg mace	8,89057	b

*LSD 1% = 1.48229

Shows that the oil yield obtained from "the young nutmeg mace" is greater and very significantly different from the oil obtained from "the old nutmeg mace". The difference in yield is due to the presence of "fixed oil" which binds the essential oils in the material (full). In "the old nutmeg mace" the amount of "fixed oil" is relatively greater than in "the young nutmeg mace", so that in "the young nutmeg mace" the oil is easier to refine. This situation is in accordance with the statement by (Rahardiyan, *et al* 2020) that the nutmeg oil produced in "the young nutmeg mace" is greater than "the old nutmeg mace" .. Besides that, during the fruit ripening process changes will occur in the chemical components of nutmeg mace oil cause a decrease in yield.



The average yield of oil for old mace is still below the criteria, while for young mace and the average total treatment is 13.35111 ml/100 grams of material and 11.1208 ml/gram of material, meeting the criteria stated above by (Moulian *et al* 2020).

Specific gravity

The distribution of specific gravity values for nutmeg mace oil at 20°/20° measurements from the distillation results and from the distillation results with the long drying treatment for the nutmeg mace and the level of maturity of the nutmeg mace can be seen in table 8.

Table 8. Specific Gravity of Nutmeg Mace Oil (20°/20°)

Tkt of maturity of nutmeg mace		Average Repeat Drying Time	
1	2	3	
"the young nutmeg mace"			
0	0.8973	0.8935	
0.9146	0.9018	8	0.9060 0.9152 0.9062 0.9091
16	0.9111	0.9300	0.8971 0.9130 24 0.9212
			0.9217 0.9335 0.9255
"The old nutmeg mace"			
0	0.9132	0.9132	0.9079
			0.9138
8	0.9399	0.9399	0.9188 0.9236
16	0.9155	0.9155	0.9535 0.9316
24	0.9382	0.9382	0.9411 0.9409

Note: Specific gravity data is the result of conversion

Table 8 shows that the highest average specific gravity value was obtained from a combination of 24 hour drying time and the maturity level of "the old nutmeg mace", namely 0.9409; while the lowest average specific gravity value was obtained from "the young nutmeg mace" without drying, namely 0.9018. Based on the analysis of variations in specific gravity of nutmeg mace oil, it was found that the effect of drying treatment was significant, the effect of treatment on mace maturity level was very real, while the interaction between the treatment of nutmeg mace drying time and nutmeg mace maturity level was not significant.

The Least Significant Difference Test (LSD) for the drying treatment on the specific gravity value of nutmeg mace oil is presented in the table 9.

Table 9. BNT Test for Drying Time of Nutmeg Mace on Specific Gravity of Nutmeg Mace Oil

Lama Pengeringan fulli (jam)	Rata-rata	Notasi
24	0,93318	a
16	0,92227	a b
8	0,91638	b
0	0,90782	b

*) LSD 5% = 0.01447

The specific gravity of nutmeg mace oil gets higher with increasing drying time for nutmeg mace. It can also be seen that the drying time of 24 hours is not significantly different from the drying time of 16 hours, but is different from the drying time of 0 and 8 hours; while the drying time of 0, 8 and 16 hours was not significantly different. Old mace can be seen. The effect of long drying treatment on mace weight. This type of mace oil is the formation of polymer compounds from the main components that make up the oil, namely d-pinene and d- champene compounds, which increase the specific gravity of the oil with increasing drying time.

Nutmeg mace maturity levels is presented in table 10. It can be said that the specific

gravity of the oil in "the old nutmeg mace" is greater than that in "the young nutmeg mace", or that nutmeg mace oil will increase in specific gravity with increasing fruit age.

Tkt Kematangan Fuli	Rata-rata	Notasi
Fuli Tua	0,92748	a
Fuli Muda	0,91234	b

*) LSD 1% = 0.01410

The specific gravity value of oil from old mace is very significantly different from that of "the young nutmeg mace".

The increase in the specific gravity value of nutmeg mace oil as the fruit ages (nutmeg mace) increases because the "fixed oil" hydrolyzes to form free acids such as myristic, butyric, acetic, caprylic and others. "The old nutmeg mace" contains relatively more "fixed oil" than "the young nutmeg mace".

The specific gravity value of nutmeg mace oil that meets the criteria proposed by Guenther (1952) was obtained from the treatment of "the young nutmeg mace" which was dried for 24 hours and "the old nutmeg mace" which was dried for 8, 16 and 24 hours.

Refractive Index

Table 11. Refractive Index of Nutmeg Mace Oil (120°C)

Tkt Maturity Nutmeg mace	Long Drying nutmeg mace (hours)	TEST			Average
		I	II	III	
"the young nutmeg mace"	0	1.4810	1.4753	1.4806	1.4790
	8	1.4773	1.4836	1.4805	1.4805
	16	1.4874	1.4893	1.4823	1,2863
	24	1.4871	1.4870	1.4874	1,4871
"the old nutmeg mace"	0	1,4856	1,4841	1,4806	1,4834
	8	1,4831	1,4892	1,4912	1,4878
	16	1,4910	1,4857	1,4881	1,4883
	24	1,4907	1,4891	1,4903	1,4900

Table 11. Shows that the lowest average value of refractive index is 1.4970 which was obtained from "the young nutmeg mace" which was not dried, while the highest average value was 1.4900 which was obtained from "the old nutmeg mace" which was dried for 24 hours.

Table 12. LSD Test for Fuli Drying Time on Refractive Index Mace nutmeg oil

Drying time for nutmeg mace (hours)	Average	Notation *)
24	1.48858	a
16	1.48730	a
8	1.48415	ab
0	1.48120	b

*) LSD 5% = 0.00482

The LSD test for the maturity level of nutmeg mace can be seen in table 13. This data shows that the oil produced from "the old nutmeg mace" has a greater refractive index value than

the oil produced from "the young nutmeg mace".

Nutmeg Mace Maturity Level against Refractive Index of Nutmeg Mace Oil

Maturity Level	Average	Notation*)
	1.48739	a
Young Nutmeg mace	1.48323	b

*) LSD 1% = 0.00341

Optical Rotation

Table 14. Optical rotation value of nutmeg mace oil

Maturity level Nutmeg mace	Long Drying nutmeg mace (hours)	TEST			Average
		I	II	III	
The young nutmeg mace	0	(+)8.57	(+)15.67	(+)16.07	13,437
	8	(+)10.78	(+)15.45	(+)11,30	12,510
	16	(+)10,73	(+)12,08	(+)8,18	10,330
	24	(+)7,60	(+)6,85	(+)4,58	6,343
The old nutmeg mace	0	(+)12,40	(+)10,20	(+)10,37	10,990
	8	(+)6,93	(+)8,20	(+)7,35	7,493
	16	(+)7,75	(+)8,55	(+)7,65	7,983
	24	(+)9.12	(+)9.67	(+) 7.60	8,797

Table 14 shows that the lowest average value of optical rotation is (+) 6.343 which was obtained from "the old nutmeg mace" which was dried for 24 hours, while the highest average value of optical rotation was (+) 13.437 which was obtained from "the young nutmeg mace" which is not dried.

Table 15. LSD Test Duration of drying nutmeg mace against rotation

Drying time for nutmeg mace (hours)	Average	Notation*)
0	(+)12.2133	a
8	(+)10.0017	ab
16	(+)9.1567	b
24	(+)7.5700	b

*) LSD 5% = 2.5255

The decrease in the value of the optical rotation of the oil is due to the drying out of the mace, the more the chemical components of the mace oil change or are damaged, the longer the constituents take, especially the main components of the oil, namely d-pinene and d-champene which have active optical properties and rotate light in the plane of polarization to the right. Damage to these chemical components may be caused by polymerization reactions oxidation or resinification (reactions in the unsaturated group, namely terpenes, where this reaction is catalyzed by the presence of heat).

Table 16. LSD Test for nutmeg mace Maturity Level against Round Optics Nutmeg mace oil

Maturity Level	Average	Notation*)
The young nutmeg mace	(+)10.6550	a

The old nutmeg mace	(+)8.8158	b
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LSD 5% = 1.7859

The low value of optical rotation in "the old nutmeg mace" is because the "old nutmeg mace" contains a lot of "fixed oil" compared to "the young nutmeg mace" so that during distillation some of the "Fixed oil" will also be distilled which will cause a decrease in rotation oil optics. This situation can also be caused by biochemical processes during the fruit ripening phase which cause changes in the main components of the oil which are optically active.

Table 17. LSD Test for Interaction of Fuli Maturity Level and Time Mace Drying against Optical Rotation

Level Maturity Fuli	Long Fuli Drying (Hours)	Average	Notasi*)
The young nutmeg mace	0	(+)13,4367	a
The young nutmeg mace	8	(+)12,5100	a
The young nutmeg mace	0	(+)10,9900	ab
The young nutmeg mace	16	(+)10,3300	ab
The old nutmeg mace	24	(+)8,7967	bc
The old nutmeg mace	16	(+)7,9833	bc
The old nutmeg mace	8	(+)7,4933	BC
The young nutmeg mace	24	(+)6.3433	c

LSD 5% = 3.5716

The LSD test for the interaction between the length of drying nutmeg mace and the level of maturity of the nutmeg mace varies greatly, where in "the young nutmeg mace" there is a tendency for the optical rotation value of the oil to decrease due to the length of time the nutmeg mace is dried, whereas in "the old nutmeg mace" this situation is not the case where all drying time treatments for "the old nutmeg mace" were not significantly different (see table 17).

The average optical rotation value of refined nutmeg mace oil largely meets the criteria for the physical properties of full oil proposed by (Grujin *et al* 2023), namely nutmeg mace oil from "the old nutmeg mace" which is dried for 0.8, 16 and 24 hours. , while for "the young nutmeg mace" the drying time is 16 and 24 hours.

Table 18. Oil Acid Number Values Nutmeg mace

Maturity level Nutmeg mace	Long Drying nutmeg mace (hours)	TEST			Ratarata
		I	II	III	
The young	0	2,06	1,66	2,06	1,9267
	8	1,90	1,88	2,13	1,9700

nutmeg	16	2,22	1,90	1,89	2,0033
mace	24	2,30	2,21	2,36	2,2900
The old	0	2,01	2,19	1,62	1.9400
nutmeg	8	2.02	1.99	2.02	2.0100
mace	16	2.29	2.56	2.17	2.3400
	24	2.76	2.98	2.49	2.7433

Table 18 shows that the lowest average value of acid number is 1.9267 which was obtained from "the young nutmeg mace" which was not dried, while the average value of the highest acid number was 2.7433 which was obtained from "the old nutmeg mace" which was dried for 24 hours.

Table 19. *Drying Time Test for Nutmeg Mace Against Acid Number nutmeg mace Oil*

Nutmeg mace drying time (hours)	Average	Notation *)
24	2.5167	a
16	2.1717	b
8	1.9900	b
0	1.9333	b

The water content of nutmeg mace greatly determines the resistance of nutmeg mace to damage due to rot. Therefore, mace needs to be dried at a safe water content of less than 12% (Beyazay, B. 2015). From the research results it turns out that when drying both "the young nutmeg mace" and "the old nutmeg mace", the water content can be achieved after a drying time of 16 hours. For nutmeg mace which is used as a source of essential oil, the water content really determines the amount of essential oil produced by distillation (Paat *et al* 2022). If nutmeg mace is ready to be directly distilled at the production site, then it may be in good condition. Wet (without drying) is more suitable because it will produce a higher yield of nutmeg mace oil compared to dried nutmeg mace.

In the production capacity of essential oil refining, large quantities of nutmeg mace are required to be sufficient, therefore it is generally dried first and then collected and when there is sufficient production capacity, the nutmeg mace is ready to be refined. Drying is a processing method using heat which aims to extend the shelf life of food (Rahardiyan *et al* 2020). Likewise, mace is needed during storage purposes drying as a preservation measure before further processing. To export nutmeg mace oil, it should be dried first until the water content meets export standards, and if nutmeg mace is used as a source of essential oil, the drying time will greatly influence the yield and physico-chemical properties of nutmeg mace oil hydroprocessing may also have an important role in the valorization of other biorefinery streams, such as lignocellulose, for the production of high value-added chemicals (Bagnato *et al* (2021).

The results of the water content analysis show that "the young nutmeg mace" with drying treatment at a temperature of 40°C for 16 hours and above and "the old nutmeg mace" with the same drying time have met the stipulated water content requirements, namely below 12%. Meanwhile, the other treatments, namely "the old nutmeg mace" and "the young nutmeg mace" which were dried for 8 hours without drying, had a water content above 12% so that the nutmeg mace rotted due to the activity of microorganisms. The amount of refined nutmeg mace oil yield is taken based on the maturity level of the nutmeg mace and the drying time.

Shows that the highest average nutmeg mace oil yield was obtained from the "young nutmeg mace" maturity level treatment and without drying, namely 14.0044 ml/100 grams of material, while the lowest average nutmeg mace oil yield was obtained from the maturity level treatment. "The old nutmeg mace" with drying for 24 hours, which is 8.0222 ml/100 grams of material.

Conclusion

The water content of nutmeg mace greatly determines the resistance of nutmeg mace to damage due to rot. Therefore, nutmeg mace needs to be dried at a safe water content of less than 12% (Beyazay, B. 2015). From the research results it turns out that when drying both "the young nutmeg" and "the old nutmeg mace", the water content is can be achieved after a drying time of 16 hours. For nutmeg mace which is used as a source of essential oil, the water content really determines the amount of essential oil resulting from distillation. If nutmeg mace is ready to be directly distilled at the production site, it may be more wet (without drying) suitable because it will produce a higher yield of nutmeg mace oil compared to dried nutmeg mace.

In the production capacity of essential oil refining, large quantities of nutmeg mace are required to be sufficient, therefore it is generally dried first and then collected and when there is sufficient production capacity, the nutmeg mace is ready to be refined. Drying is a processing method using heat which aims to extend the shelf life of food (Ugolini *et al* 2023). Likewise nutmeg mace is required during storage purposes drying as a preservation measure before further processing. If nutmeg mace is used as a source of essential oil, the drying time greatly influences the yield and physico-chemical properties of nutmeg mace oil.

The results of the water content analysis show that "the young nutmeg mace" with drying treatment at a temperature of 40°C for 16 hours and above and "the old nutmeg mace" with the same drying time have met the stipulated water content requirements, namely below 12%. Meanwhile, the other treatments, namely "the old nutmeg mace" and "the young nutmeg mace" which were dried for 8 hours without drying, had a water content above 12% so that the nutmeg mace rotted due to the activity of microorganisms. The amount of refined nutmeg mace oil yield is taken based on the maturity level of the nutmeg mace and the drying time shows that the highest average yield of nutmeg mace oil was obtained from the "young nutmeg" maturity level treatment and without drying, namely 14.0044 ml/100 grams of material, while the lowest average yield of nutmeg mace oil was obtained from the "maturity level " treatment the old nutmeg mace" with drying for 24 hours, which is 8.0222 ml/100 grams of material.

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