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# Volatile Compound Profiles of Indonesia's 'Cilembu' Sweet Potato (*Ipomea batatas* L. var. Rancing): Impact of Storage

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## ABSTRACT

*Native to the west Java Region, Indonesia, 'Cilembu' sweet potatoes (Ipomea batatas L. var Rancing) is highly valued for its unique taste. However, the volatile compound profile of Cilembu sweet potato (CSP) has not been fully characterized. Therefore, this study aimed to analyze volatile compounds in CSP after conventional baking and storage, compared to Manohara sweet potato (MSP). Volatile compounds were analyzed using Gas Chromatography Mass Spectrometry (GCMS). The result showed that benzaldehyde was a key volatile compound in fresh CSP tubers. In comparison, MSP was dominated by terpenes as the main components, including α-gurjunene, methoxy-phenyl-oxime, and cymene. During storage, the sugar content in CSP surged due to starch hydrolysis, leading to the formation of Maillard reaction products, such as furfural, benzaldehyde, and 2-furan methanol, and these compounds contributed to the distinctive flavor of oven-baked CSP.*

***Keywords:*** *cilembu, sweet potato, volatile compounds*

## INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is widely available in Indonesia because it can be cultivated in many environments and climates in most parts of the country. However, the rancing variety cultivated in Cilembu, West Java-Indonesia (cilembu sweet potato (CSP)) is the most popular because it is considered the sweetest. This variety grows in Cilembu village, Pamulihan, Sumedang, West Java, with a protected geographical indication (ID G 000000019) for authenticity due to superior taste and flavor. When baked, CSP releases sweet liquid like honey due to storage treatment before processing. During storage, sugar levels can increase because the polysaccharides content experiences hydrolysis/breakdown into a simple form, thereby accelerating the presence of acids or enzymes.

CSP is generally processed by baking using an oven because the method possesses a unique sensory profile with the best distinguishable flavor. During the baking process, a flavor will be formed to influence the taste and flavor. Chan *et al*. (2014) suggested that the main factors for panelists to prefer baked sweet potato were flavor (85.7%) and sweetness (78.6%). The flavor that develops during the cooking process, such as baking, may be generated by the degradation of food components, including carbohydrates, lipids, and proteins. Carbohydrates, proteins, and lipids can be precursors to flavor formation reactions. Common reactions due to heating are lipid degradation and Maillard reactions (Shahidi and Hossain, 2022). Tsai *et al*. (2021) stated that volatile compounds contributing to the flavor of baked sweet potato were generated from the Maillard reaction and caramelization, as well as phenylalanine, Strecker, lipids, and carotenoid degradation. Raw sweet potato generally contains approximately 13.7 mg/100 g of beta-carotene, which is reduced during thermal processing (Trancoso-Reyes *et al.,* 2016).

The flavor is important to consumers and is influenced by volatile compounds. In sweet potato, volatile compounds vary depending on the variety and environmental factors, planting methods, storage, and processing methods. Mahmudatussa'adah *et al.* (2015) cultivated sweet potato at three agro-geographical production sites in West Java–Indonesia (Cilembu village–Sumedang; Bandung and Kuningan). The results found that sweet potato planted in the Cilembu village, Sumedang, had higher sensory acceptance scores in terms of taste (sweet) and flavor (caramel-like) compared to the other two regions with different soil and climate characteristics (Bandung and Kuningan). This variation can be explained by the environmental conditions throughout growing, harvest, and storage (Paolo *et al*., 2019). However, no studies have shown volatile compound profiles of CSP. Analysis of volatile compounds is an

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alternative and promising method for verification of the geographical origin of CSP. Mahmudatussa'adah *et al.* (2015) showed that sweet potato cultivated in Cilembu had a caramel-like flavor. Therefore, it could be hypothesized that volatile compound contributing to flavor was generated from the Maillard and caramel reaction, including lipid degradation.

In addition to the location of planting, storage of sweet potato is one factor that affects the sensory profile and volatile compounds. Currently, CSP is stored for a minimum of one week before consumption or marketed for a better taste and flavor. Previous study showed that storage condition before cooking was an essential factor in determining sensory characteistics. This was because some modifications in tuber composition could occur during storage, such as fatty acids, sugars, and amino acids, leading to higher quality perception scores than fresh potatoes (Khorramifar *et al*., 2023). Therefore, this study aimed to analyze volatile compounds of CSP (variety Rancing) compared to another variety cultivated in a different region (Manohara variety), regarding storage effect both at harvest (fresh roots) and one week storage. Manohara was selected as a control because it was the most common variety cultivated and consumed in most parts of Indonesia.

## MATERIALS AND METHODS

### Materials

CSP was grown at Cilembu village, Pamulihan, Sumedang, West Java, Indonesia. Meanwhile, manohara sweet potato (MSP) used as the control was grown in Cilimus village, Kuningan, West Java. Other materials including C9-C23 *n*-alkanes and 1,4-dichlorobenzene (Aldrich, Steinheim, Germany) with MS grade were from Sigma Aldrich, Steinheim, Germany.

### Sample preparation

Both sweet potatoes (CSP and MSP) were harvested at 4.5 months. CSP was divided into two groups, namely freshly harvested and stored roots. The first group, fresh roots, were directly oven-baked after harvesting, and volatile compounds were determined by Gas Chromatography Mass Spectrometry (GCMS). The second group of CSP and MSP were stored for seven (7) days after harvest, oven-baked, and analyzed using GCMS. The roots were stored piled in bamboo baskets without cover at 27−30 °C with 85−90% relative humidity and not exposed to the sun (the conditions generally used for commercial sweet potato storage).

### Preparation of cooked samples

The healthy tubers of similar size were randomly selected, washed, dried, and baked in an oven without peeling. The oven was preheated at 180 °C, and then sweet potatoes were baked at 200 °C for ±90 min until the desire texture achieved, as assessed by a fork and considered appropriate for eating.

### Proximate composition

The moisture, protein, and fat of raw samples were determined according to the AOAC (2012). In this study, the moisture, fat, ash, protein, and carbohydrate content of samples was determined by oven drying, Soxhlet, and burning off organic matter using furnace, Kjedahl, and difference methods respectively. The analysis was conducted in three replications.

### Gas chromatography mass spectrometry (GCMS)

The determination of volatile compounds was carried out by GC-MS using a headspace solid microextraction (HS-SPME) method using DVB-CAR-PDMS fiber (Lancioni *et al*., 2022). A total of 15 grams of sweet potato and 0.04 g of the internal standard 1,4-dichlorobenzene (Aldrich, Steinhein, Germany) were added into glass vials 20 mL and were sealed tightly with polytetrafluoroethylene (PTFE). Volatile compounds were extracted by fiber (Divinylbenzene/Carboxen/Polydimethylsiloxane-DVB/CAR/PDMS-Supleco). The fiber was then pushed into the sample's headspace, and the glass vials were incubated at 80 °C for 45 min. Compound identification was conducted using a gas chromatography (Agilent GC 7890A) with a DB-WAX column (30 m×0.25 mm i.d). The GC was equipped with a mass spectrometer (Agilent MSD 5975C with a triple-axis detector). The adsorbed volatile components were thermally desorbed into the GC column at 250 °C for 5 min with the splitless injection mode. The initial temperature of the column was 40 °C and maintained for 2 min, followed by an increase to 200 °C at a 3 °C/min rate. Helium was the carrier gas with a 2.5 mL/min flow rate. The analysis was operated in a positive electron ionization mode at 70 eV, and the ion source temperature was 230 °C. The mass scan range of m/z was set from 29 to 550 amu.

A homologous series of C9-C23 *n*-alkanes (Sigma-Aldrich, Steinheim, Germany) was used to calculate the retention indices of each compound (Zhao *et al*., 2017). This was based on the formula proposed by Belgis *et al*. (2017), namely linear retention indices (LRI), as shown in Formula 1.

Linear Retention Indices (LRI) =

$$\left[\left(\frac{t_x - t_n}{t_{n+1} - t_n}\right) + n\right] \times 100 \quad (1)$$

In the formula, $t_x$ is the retention indices of sample component x, $t_n$ is the retention indices of the alkane standard that rises before component x, $t_{n+1}$ is the retention indices of the alkane standard that rises after component x, and n is the number of C atoms of the alkane standard that rises before component x. Subsequently, compounds were identified by comparing the mass spectra between sample and standard held in the MS library database (NIST). This was followed by a comparison of LRI with authentic compounds run under the same conditions and similar columns published in the literature. Compound was considered positive when both MS spectra and LRI data were consistent with those in the literature. Amounts of individual components were expressed in quantitative terms as GC peak area units with a formula proposed by Belgis *et al*. (2017), as shown in Formula 2. The concentrations obtained from this formula were statistically analyzed by SPSS for differences among samples and used to generate a PCA graph by XLStat software. Furthermore, 1,4-dichlorobenzene (Sigma-Aldrich, Steinheim, Germany) was used as the internal standard, and data were analyzed as mean of two replications.

$$\text{Concentration (ng/g)} = \left(\frac{\text{The area of sample's peak}}{\text{The area of internal standard's peak}}\right) \times \left(\frac{\text{The mass of internal standard}}{\text{The mass of sample}}\right) \ldots\ldots\ldots\ldots (2)$$

**Data analysis**

The experimental data were statistically analyzed using Analysis of Variance (ANOVA) on SPSS version 20.0 software. The significant difference between means was determined by the Duncan test ($p$<0.05). Volatile compounds and proximate analyses were performed in triplicate. All data were expressed as mean and standard deviation (SD). Additionally, principal component analysis (PCA) was conducted using the concentration of identified compounds to fully understand the differences in volatile compounds generated from CSP and MSP. PCA was carried out using XLSTAT (Addinsoft 2018). A Venn diagram was used to summarize the data obtained from GC-MS.

## RESULT AND DISCUSSION

**Volatile compound profiles**

Table 1 shows the moisture, fat, protein, and total sugar contents of raw samples on a wet basis. The results showed that the moisture and total sugar contents of CSP and MSP were different. Storage period increased the concentration of total sugar in stored CSP, while the fat content of both sweet potatoes was low.

The chromatogram resulting from the GC-MS analysis (Figure 1) showed that storage could release the new 9 volatile compounds of CSP (Figure 2). Meanwhile, 12 volatile compounds differentiated CSP from MSP. The concentrations of 42 compounds identified in all samples are summarized in Table 2. Maillard reaction and lipid oxidation products were found to be the major sources of volatile compounds of baked CSP, although other components, such as terpene, were also present at lower levels. In comparison, MSP contained terpene as the most prominent major component. A total of three known and two unknown compounds were tentatively identified.

Table 1. The moisture, protein and fat contents, and total sugar of Cilembu and Manohara sweet potatoes

| Parameter | Fresh CSP | Stored CSP | Stored MSP |
|---|---|---|---|
| Moisture (%) | 62.77±0.28$^{b}$ | 60.1±0.07$^{c}$ | 69.93±0.16$^{a}$ |
| Fat (%) | <0.02 | <0.02 | <0.02 |
| Protein (%) | 1.18±0.03$^{b}$ | 1.15±0.01$^{b}$ | 1.25±0.01$^{a}$ |
| Total sugar (%) | 3.36±0.01$^{b}$ | 4.56±0.12$^{a}$ | 2.51±0.01$^{c}$ |

Note: Samples were analyzed as raw tubers (unbaked). Values are means ±standar deviation of triplicates. Values with different superscripts ($^{a,b}$) within each row among samples showed significant difference ($p$≤0.05). CSP= Cilembu sweet potato, MSP= Manohara sweet potato

Figure 3 shows the biplot of volatile compounds identified in CSP (fresh and stored roots) compared to MSP. The PCA identified two factors that explained 80.77% of the variance. Factor 1 explained 49.99% of the variance, while factor 2 showed 30.78% of the variance (Figure 3A). According to the results of the PCA, CSP (fresh and stored roots) had similar factors 1 and 2 values, which were significantly different from MSP. As shown in Figure 3B, CSP was dominated by Maillard reaction products such as furfural, benzaldehyde, and 2-furanmethanol. Meanwhile, MSP was dominated by terpene compounds such as α-gurjunene, methoxy-phenyl-oxime, and cymene.

From Table 2, fresh and stored roots of CSP had some similar compounds but were different in their concentrations. As shown in Figure 3B, benzaldehyde is present in fresh roots of CSP, while stored roots possess furfural (Figure 3B). During storage, benzaldehyde decreased, while furfural increased significantly (Table 2). It was assumed that benzaldehyde might further participate in forming a reaction of furfural. Some previous studies stated that the common reactions due to baking were the Maillard reaction and lipid degradation (Shahidi and Hossain, 2022). In this study, 45% of compounds came from the Maillard reaction and sugar degradation, 10% from lipid degradation, 40% from terpene, and 5% from others. Moreover, identifying the main compounds contributing to the distinct flavor of CSP is a crucial step in enhancing their development through plant breeding (Wang and Kays, 2000). Improving the new flavor of sweet potato can also increase their use and acceptance.

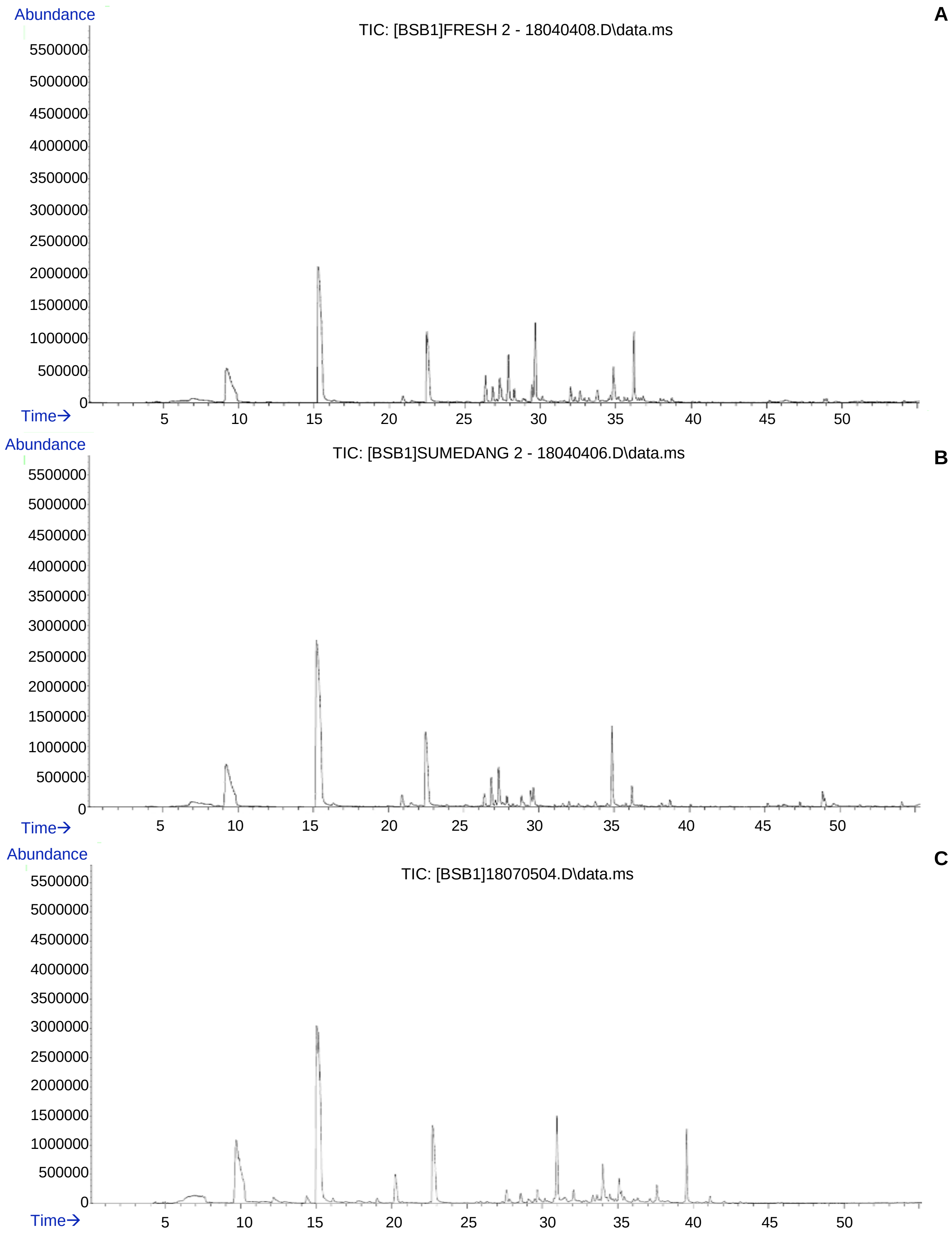



Figure 1. The GC-MS chromatogram of fresh (A) and stored (B) Cilembu sweet potatoes and Manohara sweet potato (C), samples were analyzed as oven-baked tubers using HS-SPME GC-MS for 50 min, x-axis represents retention time in minutes and y-axis represents abundance (arbitrary units)

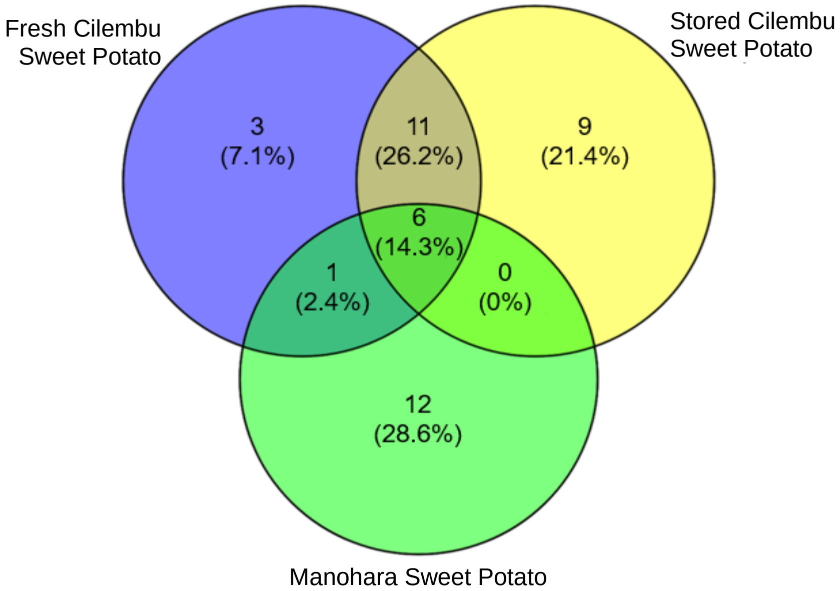



Figure 2. Venn diagram of volatile compounds number of fresh and stored Cilembu sweet potatoes (CSP) and Manohara sweet potato (MSP). The compounds were analyzed from oven-baked tubers

**Maillard reaction product compounds and sugar degradation**

The Maillard reaction generally occurs between an amine group in a protein and a carbonyl group from sugar, playing an important role in giving a taste. In this study, compounds identified from the Maillard reaction were pyridine, 1-hydroxy-2-propanone, 1-hydroxy-2-butanone, methyl pyruvate, furfuryl formate, furfural, 2-acetylfuran, benzaldehyde, acetic acid, formic acid, 5-methylfurfural, phenylacetaldehyde, 2-furanmethanol, 2(5H)-furanone, maltol, furaneol, 3-ethylphenol, and 3-hydroxy-2,3-dihydromaltol. Table 1 showed that although the protein content of CSP and MSP was not different, CSP contained more total sugar than MSP. This sugar content might explain the difference in flavor between the two samples. Sun *et al*. (1994) reported that starch hydrolysis could lead to the formation of maltose and the synthesis of volatile. During storage, the sugar content of CSP increased due to starch hydrolysis. Therefore, the higher sugar content in CSP might be a factor in the unique flavor.

Various compounds such as 1-hydroxy-2-propanone, 5-methylfurfural, maltol, and furaneol played a role in providing caramel scents, while 1-hydroxy-2-butanone and furfural gave sweet flavor (Tsai *et al*., 2021). Mahmudatussa'adah (2015) found that sweet potato planted in Cilembu village, Sumedang-West Java-Indonesia, had sweet taste and a strong caramel flavor when baked. These sensory attributes of baked CSP might come from the six compounds. Based on Table 2, the 1-hydroxy-2-propanone was found in all three samples, which increased due to storage. Maltol was only identified in CSP (fresh and stored roots), which was considered to give a caramel-like flavor (Paravisini *et al*., 2017). This phenomenon showed that maltol was a typical compound only found in CSP. Furthermore, Tsai *et al.* (2021) reported that maltol was one of the critical components making up the flavor of baked sweet potatoes. The other three compounds, 5-methylfurfural, furaneol, and 1-hydroxy-2-butanone, were identified only in CSP and formed after storage. 1-hydroxy-2-propanone, 5-methylfurfural, and maltol were formed in the presence of maltose as a precursor in the Maillard reaction (Chan *et al*., 2014). During storage, the starch in the roots would be broken into simple sugar, including maltose, by α and β-amylases (Wang *et al*., 2016). This process was responsible for the increasing concentration of 1-hydroxy-2-propanone, 5-methylfurfural, furaneol, and 1-hydroxy-2-butanone. Liu *et al.* (2022) reported that reduced moisture was an important factor affecting the levels of components formed through the Maillard reaction. From Table 1, storage treatment could decrease the moisture level of CSP. Additionally, 1-hydroxy-2-butanone might be responsible for providing a roasted aroma (Cao *et al*., 2023).

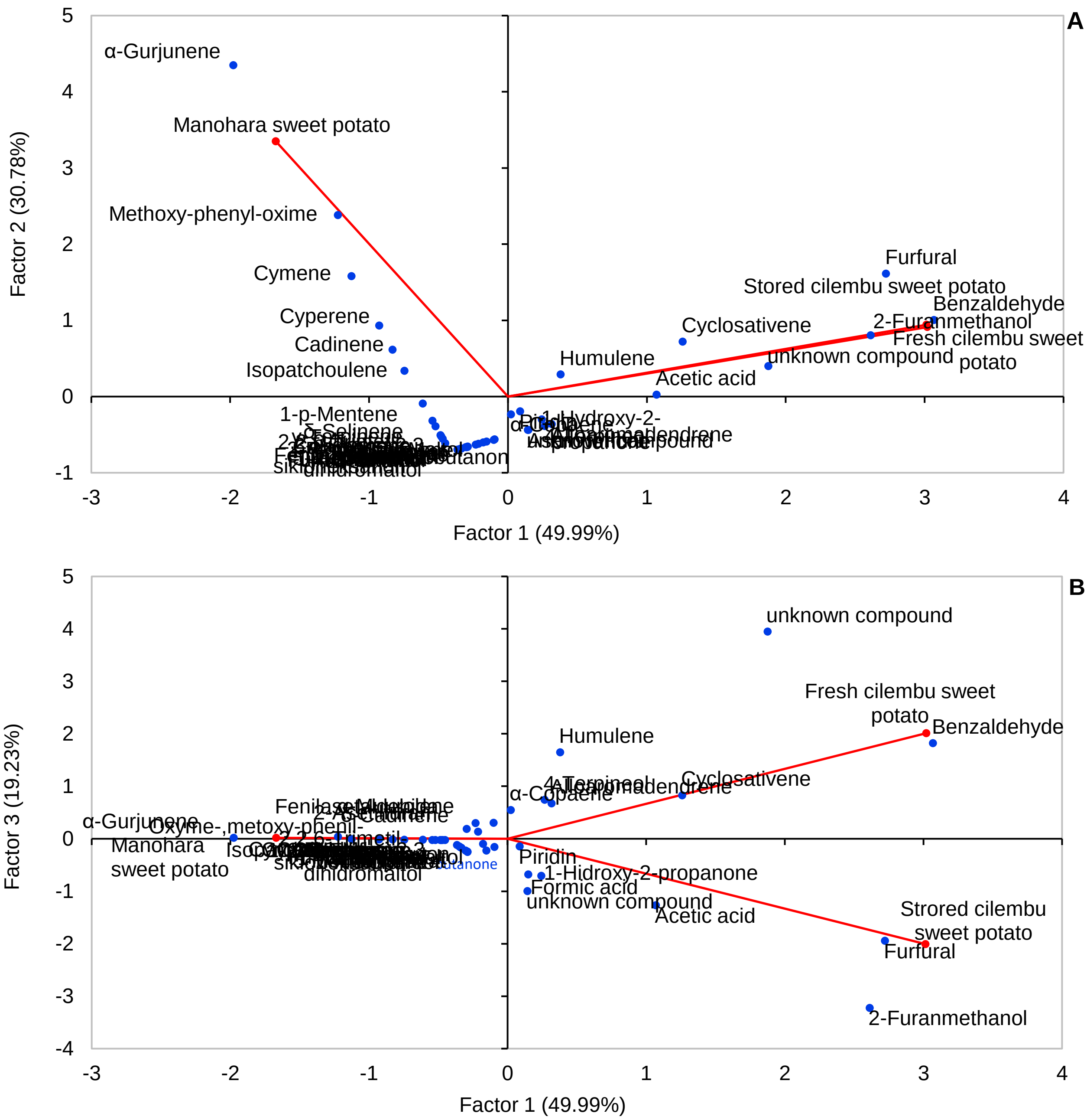
Burnt is one of the sensory attributes found in baked sweet potatoes. In this study, three compounds were suspected of giving a burnt odor, including pyridine, 2-furan methanol, and furaneol (Tsai *et al*., 2021). 2-Furan methanol was identified in fresh and stored roots of CSP. Storage process caused the formation of 2-furan methanol, furaneol, and 3-ethylphenol. Compared to the three compounds, pyridine was detected in all samples. The contribution of pyridine to flavor depended on the structure and concentration in the food, predominantly consisting of green notes (Zhu *et al.,* 2015).

Table 2. Volatile compounds identified in Cilembu and Manohara sweet potatoes after baking, analyzed by HS-SPME GC-MS

| Compound Name | LRI | Concentration (ng/g) | | | Classification of Compounds |
|---|---|---|---|---|---|
| | | Fresh CSP | Stored CSP | Stored MSP | |
| 1-p-Mentene | 1138 | nd | nd | 1.59±1.16 | Terpene |
| Pyridine | 1187 | 0.82±0.41 | 1.11±0.50 | 0.60±0.36 | Maillard reaction |
| 2-Pentylfuran | 1243 | nd | nd | 0.42±0.17 | Lipid degradation |
| γ-Terpinene | 1257 | nd | nd | 0.84±0.67 | Terpene |
| Cymene | 1283 | nd | nd | 5.82±4.37 | Terpene |
| 1-Hydroxy-2-propanone | 1298 | 0.47±0.37 | 1.83±1.82 | 0.20* | Maillard reaction |
| unknown compound | 1313 | nd | 1.91* | nd | - |
| 2,2,6-Trimethyl-cyclohexanone | 1339 | nd | nd | 0.28±0.03 | Lipid degradation |
| 1-Hydroxyi-2-butanone | 1371 | nd | 0.44* | nd | Maillard reaction |
| 1-Hepten-4-ol | 1401 | nd | 0.29* | nd | Lipid degradation |
| Acetic acid | 1444 | 1.25±0.23 | 3.75±2.29 | nd | Maillard reaction |
| Methyl pyruvate | 1452 | 0.25* | 0.65±0.55 | nd | Maillard reaction |
| Furfural | 1457 | 3.61±0.45[b] | 7.57±0.71[a] | 1.66±1.28[b] | Maillard reaction |
| Cyclosativene | 1471 | 3.77±0.78 | 2.30±0.07 | 1.34* | Terpene |
| α-Copaene | 1481 | 1.36±0.11 | 0.31±0.26 | 0.60±0.53 | Terpene |
| Furfuryl formate | 1488 | nd | 0.24* | nd | Maillard reaction |
| δ-Elemene | 1491 | nd | nd | 0.55* | Terpene |
| Formic acid | 1495 | 0.30±0.03 | 1.61±1.72 | nd | Maillard reaction |
| 2-Acetylfuran | 1499 | 0.40* | nd | nd | Maillard reaction |
| Benzaldehyde | 1516 | 7.36±0.30[a] | 4.11±0.34[b] | nd | Maillard reaction |
| Cyperene | 1549 | nd | nd | 4.18* | Terpene |
| α-Gurjunene | 1551 | nd | nd | 12.80±10.14 | Terpene |
| 1-Octanol | 1553 | nd | 0.18±0.08 | nd | Lipid degradation |
| 5-Methyl furfural | 1567 | nd | 0.46±0.28 | nd | Maillard reaction |
| Isopatchoulene | 1580 | nd | nd | 2.68±1.72 | Terpene |
| 4-Terpineol | 1595 | 1.82±0.99 | 0.41±0.31 | nd | Terpene |
| Alloaromadendrene | 1627 | 1.84±0.54 | 0.56±0.51 | nd | Terpene |
| Phenylacetaldehyde | 1636 | 0.61±0.24 | nd | nd | Maillard reaction |
| 2-Furan methanol | 1657 | 1.91±2.35 | 8.29±7.28 | nd | Maillard reaction |
| Humulene | 1659 | 3.12* | nd | 1.36* | Terpene |
| Unknown compound | 1695 | 7.42±3.19 | nd | nd | - |
| α-Muurolene | 1713 | 0.82±0.23 | 0.22* | nd | Terpene |
| δ-Selinene | 1724 | nd | nd | 1.02±0.20 | Terpene |
| Cadinene | 1735 | nd | nd | 3.38±1.37 | Terpene |
| δ-Cadinene | 1746 | 0.48±0.22 | 0.19* | nd | Terpene |
| 2(5H)-Furanone | 1752 | 0.32±0.02 | 0.48±0.41 | nd | Maillard reaction |
| Methoxy phenyl oxime | 1759 | 0.25±0.19 | 0.18±0.07 | 7.68±5.59 | Alkaloid |
| Calamenene | 1870 | nd | nd | 0.50±0.19 | Terpene |
| Maltol | 1969 | 0.40±0.29 | 0.67* | nd | Maillard reaction |
| Furaneol | 2039 | nd | 0.44±0.46 | nd | Maillard reaction |
| 3-Ethylphenol | 2176 | nd | 0.26±0.15 | nd | Maillard reaction |
| 3-Hydroxy-2,3-dihydromaltol | 2277 | nd | 0.42±0.46 | nd | Maillard reaction |

Note: Values are means ± SD of duplicates. Values with different superscripts ([a,b]) within each row among samples showed significant different ($p \leq 0.05$). *The compound was only detected in one replication. CSP= Cilembu sweet potato, MSP= Manohara sweet potato. nd= not detected

Based on Table 2, the pyridine concentration was low compared to 2-furan methanol. Therefore, 2-furan methanol was assumed to have a more significant role in giving burnt flavor to CSP. This statement was supported by the results of Yao *et al.* (2024), where pyridine compounds did not significantly contribute a distinctive taste to baked sweet potatoes. Acetic and formic acids were compounds only found in CSP. Others included 2(5H)-furanone, 2-acetylfuran with a spicy aroma, as well as furfuryl formate and phenylacetaldehyde with a floral odor (Tsai *et al.,* 2021). These compounds were only found in CSP with a relatively low concentration (Table 2). Yao *et al.* (2024) mentioned that phenylacetaldehyde was compound providing a distinctive flavor to baked sweet potato. In this study, phenylacetaldehyde was only found in baked fresh roots of CSP. Phenylacetaldehyde and furfural could be formed from phenylalanine as a precursor through Strecker degradation reaction (Liu *et al*., 2022). Based on the results, the concentration of furfural was higher than phenylacetaldehyde, which significantly increased with storage.




Note: Diagram was represented by Factor 1 (49.99%) and Factor 2 (30.78%) explaining in total 80.77% of the variation (A), and by Factor 1 (49.99%) and Factor 3 (19.23%) explaining in total 69.22% of the variation (B)

Figure 3. Biplot of the compounds identified in oven-baked tuber of CSP (fresh and stored roots) compared to MSP, generated by principal component analysis (PCA)

The higher concentration of furfural in stored roots of CSP might be due to its greater total sugar content than other samples (Table 1). With the increase in total sugar due to the breakdown of starch into simple sugar during storage, the precursors of furfural would also increase. According to previous reports, several aldehydes including furfural were found at higher levels after storage and formed during processing through dehydration of pentose sugar (Liu *et al*., 2022). In addition to providing sweet flavor, furfural also provided a nutty flavor (Paravisini *et al*., 2017).

## Products of lipid degradation

Degradation of lipids was possible during the baking of foods. Most lipid-derived compounds were formed by oxidation. In this study, compounds derived from lipid degradation were 2-pentylfuran, 1-

octanol, 1-hepten-4-ol, and 2,2,6-trimethyl-cyclohexanone. Moreover, 2-pentylfuran might give a floral odor to baked sweet potatoes (Shahidi and Hossain, 2022). As shown in Table 2, 2-pentylfuran was only found in MSP, while 1-octanol provided floral flavor in CSP (Shahidi and Hossain, 2022) formed after storage. Furthermore, 1-hepten-4-ol was only found in CSP. The concentration of the three compounds was relatively low due to the low-fat content both in CSP and MSP (<0.02%) (Table 1).

In this study, only MSP possessed 2,2,6-trimethyl-cyclohexanone, a ketone compound obtained from the degradation of β-carotene. Carotenoids were easily degraded and isomerized during heating as well as storage, with their degradation being influenced by temperature and heating time. This suggested that longer heating time and temperature correlated with more compound volatility. In this study, when sweet potatoes were processed by baking at 200 °C for ±90 min, 2,2,6-trimethyl-cyclohexanone became unavailable when extracted by HS-SPME method. This phenomenon was attributed to the low concentration of compound in MSP (Table 2).

**Terpene compounds**

The last compound category identified in this study was terpene. There were 17 terpene compounds obtained, namely 1-p-mentene, γ-terpinene, cymene, cyclosativene, α-copaene, δ-elemene, cyperene, α-gurjunene, isopatchoulene, 4-terpineol, alloaromadendrene, humulene, α-muurolene, δ-selinene, cadinene, δ-cadinene, dan calamenene. Two terpenes (isopatchoulene and cadinene) were tentatively identified because their presence has not been reported previously. Most terpene compounds were only detected in MSP, while Maillard reaction products dominated the CSP. The terpene compounds identified in MSP included 1-p-mentena, γ-terpinene, cymene, δ-elemene, cyperene, α-gurjunene, isopatchoulene, δ-selinene, cadinene, and calamenene (Table 2). These compounds contributed to flavor of baked MSP, such as green and woody for γ-terpinene (Kim *et al*., 2020). The difference in compound content between CSP and MSP could be related to the soil type and climatic factors during their growth. This result showed that agronomic factors may influence the sensory quality of boiled potatoes (Mahmudatussa'adah, 2015).

CSP contained 4-terpineol, alloaromadendrene, α-muurolene, and δ-cadinene, which contributed to the woody scent of baked CSP (Kim *et al.,* 2020). During storage, the concentration of these compounds decreased, as shown in Table 2. Cyclosativene, α-copaene, and humulene were identified in both CSP and MSP. α-Copaene was a terpene compound that contributed to the flavor of baked sweet potatoes, while humulene gave citrus flavor characteristics (Yao *et al.*, 2024).

## CONCLUSION

In conclusion, this study showed that the typical compound in fresh roots of CSP was mainly due to the presence of benzaldehyde. In comparison, terpene compounds dominated MSP as the main components, such as α-gurjunene, methoxy-phenyl-oxime, and cymene. However, during storage of CSP, the sugar content increased because of starch hydrolysis, leading to the formation of Maillard reaction products in the more significant number, such as furfural, benzaldehyde, and 2-furan methanol. These compounds provided the oven-baked CSP with a unique taste.

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## REFERENCES

[AOAC] Association of Official Analytical Chemist. (2012). Official Methods of Analytical of The Association of Official Analytical Chemist. Washington DC: AOAC.

Belgis, M., Wijaya, C. H., Apriyantono, A., Kusbiantoro, B., & Yuliana, D. Y. (2017). Volatiles and aroma characterization of several lai (*Durio kutejensis*) and durian (*Durio zibethinus*) cultivars grown in Indonesia. *Scientia Horticulturae*, *220,* 291–298. http://dx.doi.org/10.1016/j.scienta.2017.03.041

Cao, X., Wu, H., Viejo, C. G., Dunshea, F. R., & Suleria, H. A. R. (2023). Effects of postharvest processing on aroma formation in roasted coffee – a review. *International Journal of Food Science and Technology*, *58*, 1007–1027. https://doi.org/10.1111/ijfs.16261

Chan, C. F., Chiang, C. M., Lai, Y. C., Huang, C. L., Kao, S. C., & Liao, W. C. (2014). Changes in sugar composition during baking and their effects on sensory attributes of baked sweet potatoes. *Journal of Food Science and Technology, 51,* 4072–4077. https://doi.org/10.1007/s13197-012-0900-z

Khorramifar, A., Rasekh, M., Karami, H., Lozano, J., Gancarz, M., Łazuka, E., & Łagód, G. (2023). Determining the shelf life and quality changes of potatoes (*Solanum tuberosum*) during storage using electronic nose and machine learning. *PLoS One*, *18*(4), 0284612. https://doi.org/10.1371/journal.pone.0284612

Kim, M. K., Jang, H. W., & Lee, K. (2020). Characterization of key aroma-active compounds isolated from omija fruit treated differently based on odor activity values and descriptive sensory analysis. *Foods, 9,* 638. https://doi.org/10.3390/foods9050638

Lancioni, C., Castells, C., Candal, R., & Tascon, M. (2022). Headspace solid-phase microextraction: Fundamentals and recent advances. *Advance in Sample Preparation, 3*, 100035. https://doi.org/10.1016/j.sampre.2022.100035

Liu, S., Sun, H., Ma, G., Zhang, T., Wang, L., Pei, H., Li, X., & Gao, L. (2022). Insights into flavor and key influencing factors of Maillard reaction products: A recent update. *Frontiers in Nutrition, 9,* 973677. https://doi.org/10.3389/fnut.2022.973677

Mahmudatussa'adah, A., Fardiaz, D., Andarwulan, N., & Kusnandar, F. (2015). Sensory profile of baked purple sweet potato cultivated from three different locations. *International Journal of Sciences: Basic and Applied Research, 20,* 87–96.

Paolo, D., Bianchi, G., Morelli, C. F., Speranza, G., Campanelli, G., Kidmose, U., & Lo Scalzo, R. (2019). Impact of drying techniques, seasonal variation and organic growing on flavor compounds profiles in two Italian tomato varieties. *Food Chemistry, 298,* 1–14. https://doi.org/10.1016/j.foodchem.2019.125062

Paravisini, L., Moretton, C., Gouttefangeas, C., Nigay, H., Dacremont, C., & Guichard, E. (2017). Caramel flavor perception: Impact of the non-volatile compounds on sensory properties and in-vitro aroma release. *Food Research International, 100,* 209–215. http://dx.doi.org/10.1016/j.foodres.2017.07.003

Shahidi, F., & Hossain, A. (2022). Role of lipids in food flavor generation. *Molecules, 27,* 5014. https://doi.org/10.3390/molecules27155014

Sun, J. S., Severson, R. F. & Kays, S. J. 1994. Effect of heating temperature and microwave pretreatment on the formation of sugars and volatiles in Jewel sweet potato. *Journal of Food Quality, 17,* 447–456. https://doi.org/10.1111/j.1745-4557.1994.tb00165.x

Trancoso-Reyes, N., Ochoa-Martínez, L. A., Bello-Pérez, L. A., Morales-Castro, J., Estévez-Santiago, R., & Olmedilla-Alonso, B. (2016). Effect of pre-treatment on physicochemical and structural properties, and the bioaccessibility of β-carotene in sweet potato flour. *Food Chemistry, 200,* 199–205. http://doi.org/10.1016/j.foodchem.2016.01.047

Tsai, Y. -J., Lin, L. -Y., Yang, K. -M., Chiang, Y. -C., Chen, M. -H., & Chiang, P. -Y. (2021). Effects of roasting sweet potato (*Ipomoea batatas* L. Lam.): quality, volatile compound composition, and sensory evaluation. *Foods, 10,* 2602. https://doi.org/10.3390/foods10112602

Wang, S., Nie, S., & Zhu, F. (2016). Chemical constituents and health effects of sweet potato. *Food Research International, 89,* 90–116. https://doi.org/10.1016/j.foodres.2016.08.032

Wang, Y., Kays, S. J. (2000). Contribution of volatile compounds to the characteristic aroma of baked 'Jewel' sweet potatoes. *Journal of the American Society for Horticultural Science, 125*, 638–643. https://doi.org/10.21273/JASHS.125.5.638

Yao, Y., Zhang, R., Jia, R., Yao, Z., Qiao, Y., & Wang, Z. (2024). Exploration of raw pigmented-fleshed sweet potatoes volatile organic compounds and the precursors. *Molecules, 29*(3), 606. https://doi.org/10.3390/molecules29030606

Zhao, J., Wang, M., Xie, J., Zhao, M., Hou, L., Liang, J., Wang, S., & Cheng, J. (2017). Volatile flavor constituents in the pork broth of black-pig. *Food Chemistry, 226,* 51–60. https://doi.org/10.1016/j.foodchem.2017.01.011

Zhu, G., Xiao, Z., Zhou, R., & Lei, D. (2015). Preparation and simulation of a taro flavor. *Chinese Journal of Chemical Engineering, 23,* 1733–1735. https://doi.org/10.1016/j.cjche.2015.07.026