Variation in yield, morphology, and phytochemical profiles of essential oils of nutmeg populations in Lampung

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Abstract. Nutmeg is native to the Moluccan islands of Indonesia, with primary products being seeds, mace, and essential oils. These are widely used in the food industry, pharmaceuticals, and cosmetics. Nutmeg has been widely grown in Indonesia, including in Lampung. The study's objective was to observe yield, morphological characteristics, and chemical constituents of nutmeg oil of the nutmeg germplasm population grown in Lampung. Five populations belonging to the farmers were selected based on yield. Observation on yield tree¹ and morphology was carried out from each population. Analyses of essential oil were taken from mature nutmeg collected from each selected tree, bulked, and analyzed population¹ using Gas Chromatography-Mass Spectrophotometry. Results showed there was a variation in yield among the population from 4972 to 6140. Morphological characteristics also showed variation within and between populations. A variation in the essential oil contents was observed. The number of detected chemical constituents in the essential oil of nutmeg seed varies from 26 to 39 compounds. Some of the major components found in the nutmeg oil were sabinene, myristicin, β-phellandrene, P-menth-1-en-4-ol, α-pinene, and gamma-terpinene. Myristicin content varies from 13.76 % to 27.99 %. The selected trees may be recommended as genetic material for nutmeg breeding programs.

Keywords: Myristica fragrans, GCMS, dendrogram, chemical constituents, selection

1. Introduction
Nutmeg (Myristica fragrans Houtt.) is one of the major spices, native to Indonesia [1, 2]. Indonesia is also known as the center of origin of several nutmeg species [3, 4], such as M.argentea (Papua nutmeg), M. fatua (Wegio nutmeg), M. iners Bl (Penara), M. tesmanii Miq (Durenan), and M. succedanea (Maba nutmeg) [5]. In addition, a large genetic variation is found in the Moluccan islands in Ternate, Tidore, Bacan, Halmahera, Banda, and North Sulawesi (Sangihe, Talaud, Siau), and Papua [6, 7].

The main products of nutmeg are seeds and mace. They are used as spices for seasoning, cooking, baked goods, and spices mix such as curry powder. Besides that, nutmeg seeds and mace could be processed as an essential oil with higher economic value. Nutmeg oil is used in the perfumery industries and the pharmaceutical industries. Nutmeg oil has antioxidants, anticonvulsants, analgesic, anti-inflammatory, antidiabetic, antibacterial, and antifungal properties.
Nutmeg cultivation has long been developing in Indonesia and several countries such as Malaysia, Sri Lanka, India, Grenada, etc. In 2018 six provinces had the largest nutmeg plant population in Indonesia, respectively, from the largest, namely North Maluku, Maluku, West Papua, North Sulawesi, Aceh, and Central Sulawesi. Apart from these provinces, nutmeg cultivation continues to expand to other parts of Sumatra and Java. Smallholder plantations produce around 99% of Indonesia's nutmeg. Areas of nutmeg production in Indonesia are in North Maluku, Maluku, North Sulawesi, West Papua, Aceh, West Sumatra, and West Java, which accounted for a contribution of 93.92% to the total Indonesian nutmeg production [8].

Although it was not recorded as the center of nutmeg production, nutmeg has also been grown by farmers in Lampung province for several decades. Lampung nutmeg has been known in the domestic and international markets. The volume and value of Lampung nutmeg exports tend to increase [9]. However, information on the diversity of nutmeg plants in Lampung is still limited.

Genetic diversity can be identified using morphological characters (phenotypes), based on simple Mendelian inheritances, such as shape, color, size, weight, etc [10]. Morphological markers have been studied in various plant species [11]. Observation of morphological characteristics may also be used for assessing agronomic traits [12] and identifying varieties. By characterizing its morphological and agronomic characteristics, it is possible to identify the ideal type of nutmeg or superior nutmeg that can be recommended as parents for varietal improvement [13]. Besides morphological and agronomic characters, evaluation of complete phytochemistry is also needed.

Lampung nutmeg has quality characteristics according to the Indonesian National Standard and contains low levels of safrole and methyl eugenol [14]. Safrole and methyl eugenol are hallucinogenic and carcinogenic, so their concentration must be under the specified standard threshold. This information is important as breeding material for varietal development to assemble superior nutmeg varieties with low safrole and methyl eugenol levels. Therefore, Lampung nutmeg should be maintained to ensure the sustainability of nutmeg cultivation in the future. The purpose of this study was to observe the yield potential and characterize the morphology and evaluate phytochemical properties of nutmeg accessions in Lampung.

2. Material and method

This study was undertaken in the South Lampung Regency, Lampung Province. Five nutmeg plantations belonging to farmers were identified and selected as locations for observation (Table 1). For observation, sample trees were selected from each location based on the best growth performances. Trees selection was based on the guidance for nutmeg trees [15].

| No | Farmers/Village/Districts | Origin | Year of planting | Acreage (ha) | Population | Selected trees | Altitude (m asl) |
|----|---------------------------|--------|------------------|-------------|------------|---------------|-----------------|
| 1  | Fauzi, Karya Tunggal, Katibung | Ambon | 1985             | 0.50        | 50         | 14            | 107             |
| 2  | Sapwanto, Sukajaya, Katibung | Bogor  | 1960             | 0.80        | 76         | 10            | 162             |
| 3  | Basribudin, Canti, Rajabasa | Maluku | 1950             | 0.60        | 57         | 9             | 80              |
| 4  | Bustomi, Sidomekar, Katibung | Aceh   | 1985             | 2.0         | 127        | 10            | 168             |
| 5  | Muslimah, Karya Tunggal, Katibung | Sulawesi | 1985             | 0.50        | 55         | 9             | 173             |

2.1. Observation on morphological characters

Observation of morphological characters was conducted on the selected parent trees in each location, showing the best performance. The observed variable refers to the nutmeg descriptor in general. Morphological characters observed include qualitative and quantitative characters. Qualitative characters included are leaves (shape, color, base, tip, and margin) and fruit (shape, color, and base). Quantitative characters on leaf include length, width, petiole length, while fruit and seeds include...
weight, length, diameter, peduncle length, and fruit flesh thickness. Twenty samples (fruits or leaves) were observed for each selected tree. Each data was calculated for average, standard deviation, and coefficient of variation.

2.2. Observation on yield tree

Observations on yield were carried out on selected trees in each location by calculating the accumulation of fruits harvested tree⁻¹ year⁻¹.

2.3. Evaluation of oil quality

2.3.1. Oil distillation

Oil distillation was performed on samples of fully mature seeds with blackish-brown skin, and mace, separately. Seeds tree⁻¹ are harvested, then bulked for sortation, separated from their mace, then dried under the sun till dry. Dried nutmeg seeds are separated from the shell, then thinly sliced or crush finely and put on distillation chamber. Distillation is done for 7 hours. Moreover, mace is sun-dried, then directly put into the distillation chamber without crushing. The yield of essential oil is calculated based on the amount of essential oil obtained divided by the weight of total material distilled times 100% (v/w).

2.3.2. Analysis of oil chemical compounds

Analysis of chemical compounds in oil using Gas Chromatography-Mass Spectrophotometry/GCMS (Shimadzu) at the DKI Health Laboratory. The GCMS conditions used are: capillary column DB-5ms, inner column diameter 0.25 mm, film layer thickness 0.25 um, the gas carrier was helium at a pressure 100 kPa, injection volume 2 ul using split injection technique. Identification of chemical components was made by comparing fractions detected with library compounds by NIST (National Institute of Standard and Technology) based on the value of LRI (Linear Retention Indices).

3. Result and discussion

3.1. Observation on morphological characters

The results of the observation of qualitative morphological characteristics on leaves and fruits (Table 2) showed differences among nutmeg populations. The characters that demonstrated differences were in leaf shape, color, leaf base, and margin revealed differences among populations. The difference in the character of the fruit is in the shape, color, and base of the fruit. Bustomi and Muslimah populations are different in leaf shape and base, while the Basri population differs from the others in leaf margin. The fruit shape in the Bustomi is similar to the Fauzi population, but the fruit color and base are different from the others. The population of Sapwanto and Muslimah has similar fruit shapes, while Basri populations differ from the others, having oblate fruits.

The observation results on quantitative morphological characters in the Lampung nutmeg population (Table 3) showed a variation in the fruit weight from 47.96 g - 63.98 g, of which Bustomi's (Katibung) nutmeg was the heaviest. This result is within the range of the fresh fruit of Banda nutmeg variety were 51.67-67.33 g fruit⁻¹. Nutmeg with a medium fruit size of around 40-50 g is also commonly found in Sangihe Besar and Siau [16], and the nutmeg population in Lampung [17].

The fresh seed weight of the nutmeg population studied ranged from 7.61 to 11.32 g seed⁻¹, meeting the quality standards. The quality standard for seed weight is 5.8-3.3 g of dry seeds (Directorate General of Plantations 2012) equivalent to 7.1-11.8 g of fresh seeds. The fresh weight of the superior varieties seeds that have been released is 9.75 – 10.25 g seed⁻¹, but lower than the superior varieties of nutmeg in India which large seed sizes with a fresh seed weight of 13-16 g [18]. The size of the seeds from the results of this study is also equivalent to the results of [17], who reported the diversity of the size of nutmeg seeds in Lampung ranging from 4.2-12.4 g fresh seeds.
Table 2. Qualitative morphological characters on fruits and leaves of the selected trees in the five nutmeg populations in Lampung.

| No. | Morphological characters | Fauzy, Karya Tunngal, Katibung | Sapwanto, Sukajaya, Katibung | Basri Canti, Rajabasa | Bustomi Sidomekar, Katibung | Muslimah, Karya Tunngal, Katibung |
|-----|-------------------------|-------------------------------|-------------------------------|----------------------|-----------------------------|----------------------------------|
|     | Leaf                    |                               |                               |                      |                             |                                  |
| 1   | Shapes                  | Elliptic                      | Elliptic                      | Elliptic             | Ellips – obovate             | Oblong                           |
| 2   | Color                   | Dark Green                    | Dark Green                    | Green                | Dark Green                  | Dark Green                       |
| 3   | Base                    | Acute                         | Acute                         | Acute                | Obtus                        | Obtus                            |
| 4   | Tip                     | Acuminate                     | Acuminate                     | Acuminate            | Acuminate                   | Acuminate                        |
| 5   | Margin                  | Entire                        | Entire                        | Undulate             | Entire                       | Entire                           |
|     | Fruit                   |                               |                               |                      |                             |                                  |
| 1   | Shapes                  | Round                         | Pear shaped                   | Oblate               | Round                        | Pear shaped                      |
| 2   | Color                   | Golden yellow                 | Golden yellow                 | Golden yellow        | Greenish-yellow              | Light yellow                     |
| 3   | Base                    | Rotundus                      | Rotundus                      | Rotundus             | Curved                       | Rounded                          |

A variation in leaf size was also observed. The leaf size of nutmeg belonged to Bustomi (Katibung) has the longest leaf length. In addition, the nutmeg plant belonging to Bustomi (Katibung) has the tallest tree, above 11 m. The coefficient of variation (CV) of fruit length in the Basri population was > 30 %, and the Muslimah population for peduncle length. The seed length, mace weight, and leaf length were also the highest, while the Sapwanto population showed the apex tip. The high value of CV in this study demonstrated high variation among sample trees. The high CV may be related to the different genetic backgrounds of each sample as a result of outcrossing. In addition to genetic differences, the population also derived from a different origin.

Table 3. Quantitative morphological characters of the selected nutmeg trees in the five nutmeg populations in Lampung.

| Morphological characters | Fauzy, Karya Tunngal, Katibung | Sapwanto, Sukajaya, Katibung | Basri Canti, Rajabasa | Bustomi Sidomekar, Katibung | Muslimah, Karya Tunngal, Katibung |
|-------------------------|-------------------------------|-------------------------------|----------------------|-----------------------------|----------------------------------|
| Weight (g) Mean         | 47.96 ± 5.88                  | 55.56 ± 10.27                 | 61.94 ± 10.33        | 63.98 ± 10.36               | 48.91 ± 9.03                     |
| CV (%)                  | 12.26                         | 18.48                         | 16.77                | 17.68                       | 18.45                           |
| Length (cm) Mean        | 5.18 ± 0.32                   | 5.03 ± 0.31                   | 5.08 ± 0.28          | 5.00 ± 0.35                 | 4.48 ± 0.31                      |
| CV (%)                  | 6.19                          | 6.15                          | 35.54                | 7.09                        | 7.75                            |
| Diameter (cm) Mean      | 4.44 ± 0.19                   | 4.74 ± 0.31                   | 4.86 ± 0.29          | 5.08 ± 1.10                 | 4.48 ± 0.31                      |
| CV (%)                  | 4.22                          | 6.54                          | 5.93                 | 20.12                       | 6.92                            |
| Peduncle length (cm) Mean | 1.72 ± 0.16              | 1.81 ± 0.42                   | 1.79 ± 0.44          | 2.04 ± 0.45                 | 2.27 ± 0.79                      |
| CV (%)                  | 8.94                          | 22.81                         | 24.82                | 21.90                       | 34.79                           |
| Flesh thickness (cm) Mean | 1.04 ± 0.08              | 1.09 ± 0.09                   | 1.20 ± 0.10          | 1.23 ± 0.16                 | 1.06 ± 0.10                      |
| CV (%)                  | 7.48                          | 7.32                          | 8.09                 | 13.33                       | 9.70                            |
| Seed                    |                               |                               |                      |                             |                                  |
| Weight (g) Mean         | 9.62 ± 0.88                   | 9.43 ± 1.72                   | 9.80 ± 1.52          | 9.29 ± 1.01                 | 8.61 ± 1.51                      |
| CV (%)                  | 9.18                          | 18.26                         | 15.55                | 10.92                       | 17.54                           |
| Length (cm) Mean        | 3.02 ± 0.10                   | 2.80 ± 0.20                   | 2.82 ± 0.66          | 2.93 ± 0.19                 | 2.92 ± 0.15                      |
| CV (%)                  | 3.36                          | 7.26                          | 21.49                | 6.55                        | 5.18                            |
The dendrogram generated based on qualitative and quantitative characters (Figure 1) shows that the five nutmeg populations studied were divided into two main groups, namely group 1 consisting of only one tree (belongs to the Sapwanto population) group 2 consisting of 51 selected trees. Almost all of the nutmeg trees studied were in one group, indicating that the five Lampung nutmeg populations studied had high uniformity. While nutmeg tree no. 9 from the Sapwanto population shows differences with the other nutmeg trees. The nutmeg seeds planted in the five populations came from different origins, nutmeg trees in Bustomi from Aceh, Basribudin from Maluku, Fauzi from Ambon, Muslimah from Sulawesi, and nutmeg of Sapwanto from Bogor. The high uniformity among nutmeg populations may suggest that the initial genetic background of the seed sources was uniform, namely Banda nutmeg, which is genetically less diverse. Besides that, the location of the nutmeg populations is adjacent to each other, with similar/uniform agro-climatic conditions, so that the influence of the environment on plant growth may not be significant.

**Figure 1.** Dendrogram of the relationship among five nutmeg populations in Lampung based on the qualitative and quantitative morphological characters.
Notes: F-Fauzy, S-Sapwanto, Ba-Basribudin, Bu-Bustomi, M-Muslimah
However, all nutmeg trees selected from the Fauzi population are almost gathered in one group, except for F18. Several plants from the Sapwanto population were also included in the group. Plants from Sapwanto, Bustomi, Muslimah, and Basribudin were scattered into several groups and mixed with other populations (Figure 1).

3.2. Observation on yield
Observation on yield (Table 4) showed that the average yield tree\(^{-1}\) in each population vary, which may be due to different genetic background and plant age (Table 1). The highest yield tree\(^{-1}\) year\(^{-1}\) was obtained from the Bustomi Katibung population with an average harvest of 6140 fruits, followed by Basribudin in Rajabasa 6100 fruits. The lowest was shown by nutmeg trees in the Muslimah Katibung population, below 5000 fruits tree\(^{-1}\) year\(^{-1}\). The yield performances meet the criteria for high-yielding nutmeg trees [15] and are in accord with the nutmeg superior varieties released.

Nutmeg farmers rarely implement recommended cultivation technology. Differences in yields between populations may be attributed to genetic background and plant age. Basribudin’s nutmeg plantation is the oldest (planted in 1950) among the other populations, followed by the Sapwanto population (planted in 1960), while the other three populations Fauzi, Bustomi, and Muslimah, have the same plant age (planted in 1985). The last three populations are grown in Katibung but different villages, so that the agro-climate condition may not be different. The population of Bustomi, which is also in Katibung, has the highest yield tree\(^{-1}\) year\(^{-1}\), so it is considered superior compared to the other populations.

Table 4. The yield of nutmeg of the selected trees of the five nutmeg populations in Lampung.

| No | Nutmeg population              | Average yield (number of fruits tree\(^{-1}\) year\(^{-1}\)) |
|----|--------------------------------|-----------------------------------------------------------|
|    |                                | Mean ± Sd        | Coefficient of variation (%) |
| 1  | Fauzy, Karya Tunggal, Katibung | 5960 ± 813       | 13.64                       |
| 2  | Sapwanto, Sukajaya, Katibung   | 5007 ± 1188      | 23.72                       |
| 3  | Basribudin, Canti, Rajabasa    | 6100 ± 1121      | 18.37                       |
| 4  | Bustomi, Sidomekar, Katibung   | 6140 ± 1308      | 21.30                       |
| 5  | Muslimah, Karya Tunggal, Katibung | 4972 ± 1166  | 23.44                       |

3.3. Evaluation of oil quality
3.3.1. Oil distillation
The essential oils content obtained from the distillation of dried mature nutmeg seeds ranged from 2.80 to 3.75%, and from mace was 10.83 to 19.49% (Table 5). A report showed that nutmeg seeds’ essential oil content varies from 2 to 15%, while the oils of mace were 7-18% [16]. The essential oil content of mature dried nutmeg seed from this study is low (less than 10%), whereas from mace fairly high (above 10%). Such low oil content from five populations in this study may be related to differences in the genetic background and environmental condition. A study reported higher oil content from nutmeg collected from Ambon, with oil content from mature and immature seeds being 11.92% and 11.99 %, respectively [19]. A low oil content from nutmeg seeds was also reported by several researchers. A low essential oil content from seeds and mace collected from North Sulawesi islands i.e 2.41 % 3.66 % [20]. However, [19] obtained a slightly higher oil yield from the seeds of the islands of North Sulawesi and the mainland were 4.89-5.11% and 4.08-5.01%, respectively.

Other reports stated that the size of the material and the duration of distillation affect the oil content of nutmeg seeds. The smaller the material's size and the longer the distillation time, the lower the content [21] [22]. The highest oil content was obtained from 3 hours of distillation, but for other quality parameters that meet SNI criteria obtained at 6-9 hours of distillation [22]. In this study, the
duration of distillation was 7 hours. This may be the reason the oil content is low and does not fulfill the SNI 2006 and ESA/2018 [23].

The color of essential oil of nutmeg seeds and mace from this study was clear yellowish with an aroma specific to nutmeg, and this is in accord with the report by [1], [20], and [24], but different from the nutmeg oil from Ambon which was clear/colorless [19].

Table 5. The essential oil contents of nutmeg seeds and mace.

| No | Nutmeg population                        | Essential oils content (%) |
|----|------------------------------------------|----------------------------|
|    |                                          | Mature seeds | Mace         |
| 1  | Fauzy, Karya Tunggal, Katibung           | 3.00         | 10.83        |
| 2  | Sapwanto, Sukajaya, Katibung,            | 2.80         | 19.49        |
| 3  | Basri Budin, Canti, Rajabasa             | 3.50         | -            |
| 4  | Bustomi, Sidomekar, Katibung             | 3.75         | 19.15        |
| 5  | Muslimah, Karya Tunggal, Katibung        | 3.07         | 16.21        |

Indonesian National Standard (SNI) 06-2388-2006: No less than 5.0
European Spice Association (ESA): 5.0-6.5

Note: - not analyzed due to not sufficient samples.

3.3.2. Analysis of oil chemical compounds
The result of GCMS analysis of bulk seeds of selected mother trees of nutmeg from each population shows that the number of detected chemical constituents varies from 26 to 39, with the Fauzy population having the highest number of components identified (Table 6). The major components identified were sabine (8.23 % - 30.81 %), myristicin (13.76 % - 27.99 %), α-pinene (5.32 % - 17.91 %), P-menth-1-en-4-ol (6.66 % - 15.53 %), and gamma-terpinene (4.57-7.61 %), with different percentages between populations. Beta-phellandrene is also a major compound but only detected in Fauzy, Sapwanto, and Basribudin populations.

The results of this study are somewhat similar to [25] which produces the highest main components i.e. sabine (23-52%) followed by myristicin (1.58-26.41 %), then α-pinene (4.06-21, 45 %), β-pinene (2.54-13.15 %), limonene (2.05-6.52 %), 4-terpineol or terpine-4-ol (2.36-6.88%), safrole (0.43-5.86%) and elemicin (0.81-14.38%) from this nutmeg germplasm in Sukabumi. This study is also similar to [26] in that the chemical components of nutmeg quality consist of hydrocarbon monoterpenes and aromatic ether components. Hydrocarbon monoterpenes are α-pinene, β-pinene, sabine, and 4-terpineol, while the aromatic ether components i.e., myristicin, and safrole, elemicin and methyl eugenol was not detected from this study (Table 6).

Indonesian nutmeg is categorized as an East Indian nutmeg, characterized by high myristicin, and safrole levels, and the opposite with West Indian nutmeg contains low myristicin and safrole [27]. Sabine content was found > 30 % in Sapwanto and Bustomi population, while Fauzi dan Muslimah > 17 %, and Basri was the lowest with only 8.23 %. The highest α-pinene was shown by the Bustomi population, followed by Sapwanto. The other populations were almost similar content. The population of Fauzy, Basri, and Muslimah produced oil with high myristicin content > 23 %, while from Sapwanto and Bustomi population less than 15 %. The β-pinene was only detected from the Basri population and not from the others. Another component such as α-limonene, was detected in two populations only, namely Bustomi and Muslimah. Neither of them contained α-phellandrene, which were seen from three populations, namely Fauzy, Sapwanto, and Basribudin. P-menth-1-en-4-ol was detected in all populations, with the highest percentage found in the Basri population.
There were variations in yield of fruit tree year among the nutmeg population. The highest harvest was obtained from the Bustomi population. Variation was also observed in both qualitative and quantitative morphological characters. The essential oil content of mature nutmeg seeds varies from 2.80 to 3.75%. In contrast, the content of the essential oil in mace was 10.83 -19.49%. The content is slightly high levels of safrole were detected in several populations, exceeding the threshold value. The lower safrole content was obtained from Banda nutmeg from Maluku, and Ambon co-

**Table 6. GCMS profiles of nutmeg oil derived from five populations in Lampung.**

| No. | Chemical constituent     | Location of nutmeg population | %     |
|-----|--------------------------|--------------------------------|-------|
|     |                          | Fauzy, Karya Tunggal, Katibung |       |
|     |                          | Sapwanto, Sukajaya, Katibung, |       |
|     |                          | Basri Canti, Rajabasa          |       |
|     |                          | Bustomi, Sidomekar, Katibung   |       |
|     |                          | Muslimah, Karya Tunggal, Katibung |     |
| 1   | Pinene                   | 5.32                           | 14.24 |
|     |                          |                                 | 6.00  |
| 2   | Sabinene                 | 17.64                          | 30.27 |
|     |                          |                                 | 8.23  |
|     |                          |                                 | 30.81 |
|     |                          |                                 | 17.26 |
| 3   | β-pinene                 | *                              | *     |
|     |                          |                                 | 5.99  |
|     |                          |                                 | *     |
| 4   | β-myrcene                | 1.62                           | 2.31  |
|     |                          |                                 | 1.50  |
|     |                          |                                 | 2.24  |
| 5   | α-phellandrene           | 0.96                           | 1.08  |
|     |                          |                                 | 1.23  |
|     |                          |                                 | *     |
|     |                          |                                 | 0.51  |
| 6   | α-terpinene              | 2.57                           | 4.08  |
|     |                          |                                 | 4.72  |
|     |                          |                                 | 3.11  |
|     |                          |                                 | 3.37  |
| 7   | α-limonene               | *                              | *     |
|     |                          |                                 | 7.27  |
|     |                          |                                 | 5.37  |
| 8   | β-phellandrene           | 8.36                           | 7.92  |
|     |                          |                                 | 6.30  |
|     |                          |                                 | *     |
|     |                          |                                 | *     |
| 9   | Gamma terpinene          | 4.57                           | 5.95  |
|     |                          |                                 | 7.61  |
|     |                          |                                 | 4.60  |
|     |                          |                                 | 5.18  |
| 10  | α-terpinolene            | 1.81                           | 1.67  |
|     |                          |                                 | 2.26  |
|     |                          |                                 | 1.80  |
|     |                          |                                 | 1.64  |
| 11  | P-menth-1-en-4-ol        | 12.39                          | 7.34  |
|     |                          |                                 | 15.53 |
|     |                          |                                 | 6.66  |
|     |                          |                                 | 11.74 |
| 12  | α-terpineol              | 2.31                           | 0.72  |
|     |                          |                                 | 1.54  |
|     |                          |                                 | 0.85  |
|     |                          |                                 | 1.70  |
| 13  | Safrole                  | 2.77                           | 2.79  |
|     |                          |                                 | 4.41  |
|     |                          |                                 | 2.40  |
|     |                          |                                 | 4.15  |
| 14  | Eugenol (P-allylguaiacol) | 1.01                           | 0.72  |
|     |                          |                                 | 1.48  |
|     |                          |                                 | 0.62  |
|     |                          |                                 | 1.37  |
| 15  | Isoeugenol               | 3.24                           | 0.71  |
|     |                          |                                 | 1.27  |
|     |                          |                                 | *     |
|     |                          |                                 | 3.24  |
| 16  | Myristicin               | 23.34                          | 13.76 |
|     |                          |                                 | 26.51 |
|     |                          |                                 | 14.91 |
|     |                          |                                 | 27.99 |
| 17  | Elemicin                 | 1.16                           | *     |
|     |                          |                                 | 0.64  |
|     |                          |                                 | 0.56  |
|     |                          |                                 | 1.26  |

| Number of components | 38 | 26 | 27 | 27 | 32 |

Note: Chemical components with < 0.50 % are not listed

Slightly high levels of safrole were detected in several populations, exceeding the threshold value. The lower safrole content was obtained from Bustomi populations (2.40 %) similar to those obtained from Maluku and Ambon 2.44-2.46 %, respectively [17]. The highest content of safrole was found in the Muslimah population (4.15 %). ISO 3215 (2002) [28] determined the safrole content 0.5-2.5 %. The results of this study are not in accord with [14] which states that the levels of safrole in Lampung nutmeg oil are below the standard threshold value. The population studied in this research was different from those reported by [14]. Variations in the numbers of chemical components and major compounds were reported. A report indicated that Banda nutmeg from Maluku, and Ambon contains 28 and 31 peaks, respectively [17]. Analysis of nutmeg oil from India of 65 nutmeg germplasm accessions showed the main component is myristicin, elemicin, safrone, and sabinene [29]. Several minor compounds were detected only in a specific population. These compounds may be used as markers to distinguish between populations. The differences in the chemical components of essential oils are the result of secondary metabolites that are influenced by genetic, environmental, and ontogenetic factors [30, 31].

4. Conclusion
There were variations in yield of fruit tree year among the nutmeg population. The highest harvest was obtained from the Bustomi population. Variation was also observed in both qualitative and quantitative morphological characters. The essential oil content of mature nutmeg seeds varies from 2.80 to 3.75%. In contrast, the content of the essential oil in mace was 10.83 -19.49%. The content is
classified as moderate to high. The number of chemical constituents detected in nutmeg seeds’ volatile oil varies from 26 to 39. The main chemical components are sabinene, myristicin, α-pinene, P-menth-1-en-4-ol, and gamma-terpinene.

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