Original Article
Food Science and Technology
ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.5327/fst.127222



# Physicochemical properties, sensory characteristics, and volatile compounds of Indonesian traditional drink (Sarabba)

Adiansyah Syarifuddin[1]*, Nurul Azizah[1], Andi Dirpan[1]

**Abstract**

'Sarabba' is a popular traditional drink that is mostly consumed in South Sulawesi Province, Indonesia. 'Sarabba' has been known for its health benefits because its ingredients contain some spices, but this drink has been poorly studied. This study aimed to characterise the physicochemical properties, sensory perception, and volatile compounds of 'Sarabba'. The importance of this study was to provide valuable insight for small-scale manufacturers on how the use of chicken egg yolk and sweetened condensed milk can affect the physicochemical properties and perception of Sarabba. Physicochemical properties, including colour, protein content, total soluble solid, pH, viscosity, and sensory evaluation from Sarabba, Sarabba with chicken egg yolk, and Sarabba with sweetened condensed milk, were performed in this study. Volatile compounds extracted by solid-phase microextraction and analysed by gas chromatography-mass spectrometry were also performed. The results showed that Sarabba with egg yolk has the highest protein content and viscosity, whereas 99 volatile compounds were found in Sarabba with sweetened condensed milk. The most common chemical groups identified in all Sarabba include terpenes, alcohols, ketones, ester, and alkanes. The addition of egg yolk and sweetened condensed milk could affect physicochemical properties and increase volatile compounds while maintaining the liking of 'Sarabba'.

**Keywords:** traditional drink; 'Sarabba'; ginger; lemongrass; pepper.

**Practical Application:** Chicken egg yolk or sweetened condensed milk can be used as a potential main ingredient for maintaining liking attributes in spicy-based beverages.

## 1 INTRODUCTION

Indonesia has many varieties of traditional drinks containing spices that are produced in the traditional manner. All traditional drinks produced by local manufacturers contribute significantly to social, cultural, and economic development through cultural products for culinary tourism development.

'Sarabba' is a traditional drink that originally comes from South Sulawesi Province. Sarabba is produced by local manufacturers, and it has been mostly consumed because of its health claims that have been associated with some of the spices used. Although Sarabba is popular, there is no information on its consumption ratio. The raw materials of Sarabba include ginger (*Zingiber officinale*), lemongrass (*Cymbopogon citratus*), pepper (*Piper nigrum*), coconut milk, brown sugar, salt, and water. These raw materials are mixed in a traditional manner and boiled, resulting in a pleasant aroma and flavour as well as a sweet taste, which can eliminate fatigue and prevent common cold. At present, Sarabba has been introduced to consumers with some variants with regard to taste or nutrients by adding sweetened condensed milk or chicken egg yolk. In local communities, drinking Sarabba has been an activity to build social interaction and psychological expression. The local community can also utilise Sarabba as a tourism product to accelerate culinary tourism of the province.

The use of ginger in traditional foods and drinks in many forms, such as dried slices, powdered, pasta, or essential oil, has grown extensively because of its ability to give a spicy, pungent, and pleasant smell (Purnomo et al., 2010) and to reduce the level of oxidative stress and inflammation (Mao et al., 2019). In fresh ginger, volatile compounds are determined using solid-phase microextraction (SPME) and gas chromatography-mass spectrometry (GC-MS) (Shao et al., 2003). The authors revealed that the volatile compounds of fresh ginger were dominated by camphene, β-phellandrene, γ-curcumene, α-muurolene, α-zingiberene, Z-α-bisabolene, α-farnesene, and β-sesquiphellandrene. The pungent taste of ginger is due to a group of volatile phenolic compounds, namely gingerol (Baliga et al., 2013). 6-Gingerol is primarily responsible for the spicy taste, followed by 4-, 8-, 10-, and 12-gingerol, but in limited amounts (Mahomoodally et al., 2021). Lemongrass is known for its characteristic lemon odour and flavour in the food industry (Viktorová et al., 2020). In traditional beverages, lemongrass extract is added as an aromatic drink, whereas the whole plant can be incorporated into traditional foods for having a lemon flavour (Olorunnisola et al., 2014). Several studies have been conducted for analysing volatile compounds of lemongrass that are responsible for flavours such as neral, geranial, limonene, citronellal, caryophyllene, 6-methyl hept-5-en-3-one, linalool, and beta-myrcene (Kasali et al., 2001; Schaneberg & Khan, 2002). Based on previous reports,

*Received 16 Dec., 2022.*
*Accepted 26 Jun., 2023.*
[1]*Hasanuddin University, Department of Agricultural Technology, Makassar, Indonesia.*
*Corresponding author: adiansyah@agri.unhas.ac.id

the addition of lemongrass and its volatiles to food products can prevent food contamination and deterioration as well as maintain their sensory properties (Abdulazeez et al., 2016). Apart from ginger and lemongrass, pepper is also added in preparing Sarabba drink (*P. nigrum*) because of its volatile compounds that contribute to the flavour. Liu et al. (2013) studied volatile compounds using headspace solid phase micro-extraction gas chromatography-mass spectrometry (HS-SPME-GC-MS) and sensory analysis from five new genotypes of white pepper. The authors reported that Jianyin-1 (a hybrid of Kamchay and Indonesian pepper) has the highest piperine content and the most intense pungency. In addition, sensory analysis was performed to assess the flavour quality of white peppers. The authors reported that Jianyin-1 showed a significantly high content of piperine and the most intense pungency. Alkaloid piperine that is responsible for pungent flavour was also found not only in white pepper but also in black pepper (Orav et al., 2004).

The other ingredients used in Sarabba are sweetened condensed milk or egg yolk, depending on the consumer's request. Sweetened condensed milk is used in various foods because it can improve the flavour, taste, and mouthfeel of products. Shimoda et al. (2001) determined the volatile compounds of sweetened condensed milk, including fatty acids, lactones, ketones, hydrocarbons, alcohols, aldehydes, and some miscellaneous compounds. Furthermore, they reported that $\delta$-decalactone and $\delta$-dodecalactone were the key aromatic compounds contributing to the flavour of sweetened condensed milk. Meanwhile, cooked egg yolk contains more aldehydes (2-methyl propanal) and pyrazines compared with egg white (Umano et al., 1990).

The characterisation of Sarabba based on its physicochemical properties and volatile compounds primarily affects the aroma of the aforementioned traditional drink. To the best of our knowledge, no investigations have been conducted on the physicochemical properties, sensory evaluation, or volatile compounds of Sarabba subjected to the addition of chicken egg yolk or sweetened condensed milk. Furthermore, there is a growing demand for Sarabba with the addition of chicken egg yolk or sweetened condensed milk. Thus, the characterisation of the physicochemical properties, sensory characteristics, and volatile compounds of Sarabba drink was conducted in this study. The volatile compounds were systematically measured using SPME-GC/MS. Moreover, the present study aimed to examine whether the addition of chicken egg yolk and sweetened condensed milk affects the physicochemical properties and sensory perception of Sarabba and analyse the volatile compounds in Sarabba determined using SPME-GC/MS. Therefore, three Sarabba drinks (Sarabba, Sarabba with chicken egg yolk, and Sarabba with sweetened condensed milk) were collected from small-scale producers.

## 2. MATERIALS AND METHODS

### *2.1 Materials*

Three types of Sarabba drinks, namely, Sarabba, Sarabba with chicken egg yolk, and Sarabba with sweetened condensed milk, were selected and collected from January to February 2021 from small-scale producers. These Sarabba drinks were selected on the basis of interviews of producers and consumers. The interviews were conducted using questionnaires related to raw materials used for Sarabba production, how to obtain the raw materials, storage of raw materials, description of operation unit, and the preferred types of Sarabba drinks. The ingredients used for Sarabba included ginger (*Zingiber officinale* var. amarum), lemongrass (*Cymbopogon citratus*), pepper (*Piper nigrum* L.), salt, brown sugar, coconut milk, chicken egg yolk, and sweetened condensed milk (Omela, PT Frisian Flag Indonesia). All the ingredients were obtained from a local market.

### *2.2. Preparation of Sarabba*

The preparation of the Sarabba drink is quite simple and easy, which is performed in a traditional manner. First, ginger and lemongrass were washed and mashed using a mortar and pestle. Afterwards, the mashed ginger and lemongrass were placed into a bowl containing brown sugar, and then tap water was added and stirred gently. The mashed salt and pepper were successively added and continuously stirred until the mixture was homogeneous. Then, the mixture was allowed to boil (94±2°C), and coconut milk was finally added to the mixture. The product mixture was continuously boiled. The product obtained from this process is called Sarabba.

In obtaining Sarabba with sweetened condensed milk and Sarabba with chicken egg yolk, 28 g of sweetened condensed milk and chicken egg yolk were added to 250 ml of Sarabba and then stirred manually until homogenised. The Sarabba was prepared in three batches.

### *2.3 Physicochemical properties and sensory characterisation*

#### *2.3.1 Protein content*

The protein content of each Sarabba was assessed in accordance with the procedure described by Ranjini et al. (2017). The measurements were conducted in triplicate.

#### *2.3.2 pH measurement*

The pH of double emulsions was tested at room temperature using a pH metre (Oakton pH 510 series).

#### *2.3.3 Colour measurement*

Sarabba colour was determined by using a Minolta CR-300 chromameter. The scale used was L* (brightness), a* (red-green chromatic colour), and b* (blue-yellow chromatic colour). The testing was performed by placing sensors on the surface of Sarabba and firing rays at two different parts. Measurement was performed three times for each section. Then, the obtained data were averaged.

#### *2.3.4 Total soluble solids*

The TSS was determined using a pocket refractometer (N-1α Atago, Tokyo, Japan) with a scale of 0°–32°Brix, and the results were expressed in °Brix.

*2.3.5 Viscosity measurement*

The viscosity of the Sarabba drink was analysed using a Brookfield Viscometer Model NDJ-8S (Brookfield Rotational Laboratory Digital) with spindle no. 1 at a speed of 60 rpm.

*2.3.6 Sensory characterisation*

A total of 25 panellists from student food science and technology study programme (22 females, 3 males, with 18–21 years of age) were recruited for this experiment and were not informed of the experiment's objectives. The panellists were familiar with and had previous experience in sensory evaluation of various food products, including spicy-based beverages. They performed sensory analysis on the nine samples. For each sample, panellists were asked to rate the taste, odour, and texture intensity using a linear scale ranging from 0 to 10 (0: none and 10: extremely strong). Among the subsequent evaluations, the panellists received mineral water to neutralise the taste. Sarabba, prepared in a cup (50 ml) with a three-digit code, was in a hot condition (74.3°C) and served in a random order.

*2.3.7 Identification of volatile compounds using SPME-GC/MS*

The extraction, identification, and quantification of samples using SPME-GC/MS were performed according to Amalia et al. (2022) with slight modifications.

<u>2.3.7.1 SPME procedure</u>

The volatiles of the samples were absorbed using a DVB/CAR/PDMS 2-cm fibre SPME. Before use, the fibre was conditioned by heating it in a GC-MS injector at 250°C for 30 min. Next, 5 ml of sample with 7 µl of 3-heptanone 1 mg in 100 mL as an internal standard was added into a 22 ml SPME vial with a PTFE/Silicon septa. The vial was closed hermetically, the contents were put in a water bath for 30 min at 60°C to extract volatile compounds, and the extracted fibre was injected into GC-MS. Desorption of volatile compounds occurs in the injection port of GC-MS for 5 min.

<u>2.3.7.2 GC-MS protocol</u>

An Agilent 7890A GC and an Agilent 5975C XL EI/CI MS were used in this study. As a carrier gas, helium was used at a constant flow rate of 1 mL/min. The injection port was equipped with a 0.75 mm i.d., Agilent liner suitable for SPME. GC-MS analysis was conducted by inserting the fibre previously exposed to the samples into the injection port. The sample was injected in split mode with a split ratio of 50:1. The compounds were separated in a capillary HP-5MS column with 30 m × 250 µm × 0.25 µm dimensions and a film thickness of 0.25 µm. The oven temperature was set at 35°C for 5 min, then increased to 60°C (60°C/min), and then increased to 200°C (6°C/min). The temperature was further raised to 250°C (30°C/min) and held for 5 min. The interface temperature was maintained at 250°C. The MS was operated in electron ionisation (70 eV), with a scanning range of 29–550 m/z. The ion source and quadrupole analyser temperatures were set at 230 and 150°C, respectively.

*2.3.8 Data processing for volatile compounds*

The Agilent GC-MS Chemstation software was used to process the collected raw data, including peak integration and normalisation. This process obtained a data matrix containing sample information and relative intensities of the compounds. GC-MS data were also manually annotated based on metabolite mass spectra comparisons between the Chemstation E. 02.02.1431 output and the NIST 14 Mass Spectral Library. The ratio of the unique molecule area to the total of all recognised peaks in the chromatogram (% peak area normalisation method) has been used to determine each compound's relative intensity (Kafkas et al., 2006) and also quantify it using the internal standard method (Ayseli et al., 2021).

The internal standard employed for the semi-quantification of the volatile compounds was 3-heptanone. Since there were no standard curves created for the quantified volatile compounds, the data in this study should be regarded as semi-quantitative.

### *2.4 Statistical analyses*

Data analyses were performed using the R software (release 4.1.0, 2021). Analysis of variance (ANOVA) was performed for physicochemical and sensory data. Post hoc tests were performed through multiple comparisons of means with the Bonferroni correction. For all data analyses, the effects were considered significant when $p<0.05$. The results were analysed using principal component analysis (PCA) function of the *FactoMineR* package (version 2.4) to interpret the relationship among physical-chemical parameters, sensory attributes, and volatile compounds in Sarabba.

## 3 RESULTS

### *3.1 Effect of the addition of chicken egg yolk and sweetened condensed milk on physicochemical properties*

The physicochemical properties data obtained for Sarabba, Sarabba with chicken egg yolk, and Sarabba with sweetened condensed milk were analysed to evaluate the effect of chicken egg yolk and sweetened condensed milk addition on their physicochemical properties, notably colour values as L*, a*, b*, protein content, TSS, pH, and viscosity. To further investigate the influence of chicken egg yolk and sweetened condensed milk addition on physicochemical properties of Sarabba, Sarabba with chicken egg yolk, and Sarabba with sweetened condensed milk, a series of ANOVA was performed on each sensory descriptor with Sarabba, Sarabba with chicken egg yolk, and Sarabba with sweetened condensed milk as the factors. The results are summarised in Table 1. The main findings were that both the chicken egg yolk and sweetened condensed milk additions significantly influenced L* and b* values: Sarabba with sweetened condensed milk gave higher L* and b* values than Sarabba with chicken egg yolk and Sarabba. However, the a* values of all Sarabba were not statistically different. The addition of chicken egg yolk was significant for protein content. Sarabba with chicken egg yolk had significantly higher protein content than Sarabba and Sarabba with sweetened condensed milk. Moreover, Sarabba with chicken egg yolk had significantly higher viscosity than Sarabba and Sarabba with sweetened condensed milk. In contrast to colour, protein content, and viscosity, adding chicken egg yolk and sweetened condensed milk had no significant effect on TSS or pH.

### *3.2 Effect of chicken egg yolk and sweetened condensed milk addition on sensory perception*

The sensory characteristics of Sarabba, Sarabba with chicken egg yolk, and Sarabba with sweetened condensed milk including sweetness, sourness, saltiness, bitterness, spicy, warmness, umami, graininess, ginger aroma, overall aroma, and liking were evaluated, as seen in Figure 1 and Table 2. For sourness, the results showed a significant effect among the samples. Post hoc analyses showed that Sarabba was perceived as more sour than Sarabba with chicken egg yolk and Sarabba with sweetened condensed milk. For bitterness, the results showed a significant effect among the samples. Post hoc analyses showed that Sarabba was perceived as more bitter than Sarabba with chicken egg yolk.

**Table 1**. Physicochemical properties of three of Sarabba*.

| Samples | Colour | | | Protein content (%) | Total soluble solid (°Brix) | pH | Viscosity (cP) |
|---|---|---|---|---|---|---|---|
| | L* | a* | b* | | | | |
| Sarabba | 31.88±0.34[a] | 0.95±0.22[a] | 9.26±0.09[a] | 0.42±0.04[a] | 15.00±0.00[a] | 7.03±0.06[a] | 5.27±0.64[a] |
| Sarabba with chicken egg yolk | 38.00±3.74[b] | 1.73±0.96[a] | 13.52±3.62[b] | 1.10±0.08[b] | 14.40±1.22[a] | 7.00±0.09[a] | 20.83±8.71[b] |
| Sarabba with sweetened condensed milk | 44.01±0.52[c] | 2.01±0.16[a] | 17.77±0.39[c] | 0.40±0.08[a] | 15.40±0.00[a] | 7.07±0.11[a] | 5.53±0.47[a] |

*Values are expressed as mean±SD. Means with different lowercase superscripts within the same column are significantly different ($p<0.05$) for each parameter.

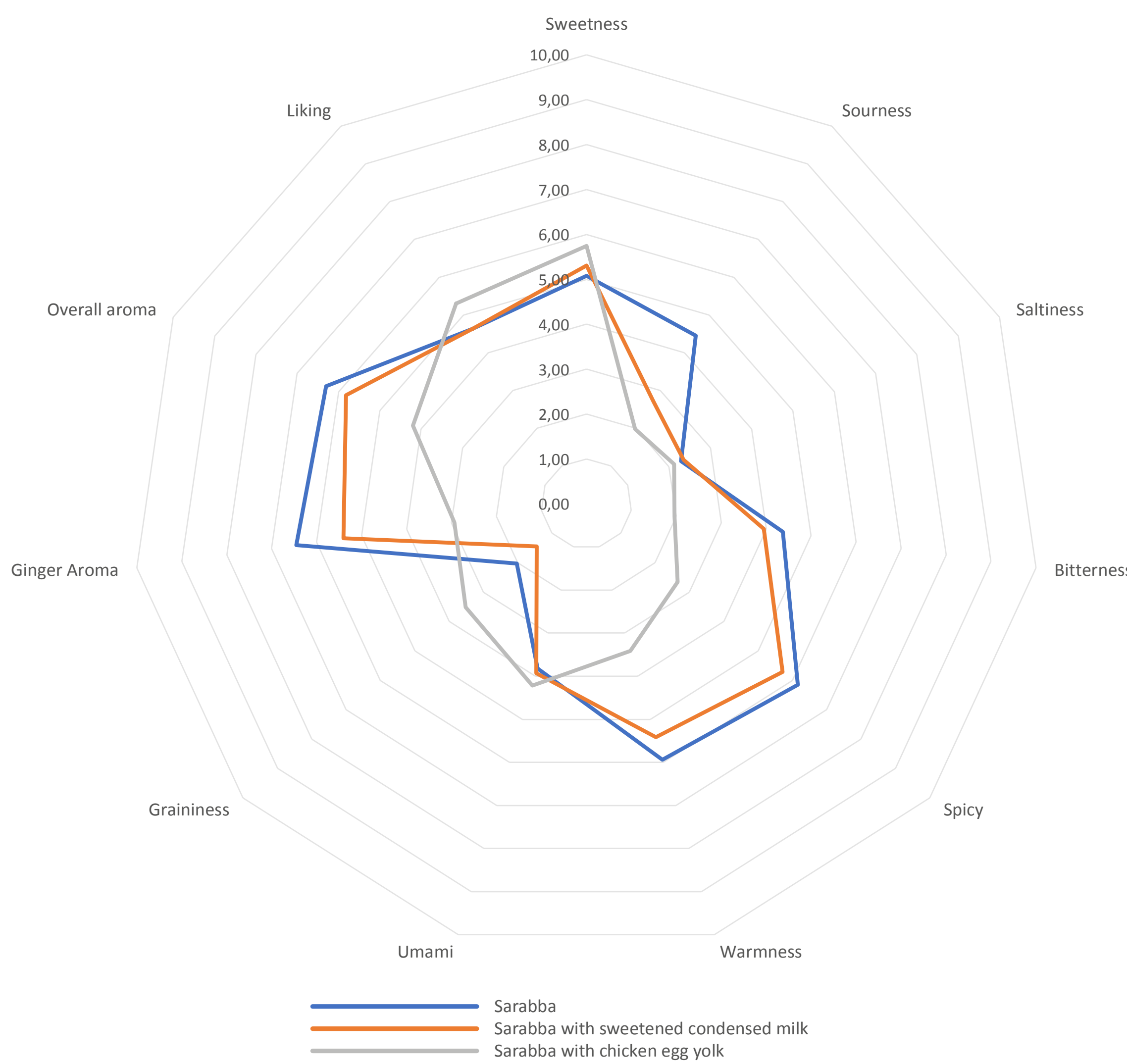



**Figure 1**. Descriptive sensory evaluation of taste, texture, and flavour attributes of three types of Sarabba. Values represented are the mean of 9 products and 25 panellists.

**Table 2**. ANOVA on the sensory attribute intensity of Sarabba, Sarabba with chicken egg yolk, and Sarabba with sweetened condensed milk. Dark grey cells indicate significance at p<0.0001, and empty cells indicate no significant effects (p>0.05).

| | Sensory attributes | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Sweetness** | **Sourness** | **Saltiness** | **Bitterness** | **Umami** | **Spicy** | **Warmness** | **Grainines** | **Ginger aroma** | **Overall aroma** | **Liking** |
| F(2;222) | 1.31 | 17.89 | 0.22 | 17.36 | 0.31 | 49.05 | 23.34 | 12.53 | 40.47 | 15.16 | 1.81 |
| p-value | 0.27 | <0.0001 | 0.83 | <0.0001 | 0.73 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 0.17 |

For spicy, the results revealed a significant difference among the samples. Post-hoc analyses showed that Sarabba and Sarabba with sweetened condensed milk were perceived as spicier than Sarabba with chicken egg yolk. For warmness, the results showed a significant effect among the samples. Post hoc analyses showed that Sarabba and Sarabba with sweetened condensed milk were perceived as warmer than Sarabba with chicken egg yolk. For graininess, the results revealed a significant effect of samples. Post hoc analyses showed that Sarabba with chicken egg yolk was perceived as grainier than Sarabba and Sarabba with sweetened condensed milk. For ginger aroma, the results revealed a significant effect of the samples. Post hoc analyses showed that Sarabba had a higher ginger aroma than Sarabba with chicken egg yolk and Sarabba with sweetened condensed milk. For overall aroma, the results revealed a significant effect of the samples. Post hoc analyses showed that Sarabba had a higher ginger aroma than Sarabba with chicken egg yolk and Sarabba with sweetened condensed milk. For sweetness, saltiness, umami, and liking, the results showed no significant effect among the samples.

### *3.3 Impact of chicken egg yolk and sweetened condensed milk addition on volatile compounds*

SPME-GC/MS analysis resulted in the identification of volatile compounds detected in Sarabba without the addition of chicken egg yolk or sweetened condensed milk, Sarabba with the addition of chicken egg yolk, and Sarabba with the addition of sweetened condensed milk, which are reported in the present study for the first time.

A total of 85 volatile compounds were detected and identified in the headspace of Sarabba (Table 3). The identified compounds were assigned to 13 chemical families: alcohols, pyridines, toluene, terpenes, benzene, acids, ketone, phenols, alkanes, alkenes, esters, flavonoids, and hydrazine. A total of 99 volatile compounds could be detected and identified in the headspace of Sarabba with the addition of sweetened condensed milk (Table 4). A total of 96 volatile compounds were detected and identified in the headspace of Sarabba with the addition of egg yolk (Table 5). Volatile aroma compounds found in Sarabba with the addition of sweetened condensed milk and Sarabba with the addition of chicken egg yolk were grouped into 11 chemical families: alcohols, pyridines, toluene, terpenes, ketones, phenols, alkanes, alkenes, ester, flavonoid, and aldehydes.

### *3.4 Relationship among physicochemical properties, sensory attributes, and volatile compounds of Sarabba*

In observing the relationship among physicochemical properties, sensory attributes, and volatile compounds of all Sarabba, a PCA was performed, and a biplot illustrating the information of samples (Figure 2A) and variables (Figure 2B) was represented for the two first dimensions. Sweetness and protein content of Sarabba with the addition of chicken egg yolk were correlated with esters. pH and TSS were negatively correlated with viscosity. Terpenes were correlated with warmness and spiciness of Sarabba. Moreover, terpenes are primarily responsible for the unique aroma and taste of spicy-based products.

## 4 DISCUSSION

This study aimed to examine whether the addition of chicken egg yolk and sweetened condensed milk affects the physicochemical properties, sensory perception, and volatile compounds of Sarabba. Few studies that used chicken egg yolk or sweetened condensed milk have been performed on traditional drinks, but most of them have been performed on traditional foods. In the case of Sarabba, the addition of chicken egg yolk or sweetened condensed milk was performed in the final product because it can enhance the taste, aroma, and probably stamina.

Colour is an important attribute that affects consumer's choice and preference and is associated with nutritional properties of foods (Markovic et al., 2013; Pathare et al., 2013). We observed that the addition of sweetened condensed milk or chicken egg yolk increased L* and b* (Table 1). The highest L* and b* were detected in Sarabba with sweetened condensed milk or egg yolk addition, indicating that the brightness and yellow level of the Sarabba beverage were affected by the addition of milk or egg yolk. Based on previous reports, egg yolk is light and clear yellow (Réhault-Godbert et al., 2019). Sweetened condensed milk added to the Sarabba is light brown (Jouki et al., 2021), which results in the high brightness of the Sarabba. Egg yolk and sweetened condensed milk that have light and bright colour levels produce a Sarabba with the highest brightness. Protein content is a micronutrient in food and beverages, which has satisfying effects. Table 1 shows a significant increase in protein content with the addition of chicken egg yolk. Sarabba with chicken egg yolk had the highest protein content of 1.10%, which is 2.75 times higher than that of Sarabba and Sarabba with sweetened condensed milk. Typically, the quality of the final product depends on the raw materials used. According to Réhault-Godbert et al. (2019), egg yolk has a higher protein level (15.50%) than sweetened condensed milk (7.9%) (Shimoda et al., 2001), which contributed to the high protein content of Sarabba with egg yolk. Viscosity is a vital parameter in cocoa beverages because it determines the 'body' of the product. Table 1 shows that the addition of chicken egg yolk to Sarabba has the highest viscosity, followed by the addition of sweetened

**Table 3**. Volatile compounds of Sarabba.

| RT (min) | Compounds | Concentration (ppb) | Area (%) |
|---|---|---|---|
| 1.1503 | Hydrazine | 91.96 | 3.66 |
| 1.2035 | Ethanol | 275.8 | 10.99 |
| 1.4442 | Cyclobutanol | 13.88 | 0.55 |
| 1.5721 | Isobutanol | 18.58 | 0.74 |
| 1.6683 | Acetic acid | 9.51 | 0.38 |
| 2.1315 | Isopentanol | 23.56 | 0.94 |
| 2.155 | 2-Methylbutanol | 22.78 | 0.91 |
| 2.4101 | Toluene | 4.83 | 0.19 |
| 2.9903 | Pyrazine, methyl- | 2.81 | 0.11 |
| 3.5443 | p-Xylene | 1.93 | 0.08 |
| 3.7972 | 2-Heptanone | 19.15 | 0.76 |
| 3.9555 | 2-Heptanol | 12.52 | 0.50 |
| 4.1828 | Pyrazine, 2,6-dimethyl- | 5.05 | 0.20 |
| 4.3261 | γ-Terpinene | 2.93 | 0.12 |
| 4.5197 | 1R-α-Pinene | 39.92 | 1.59 |
| 4.7905 | Camphene | 108.4 | 4.32 |
| 5.2273 | β-Thujene | 1.62 | 0.06 |
| 5.3007 | β-Pinene | 11.06 | 0.44 |
| 5.4527 | 5-Hepten-2-one, 6-methyl- | 52.16 | 2.08 |
| 5.526 | β-Myrcene | 49.17 | 1.96 |
| 5.6712 | 6-Methyl-5-hepten-2-ol | 5.95 | 0.24 |
| 5.8253 | α-Phellandrene | 31.4 | 1.25 |
| 5.9346 | 3-Carene | 49.95 | 1.99 |
| 6.0689 | (+)-4-Carene | 3.81 | 0.15 |
| 6.2408 | β-Cymene | 9.53 | 0.38 |
| 6.3404 | Sabinene | 225.4 | 8.98 |
| 6.3721 | Eucalyptol | 245,3 | 9.77 |
| 6.4747 | α-Pinene | 3.25 | 0.13 |
| 6.5349 | 2-Heptanol, acetate | 3.45 | 0.14 |
| 6.6997 | cis-β-Ocimene | 4.59 | 0.18 |
| 6.947 | (+)-3-Carene | 3.24 | 0.13 |
| 7.5345 | 2-Carene | 2.09 | 0.08 |
| 7.5878 | α-Terpinolene | 12.06 | 0.48 |
| 7.641 | 2-Nonanone | 19.03 | 0.76 |
| 7.7644 | 4-Vinylguaiacol | 2.17 | 0.09 |
| 7.8574 | β-Linalool | 75.56 | 3.01 |
| 8.1422 | Bicyclo[2.2.1]heptane, 2-methoxy-1,7,7-trimethyl- | 2.24 | 0.09 |
| 8.1755 | 2,6-Dimethyleneoct-7-en-3-one | 1.94 | 0.08 |
| 8.3717 | p-Menth-2-en-1-ol, trans | 4.58 | 0.18 |
| 8.7794 | cis-2-p-Menthen-1-ol | 2.69 | 0.11 |
| 8.8776 | Camphor | 6.49 | 0.26 |
| 9.1933 | Isoborneol | 1.87 | 0.07 |

Continue...

**Table 3**. Continuation.

| RT (min) | Compounds | Concentration (ppb) | Area (%) |
|---|---|---|---|
| 9.2663 | p-Mentha-1,5-dien-8-ol | 2.43 | 0.10 |
| 9.3318 | β-Terpineol | 0.81 | 0.03 |
| 9.3995 | Borneol | 39.61 | 1.58 |
| 9.6424 | L-4-Terpineol | 17.46 | 0.70 |
| 9.781 | 2-Methylisoborneol | 4.02 | 0.16 |
| 9.8576 | m-Cymen-8-ol | 4.16 | 0.17 |
| 9.9612 | α-Terpineol | 32.56 | 1.30 |
| 10.033 | Dodecane | 9.02 | 0.36 |
| 10.2228 | cis-Sabinol | 2.86 | 0.11 |
| 10.3461 | cis-Verbenone | 4.47 | 0.18 |
| 10.7598 | cis-Geraniol | 129.2 | 5.15 |
| 11.3439 | trans-Geraniol | 117.3 | 4.67 |
| 11.6977 | α-Citral | 23.37 | 0.93 |
| 12.046 | (-)-Bornyl acetate | 7.48 | 0.30 |
| 12.1952 | 2-Undecanone | 7.82 | 0.31 |
| 13.2036 | δ-EIemene | 19.71 | 0.79 |
| 13.4948 | 2,6-Octadiene, 2,6-dimethyl- | 2.1 | 0.08 |
| 13.8557 | Cyclosativene | 3.11 | 0.12 |
| 14.0622 | α-Cubebene | 5 | 0.20 |
| 14.1626 | Geranyl acetate | 1.64 | 0.07 |
| 14.4117 | β-Elemene | 12.35 | 0.49 |
| 14.4803 | Tetradecane | 1.88 | 0.07 |
| 14.6592 | trans-α-Bergamotene | 1.49 | 0.06 |
| 14.7444 | Alloaromadendrene | 1.07 | 0.04 |
| 15.0312 | Caryophyllene | 327.2 | 13.04 |
| 15.2036 | β-Ylangene | 3.62 | 0.14 |
| 15.2838 | Longifolene-(V4) | 1.79 | 0.07 |
| 15.389 | α-Guaiene | 9.61 | 0.38 |
| 15.6571 | Valencene | 2.93 | 0.12 |
| 15.749 | α-Caryophyllene | 18.78 | 0.75 |
| 15.8944 | Aromandendrene | 2.83 | 0.11 |
| 16.2244 | α-Bergamotene | 8.15 | 0.32 |
| 16.3129 | α-Curcumene | 23.09 | 0.92 |
| 16.4379 | β-Selinene | 8.89 | 0.35 |
| 16.5598 | Zingiberene | 87.92 | 3.50 |
| 16.6693 | γ-Muurolene | 15.88 | 0.63 |
| 16.7933 | α-Farnesene | 14.48 | 0.58 |
| 16.8241 | β-Bisabolene | 16.66 | 0.66 |
| 16.9529 | γ-Cadinene | 2.79 | 0.11 |
| 17.0787 | (-)-α-Panasinsen | 1.81 | 0.07 |
| 17.1499 | β-Sesquiphellandrene | 25.08 | 1.00 |
| 17.8637 | α-Gurjunene | 1.63 | 0.06 |
| 18.4044 | Caryophyllene oxide | 1.65 | 0.07 |

**Table 4**. Volatile compounds of Sarabba with sweetened condensed milk.

| RT (min) | Compounds | Concentration (ppb) | Area (%) |
|---|---|---|---|
| 2.0191 | Dimethylsilanediol | 0.87 | 0.02 |
| 2.4101 | Toluene | 0.62 | 0.02 |
| 2.6775 | Hexanal | 2.41 | 0.07 |
| 2.9938 | Pyrazine, methyl- | 0.93 | 0.03 |
| 3.7983 | 2-Heptanone | 2.26 | 0.06 |
| 3.9557 | 2-Heptanol | 1.53 | 0.04 |
| 4.1889 | Pyrazine, 2,6-dimethyl- | 1.78 | 0.05 |
| 4.3249 | γ-Terpinene | 5.75 | 0.16 |
| 4.3903 | α-Thujene | 1.55 | 0.04 |
| 4.518 | 1R-α-Pinene | 82.23 | 2.33 |
| 4.79 | Camphene | 329.5 | 9.32 |
| 5.0539 | Isodurene | 2.61 | 0.07 |
| 5.2245 | β-Thujene | 3.15 | 0.09 |
| 5.298 | β-Pinene | 26.58 | 0.75 |
| 5.4501 | 5-Hepten-2-one, 6-methyl- | 42.34 | 1.20 |
| 5.525 | β-Myrcene | 164.7 | 4.66 |
| 5.761 | Octanal | 3.38 | 0.10 |
| 5.8228 | α-Phellandrene | 56.72 | 1.61 |
| 5.9333 | 3-Carene | 124.1 | 3.51 |
| 6.0654 | (+)-4-Carene | 4.62 | 0.13 |
| 6.1751 | o-Cymene | 0.7 | 0.02 |
| 6.2383 | β-Cymene | 16.23 | 0.46 |
| 6.3351 | Sabinene | 427.7 | 12.14 |
| 6.375 | Eucalyptol | 17.51 | 0.50 |
| 6.4711 | α-Pinene | 4.56 | 0.13 |
| 6.5316 | 2-Heptanol, acetate | 6.82 | 0.19 |
| 6.6958 | cis-β-Ocimene | 5.45 | 0.15 |
| 6.817 | 5-Heptenal, 2,6-dimethyl- | 1.41 | 0.04 |
| 6.8859 | α-Thujene | 0.98 | 0.03 |
| 6.9426 | (+)-3-Carene | 6.4 | 0.18 |
| 7.5298 | 2-Carene | 3.16 | 0.09 |
| 7.5842 | α-Terpinolene | 36.16 | 1.02 |
| 7.6367 | 2-Nonanone | 20.74 | 0.59 |
| 7.7749 | 4-Vinylguaiacol | 10.3 | 0.29 |
| 7.8533 | β-Linalool | 64.81 | 1.83 |
| 8.1339 | Bicyclo[2.2.1]heptane, 2-methoxy-1,7,7-trimethyl- | 2.72 | 0.08 |
| 8.1725 | 2,6-Dimethyleneoct-7-en-3-one | 3.98 | 0.11 |
| 8.3663 | p-Menth-2-en-1-ol, trans | 1.49 | 0.04 |
| 8.6673 | p-Mentha-1,5,8-triene | 1.31 | 0.04 |
| 8.778 | cis-2-p-Menthen-1-ol | 0.81 | 0.02 |
| 8.8289 | 6-Octenal, 7-methyl-3-methylene- | 1.73 | 0.05 |
| 8.8745 | Camphor | 2.03 | 0.06 |
| 9.194 | Isoborneol | 1.05 | 0.03 |
| 9.2761 | p-Mentha-1,5-dien-8-ol | 4.62 | 0.13 |
| 9.3975 | Borneol | 30.08 | 0.85 |
| 9.6375 | L-4-Terpineol | 8.05 | 0.23 |
| 9.6853 | Isogeranial | 12.6 | 0.36 |
| 9.7886 | 2-Methylisoborneol | 3.91 | 0.11 |

Continue...

**Table 4**. Continuation.

| RT (min) | Compounds | Concentration (ppb) | Area (%) |
|---|---|---|---|
| 9.845 | m-Cymen-8-ol | 3.4 | 0.10 |
| 9.9579 | α-Terpineol | 15.31 | 0.43 |
| 10.01 | Dodecane | 2.22 | 0.06 |
| 10.2018 | cis-Sabinol | 3.37 | 0.10 |
| 10.3105 | cis-Verbenone | 3.14 | 0.09 |
| 10.7687 | cis-Geraniol | 32.66 | 0.92 |
| 10.8758 | Citronellol | 31.27 | 0.88 |
| 11.033 | β-Citral | 150.8 | 4.27 |
| 11.3463 | trans-Geraniol | 236 | 6.68 |
| 11.6995 | α-Citral | 180.9 | 5.12 |
| 12.0445 | (-)-Bornyl acetate | 36.44 | 1.03 |
| 12.1899 | 2-Undecanone | 50.13 | 1.42 |
| 13.199 | δ-EIemene | 4.83 | 0.14 |
| 13.4877 | 2,6-Octadiene, 2,6-dimethyl- | 17.27 | 0.49 |
| 13.7378 | Nerol acetate | 1.86 | 0.05 |
| 13.8531 | Cyclosativene | 4.52 | 0.13 |
| 14.0579 | α-Cubebene | 5.62 | 0.16 |
| 14.1522 | Geranyl acetate | 69.2 | 1.96 |
| 14.4082 | β-Elemene | 14.26 | 0.40 |
| 14.6569 | trans-α-Bergamotene | 6.02 | 0.17 |
| 15.0203 | Caryophyllene | 68.83 | 1.95 |
| 15.1987 | β-Ylangene | 1.67 | 0.05 |
| 15.2859 | Longifolene-(V4) | 7.32 | 0.21 |
| 15.3789 | α-Guaiene | 3 | 0.08 |
| 15.652 | Valencene | 0.93 | 0.03 |
| 15.7381 | α-Caryophyllene | 14.09 | 0.40 |
| 15.8898 | Aromandendrene | 4.99 | 0.14 |
| 16.0585 | α-Curcumene | 1.13 | 0.03 |
| 16.138 | α-Elemene | 1.32 | 0.04 |
| 16.2287 | α-Bergamotene | 15.1 | 0.43 |
| 16.3101 | α-Curcumene | 170.4 | 4.82 |
| 16.4374 | β-Selinene | 4.43 | 0.13 |
| 16.564 | Zingiberene | 423.8 | 12.02 |
| 16.6687 | γ-Muurolene | 29.45 | 0.83 |
| 16.787 | α-Farnesene | 82.94 | 2.35 |
| 16.8244 | β-Bisabolene | 84.21 | 2.38 |
| 16.9506 | γ-Cadinene | 5.52 | 0.16 |
| 17.074 | (-)-α-Panasinsen | 0.84 | 0.02 |
| 17.1489 | β-Sesquiphellandrene | 156.1 | 4.42 |
| 17.2943 | α-Patchoulene | 5.47 | 0.15 |
| 17.361 | α-Cedrene | 1.83 | 0.05 |
| 17.5208 | trans-β-Ionone | 2.89 | 0.08 |
| 17.7142 | Elemol | 3.84 | 0.11 |
| 17.8596 | α-Gurjunene | 2.08 | 0.06 |
| 17.9351 | Nerolidol | 2.3 | 0.07 |
| 18.5099 | Geranyl-α-Terpinene | 1.49 | 0.04 |
| 18.9556 | Farnesol | 2.41 | 0.07 |
| 19.1191 | Cadinene | 2.96 | 0.08 |
| 19.2915 | Cubenol | 2.45 | 0.07 |
| 19.727 | β-Selinenol | 1.09 | 0.03 |
| 19.8056 | α-Cadinol | 2.55 | 0.07 |

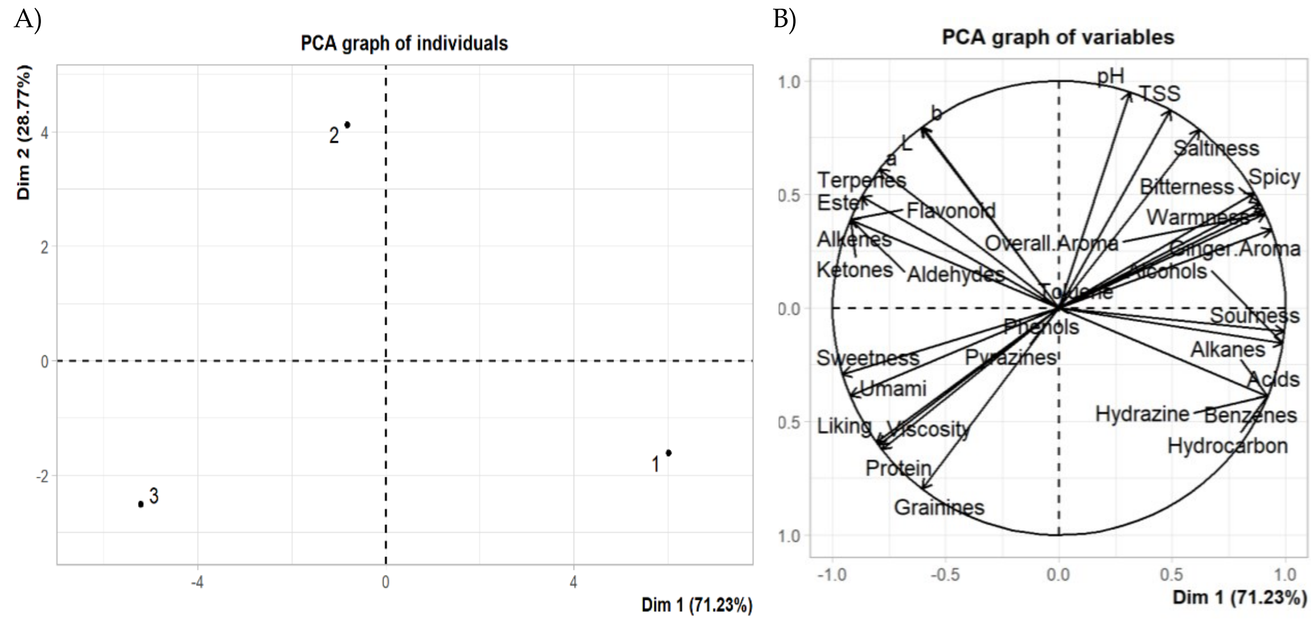
**Table 5**. Volatile compounds of Sarabba with chicken egg yolk.

| RT (min) | Compound | Cons (ppb) | Area (%) |
|---|---|---|---|
| 2.4098 | Toluene | 0.73 | 0.03 |
| 2.6767 | Hexanal | 6.,1 | 0.22 |
| 2.9914 | Pyrazine, methyl- | 0.82 | 0.03 |
| 3.7976 | 2-Heptanone | 1.64 | 0.06 |
| 3.9557 | 2-Heptanol | 1.09 | 0.04 |
| 4.1895 | Pyrazine, 2,6-dimethyl- | 1.55 | 0.06 |
| 4.3251 | γ-Terpinene | 3.79 | 0.14 |
| 4.3911 | α-Thujene | 0.98 | 0.04 |
| 4.5182 | 1R-α-Pinene | 56.2 | 2.02 |
| 4.7897 | Camphene | 208.13 | 7.48 |
| 5.0519 | Isodurene | 1.98 | 0.07 |
| 5.2255 | β-Thujene | 1.91 | 0.07 |
| 5.2991 | β-Pinene | 16.81 | 0.60 |
| 5.4501 | 5-Hepten-2-one, 6-methyl- | 70.77 | 2.54 |
| 5.5672 | β-Myrcene | 725.05 | 26.04 |
| 5.7615 | Octanal | 2.68 | 0.10 |
| 5.8236 | α-Phellandrene | 36.53 | 1.31 |
| 5.9332 | 3-Carene | 81.3 | 2.92 |
| 6.0657 | (+)-4-Carene | 3.13 | 0.11 |
| 6.172 | *o*-Cymene | 0.46 | 0.02 |
| 6.2386 | β-Cymene | 9.29 | 0.33 |
| 6.3334 | Sabinene | 265.23 | 9.53 |
| 6.367 | Eucalyptol | 12.17 | 0.44 |
| 6.4718 | α-Pinene | 2.54 | 0.09 |
| 6.5337 | 2-Heptanol, acetate | 3.86 | 0.14 |
| 6.696 | cis-β-Ocimene | 2.75 | 0.10 |
| 6.819 | 5-Heptenal, 2,6-dimethyl- | 0.84 | 0.03 |
| 6.88 | α-Thujene | 0.6 | 0.02 |
| 6.9433 | (+)-3-Carene | 3.56 | 0.13 |
| 7.5309 | 2-Carene | 1.8 | 0.06 |
| 7.5852 | α-Terpinolene | 20.82 | 0.75 |
| 7.6378 | 2-Nonanone | 10.48 | 0.38 |
| 7.7741 | 4-Vinylguaiacol | 5.83 | 0.21 |
| 7.8536 | β-Linalool | 32.81 | 1.18 |
| 8.127 | Bicyclo[2.2.1]heptane, 2-methoxy-1,7,7-trimethyl- | 2.16 | 0.08 |
| 8.1751 | 2,6-Dimethyleneoct-7-en-3-one | 2.52 | 0.09 |
| 8.355 | *p*-Menth-2-en-1-ol, trans | 0.94 | 0.03 |
| 8.6616 | *p*-Mentha-1,5,8-triene | 0.63 | 0.02 |
| 8.775 | cis-2-*p*-Menthen-1-ol | 0.45 | 0.02 |
| 8.828 | 6-Octenal, 7-methyl-3-methylene- | 0.7 | 0.03 |
| 8.8771 | Camphor | 1.42 | 0.05 |
| 9.203 | Isoborneol | 0.95 | 0.03 |
| 9.2772 | *p*-Mentha-1,5-dien-8-ol | 1.79 | 0.06 |
| 9.3986 | Borneol | 11.08 | 0.40 |
| 9.5277 | L-Borneol | 4.42 | 0.16 |
| 9.6397 | L-4-Terpineol | 3.98 | 0.14 |
| 9,6864 | Isogeranial | 6.39 | 0.23 |

Continue...

**Table 5**. Continuation.

| RT (min) | Compound | Cons (ppb) | Area (%) |
|---|---|---|---|
| 9.791 | 2-Methylisoborneol | 1.83 | 0.07 |
| 9.851 | *m*-Cymen-8-ol | 2.06 | 0.07 |
| 9.959 | α-Terpineol | 7.8 | 0.28 |
| 10.022 | Dodecane | 1.06 | 0.04 |
| 10.2053 | cis-Sabinol | 2.12 | 0.08 |
| 10.3094 | cis-Verbenone | 1.56 | 0.06 |
| 10.84 | cis-Geraniol | 9.6 | 0.34 |
| 10.8755 | Citronellol | 13.23 | 0.48 |
| 11.0303 | β-Citral | 43.95 | 1.58 |
| 11.3441 | trans-Geraniol | 84.29 | 3.03 |
| 11.6945 | α-Citral | 55.29 | 1.99 |
| 12.0436 | (-)-Bornyl acetate | 18.02 | 0.65 |
| 12.1908 | 2-Undecanone | 23.35 | 0.84 |
| 13.199 | δ-EIemene | 3.25 | 0.12 |
| 13.4887 | 2,6-Octadiene, 2,6-dimethyl- | 8.68 | 0.31 |
| 13.735 | Nerol acetate | 0.84 | 0.03 |
| 13.8537 | Cyclosativene | 3.06 | 0.11 |
| 14.0592 | α-Cubebene | 3.68 | 0.13 |
| 14.1529 | Geranyl acetate | 32.11 | 1.15 |
| 14.4079 | β-Elemene | 9.97 | 0.36 |
| 14.6566 | trans-α-Bergamotene | 4.05 | 0.15 |
| 15.0216 | Caryophyllene | 52.12 | 1.87 |
| 15.2055 | β-Ylangene | 1.03 | 0.04 |
| 15.2847 | Longifolene-(V4) | 5.08 | 0.18 |
| 15.3819 | α-Guaiene | 2.04 | 0.07 |
| 15.6539 | Valencene | 0.68 | 0.02 |
| 15.739 | α-Caryophyllene | 10.29 | 0.37 |
| 15.8894 | Aromandendrene | 3.45 | 0.12 |
| 16.051 | α-Curcumene | 0.61 | 0.02 |
| 16.1334 | α-Elemene | 0.83 | 0.03 |
| 16.2278 | α-Bergamotene | 10.67 | 0.38 |
| 16.3092 | α-Curcumene | 127.35 | 4.58 |
| 16.4356 | β-Selinene | 2.94 | 0.11 |
| 16.5619 | Zingiberene | 325.17 | 11.68 |
| 16.6681 | γ-Muurolene | 22.45 | 0.81 |
| 16.7877 | α-Farnesene | 59.13 | 2.12 |
| 16.8236 | β-Bisabolene | 63.29 | 2.27 |
| 16.9503 | γ-Cadinene | 4.78 | 0.17 |
| 17.1482 | β-Sesquiphellandrene | 115.26 | 4.14 |
| 17.2953 | α-Patchoulene | 3.77 | 0.14 |
| 17.35 | α-Cedrene | 1.2 | 0.04 |
| 17.51 | trans-β-Ionone | 0.86 | 0.03 |
| 17.7148 | Elemol | 1.47 | 0.05 |
| 17.8584 | α-Gurjunene | 1.2 | 0.04 |
| 17.933 | Nerolidol | 0.83 | 0.03 |
| 18.948 | Farnesol | 1.13 | 0.04 |
| 19.1153 | Cadinene | 1.02 | 0.04 |
| 19.734 | β-Selinenol | 0.71 | 0.03 |
| 19.8121 | α-Cadinol | 2.62 | 0.09 |




1 = Sarabba; 2 = Sarabba with sweetened condensed milk; 3 = Sarabba with chicken egg yolk.

**Figure 2**. Plot of principal component analysis of the physicochemical parameters, sensory attributes, and volatile compounds of Sarabba.

condensed milk, probably because the protein from egg yolk can form a colloidal system as an emulsion. Egg yolk contains high protein (15.50%) (Réhault-Godbert et al., 2019) when compared with sweetened condensed milk (7.9%) (Shimoda et al., 2001). In addition, the coconut milk contained in Sarabba beverages has protein (Karunasiri et al., 2020). In this case, the attraction and repulsion among protein molecules were more intense, leading to greater viscosity (Hong et al., 2017). In contrast, the addition of chicken egg yolk and sweetened condensed milk has no significant effect on the TSS or pH of Sarabba, thereby indicating the biological stability of the samples.

Considering the influence of the addition of chicken egg yolk and sweetened condensed milk on sensory perception, our sensory results show that sensory perception was not fully driven by the addition of chicken egg yolk and sweetened condensed milk. The taste dimensions are of great importance, and the addition of sweetened condensed milk and chicken egg yolk led to a decrease in perceived sourness and bitterness. This result can be explained by the higher protein content of egg yolk, which interacts with phenolic compounds, causing insoluble compounds to interact with the taste receptors (Keast, 2008; Peyrot et al., 2021). With regard to warmness perception, Sarabba without the addition of chicken egg yolk and sweetened condensed milk led to a higher perceived warmth. The high perceived spiciness could indicate that ginger has a high content of non-volatile compounds, which could be easily broken down and hydrated by saliva. In this study, we also observed that Sarabba has a higher ginger aroma and overall aroma (see Figure 1).

Examining whether the addition of chicken egg yolk and sweetened condensed milk influences the physicochemical properties and sensory perception of Sarabba, this study investigated the effect of chicken egg yolk and sweetened condensed milk addition on the volatile compounds of Sarabba. We observed that the addition of chicken egg yolk and condensed sweetened milk could increase and decrease the compounds, probably because yolk protein and sweetened condensed milk have a higher adsorption capacity because of their flexible molecular structure and greater surface hydrophobicity (Campbell et al., 2005; Mine, 1998). These compounds might be generated from ginger, lemongrass, and pepper through thermal degradation.

A high percentage of volatile aromatic compounds in these Sarabba belonged to terpenes. A total of 53 individual compounds of terpenes were detected in Sarabba (Table 3). A total of 72 and 73 individual compounds were detected in Sarabba with sweetened condensed milk (Table 4) and Sarabba with chicken egg yolk (Table 5), respectively. Among all terpenes, caryophyllene (13.04%) contributed the largest amount in Sarabba, whereas sabinene (12.14%) and β-myrcene (26.04%) accounted for the highest percentage of area in Sarabba with sweetened condensed milk and Sarabba with chicken egg yolk. In this study, the composition of Sarabba volatile compounds is consistent with that of the previous study. The results reported by the authors indicated that monoterpenoids, sesquiterpenoids, and their derivatives were the major components of typical ginger (Pang et al., 2017). Sabulal et al. (2006) also identified caryophyllene as the major constituent of *Zingiber nimmonii*. In addition, caryophyllene contributed to the spiciness of black pepper oil (Singh et al., 2004). Meanwhile, Sukatta et al. (2009) identified that sabinene was the major constituent of *Z. cassumuna*. Apart from caryophyllene and sabinene, β-myrcene was also found in ginger, and it accounted for 20% of lemongrass (*C. citratus*) (Lorenzetti et al., 1991). Therefore, camphene and α-curcumene are found in Sarabba, posing a turmeric odour and slightly pungent, bitter taste (Jain et al., 2007). Yeh et al. (2014) reported the presence of α-curcumene, α-farnesene, β-bisabolene, β-sesquiphellandrene, and zingiberene in ginger, which were also found in Sarabba. Zingiberene found in ginger oil can provide a warm sensation as well as a woody-spicy and tenacious odour, whereas α-farnesene might be associated with a mild, sweet, and warm odour. Moreover, cis-*p*-menth-2-en-1-*o* and trans-*p*-menth-2-en-1-ol found in this Sarabba were found in *Cymbopogon jwarancusa* (Kumar et al., 2021). Each volatile terpene compound in this Sarabba might contribute to a typical spicy ginger odour and taste.

Terpenes, alcohols, and aldehydes were represented in Sarabba. The alcohol group comprised ethanol, cyclobutanol, isobutanol, isopentanol, 2-methylbutanol, *m*-cymen-8-ol, and 2-heptanol, with ethanol as the dominant alcohol, whereas the aldehyde group was primarily composed of hexanal and octanal. Alcohols were also well studied in brown sugar (Asikin et al., 2014), which are generally responsible for the aroma. Ding et al. (2012) reported that the presence of alcohols and aldehydes influenced the ginger aroma, which is responsible for the fruity, floral, gingery, and sweet aromas. Compared with Sarabba, Sarabba with sweetened condensed milk and Sarabba with egg yolk present the aldehyde group. Therefore, the addition of milk and egg yolk in hot conditions where oxygen exists can lead to the disappearance of some volatile constituents and the appearance of some novel molecules (Ding et al., 2012).

Ketones were also detected in the samples. The most abundant ketones in Sarabba were 6-methyl-5-hepten-2-one (2.08%), whereas 2-undecanone was dominant in Sarabba with sweetened condensed milk (1.42%) and Sarabba with egg yolk (0.84%). Based on previous reports, 2-undecanone, associated with a fruity odour, was found not only in sweetened condensed milk (Shimoda et al., 2001) but also in egg yolk on chicken (Patil et al., 2022). In addition, 2-undecanone and 6-methyl-5-hepten-2-one, both associated with a grassy odour, were also found in ginger-flavoured beverages. Among esters, bornyl acetate and geranyl acetate accounted for the highest proportion in Sarabba. Esters were formed through esterification of sugars or polysaccharides with fatty acids by chemical and enzymatic reactions, which pronounced the sweetness of Sarabba. Notably, the addition of sweetened condensed milk and chicken egg yolk was also associated with perceived sweetness and the presence of the ester group. Esters have a fruity aroma, particularly those that arise from short-chain acids (high concentrations of esters and more pronounced sweetness of the products) (Marušić et al., 2014). Other volatile compounds such as pyridines, phenols, and alkanes are considered minor volatile compounds. Most of the minor volatile compounds might also play important roles in the specific aromas of Sarabba. Pyrazines such as methyl pyrazine and 2,6-dimethyl pyrazines were found in all Sarabba, which were formed by Maillard-type reactions that occur during conventional cooking of Sarabba at high temperatures. Meanwhile, phenols such as 4-vinylguaiacol found in this study could originate from the added coconut milk.

## 5 CONCLUSION

A total of 85–99 aromatic compounds were found in Sarabba. The most abundant chemical groups identified in Sarabba were terpenes, alcohols, ketones, ester, and alkanes. Aldehydes and flavonoid compounds were not identified in Sarabba, whereas benzenes, acids, hydrocarbon, and hydrazine were not found in Sarabba with sweetened condensed milk or Sarabba with chicken egg yolk. Terpenes and ester were correlated to sweetness and umami taste, which were also positively correlated to protein content. These results indicate that the addition of chicken egg yolk and sweetened condensed milk can affect some physicochemical properties and increase volatile compounds while maintaining the liking of Sarabba. Further studies regarding aroma release, texture, and sensory perception in Sarabba compared with other spicy-based traditional drinks will be conducted.

## REFERENCES


Abdulazeez, M. A., Abdullahi, A. S., James, B. (2016). Essential Oils in Food. In V. R. Preedy (ed.), *Essential Oils in Food Preservation, Flavor and Safety*. Elsevier.

Amalia, L., Yuliana, N. D., Sugita, P., Arofah, D., Syafitri, U. D., Windarsih, A., Rohman, A., Kartini, N., Bakar, A., & Kusnandar, F. (2022). Volatile compounds, texture, and color characterization of meatballs made from beef, rat, wild boar, and their mixtures. *HELIYON*, *8*(10), e10882. https://doi.org/10.1016/j.heliyon.2022.e10882

Asikin, Y., Kamiya, A., Mizu, M., Takara, K., Tamaki, H., & Wada, K. (2014). Changes in the physicochemical characteristics, including flavour components and Maillard reaction products, of non-centrifugal cane brown sugar during storage. *Food Chemistry*, *149*, 170-177. https://doi.org/10.1016/j.foodchem.2013.10.089

Ayseli, M. T., Kelebek, H., & Selli, S. (2021). Elucidation of aroma-active compounds and chlorogenic acids of Turkish coffee brewed from medium and dark roasted Coffea arabica beans. *Food Chemistry*, *338*, 127821. https://doi.org/10.1016/j.foodchem.2020.127821

Baliga, M. S., Shivashankara, A. R., Haniadka, R., Palatty, P. L., Arora, R., & Fayad, R. (2013). Ginger (Zingiber officinale Roscoe): An ancient remedy and modern drug in gastrointestinal disorders. In *Bioactive Food as Dietary Interventions for Liver and Gastrointestinal Disease*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-397154-8.00189-5

Campbell, L., Raikos, V., & Euston, S. R. (2005). *Heat stability and emulsifying ability of whole egg and egg yolk as related to heat treatment*, *19*(3), 533-539. https://doi.org/10.1016/j.foodhyd.2004.10.031

Ding, S. H., An, K. J., Zhao, C. P., Li, Y., Guo, Y. H., & Wang, Z. F. (2012). Effect of drying methods on volatiles of Chinese ginger (Zingiber officinale Roscoe). *Food and Bioproducts Processing*, *90*(3), 515-524. https://doi.org/10.1016/j.fbp.2011.10.003

Hong, T., Iwashita, K., & Shiraki, K. (2017). Viscosity Control of Protein Solution by Small Solutes: A Review. *Current Protein & Peptide Science*, *19*(8), 746-758. https://doi.org/10.2174/1389203719666171213114919

Jain, S., Shrivastava, S., Nayak, S., & Sumbhate, S. (2007). Recent trends in Curcuma longa Linn. *Pharmacognosy Reviews*, *1*(1), 119-128.

Jouki, M., Jafari, S., Jouki, A., & Khazaei, N. (2021). Characterization of functional sweetened condensed milk formulated with flavoring and sugar substitute. *Food Science and Nutrition*, *9*(9), 5119-5130. https://doi.org/10.1002/fsn3.2477

Kafkas, E., Cabaroglu, T., Selli, S., Bozdoğan, A., Kürkçüoğlu, M., Paydaş, S., & Başer, K. H. C. (2006). Identification of volatile aroma compounds of strawberry wine using solid-phase microextraction techniques coupled with gas chromatography-mass spectrometry. *Flavour and Fragrance Journal*, *21*(1), 68-71. https://doi.org/10.1002/ffj.1503

Karunasiri, A. N., Gunawardane, M., Senanayake, C. M., Jayathilaka, N., & Seneviratne, K. N. (2020). Antioxidant and Nutritional

Properties of Domestic and Commercial Coconut Milk Preparations. *International Journal of Food Science*, *2020*, 3489605. https://doi.org/10.1155/2020/3489605

Kasali, A. A., Oyedeji, A. O., & Ashilokun, A. O. (2001). Volatile leaf oil constituents of Cymbopogon citratus (DC) Stapf. *Flavour and Fragrance Journal*, *16*(5), 377-378. https://doi.org/10.1002/ffj.1019

Keast, R. S. J. (2008). Modification of the bitterness of caffeine. *Food Quality and Preference*, *19*, 465-472. https://doi.org/10.1016/j.foodqual.2008.02.002

Kumar, A., Bhatt, G., Pandey, P., Chauhan, A., Upadhyay, R. K., Saikia, D., Verma, R. S., Chanotiya, C. S., & Padalia, R. C. (2021). Chemical characterization, antimicrobial and antioxidant evaluation of Cymbopogon jwarancusa (Jones) Schult. essential oil. *Journal of Essential Oil Research*, *33*(4), 351-358. https://doi.org/10.1080/10412905.2021.1886186

Liu, H., Zeng, F. K., Wang, Q. H., Wu, H. S., & Tan, L. H. (2013). Studies on the chemical and flavor qualities of white pepper (Piper nigrum L.) derived from five new genotypes. *European Food Research and Technology*, *237*(2), 245-251. https://doi.org/10.1007/s00217-013-1986-x

Lorenzetti, B. B., Souza, G. E. P., Sarti, S. J., Santos Filho, D., & Ferreira, S. H. (1991). Myrcene mimics the peripheral analgesic activity of lemongrass tea. *Journal of Ethnopharmacology*, *34*(1), 43-48. https://doi.org/10.1016/0378-8741(91)90187-I

Mahomoodally, M. F., Aumeeruddy, M. Z., Rengasamy, K. R. R., Roshan, S., Hammad, S., Pandohee, J., Hu, X., & Zengin, G. (2021). Ginger and its active compounds in cancer therapy: From folk uses to nano-therapeutic applications. *Seminars in Cancer Biology*, *69*(August), 140-149. https://doi.org/10.1016/j.semcancer.2019.08.009

Mao, Q. Q., Xu, X. Y., Cao, S. Y., Gan, R. Y., Corke, H., Beta, T., & Li, H. Bin. (2019). Bioactive compounds and bioactivities of ginger (zingiber officinale roscoe). *Foods*, *8*(6), 185. https://doi.org/10.3390/foods8060185

Markovic, I., Ilic, J., Markovic, D., Simonovic, V., & Kosanic, N. (2013). Color Measurement of Food Products using CIE L * a * b * and RGB Color Space. *Journal of Hygienic Engineering and Design*, *4*, 50-53.

Marušić, N., Vidaček, S., Janči, T., Petrak, T., & Medić, H. (2014). Determination of volatile compounds and quality parameters of traditional Istrian dry-cured ham. *Meat Science*, *96*(4), 1409-1416. https://doi.org/10.1016/j.meatsci.2013.12.003

Mine, Y. (1998). Adsorption Behavior of Egg Yolk Low-Density Lipoproteins in Oil-in-Water Emulsions. *Journal of Agricultural and Food Chemistry*, *46*(1), 36-41. https://doi.org/10.1021/jf970306y

Olorunnisola, S. K., Asiyanbi, H. T., Hammed, A. M., & Simsek, S. (2014). Biological properties of lemongrass: An overview. *International Food Research Journal*, *21*(2), 455-462.

Orav, A., Stulova, I., Kailas, T., & Müürisepp, M. (2004). Effect of Storage on the Essential Oil Composition of Piper nigrum L. Fruits of Different Ripening States. *Journal of Agricultural and Food Chemistry*, *52*(9), 2582-2586. https://doi.org/10.1021/jf030635s

Pang, X., Cao, J., Wang, D., Qiu, J., & Kong, F. (2017). Identification of Ginger (Zingiber officinale Roscoe) Volatiles and Localization of Aroma-Active Constituents by GC-Olfactometry. *Journal of Agricultural and Food Chemistry*, *65*(20), 4140-4145. https://doi.org/10.1021/acs.jafc.7b00559

Pathare, P. B., Opara, U. L., & Al-Said, F. A. J. (2013). Colour Measurement and Analysis in Fresh and Processed Foods: A Review. *Food and Bioprocess Technology*, *6*(1), 36-60. https://doi.org/10.1007/s11947-012-0867-9

Patil, S., Rao, B., Matondkar, M., Bhushette, P., & Sonawane, S. K. (2022). a Review on Understanding of Egg Yolk As Functional Ingredients. *Journal of Microbiology, Biotechnology and Food Sciences*, *11*(4), e4627. https://doi.org/10.55251/jmbfs.4627

Peyrot, C., Keefe, A. J. O., Slade, L., & Beauchamp, G. K. (2021). Protein suppresses both bitterness and oleocanthal - elicited pungency of extra virgin olive oil. *Scientific Reports*, *0123456789*. https://doi.org/10.1038/s41598-021-91046-0

Purnomo, H., Jaya, F., & Widjanarko, S. B. (2010). The effects of type and time of thermal processing on ginger (Zingiber officinale Roscoe) rhizome antioxidant compounds and its quality. *International Food Research Journal*, *17*(2), 335-347.

Ranjini, H. S., Padmanabha Udupa, E. G., Kamath, S. U., Setty, M., & Hadapad, B. (2017). A specific absorbance to estimate a protein by lowry's method. *Advanced Science Letters*, *23*(3), 1889-1891. https://doi.org/10.1166/asl.2017.8509

Réhault-Godbert, S., Guyot, N., & Nys, Y. (2019). The golden egg: Nutritional value, bioactivities, and emerging benefits for human health. *Nutrients*, *11*(3), 684. https://doi.org/10.3390/nu11030684

Sabulal, B., Dan, M., J, A. J., Kurup, R., Pradeep, N. S., Valsamma, R. K., & George, V. (2006). Caryophyllene-rich rhizome oil of Zingiber nimmonii from South India: Chemical characterization and antimicrobial activity. *Phytochemistry*, *67*(22), 2469-2473. https://doi.org/10.1016/j.phytochem.2006.08.003

Schaneberg, B. T., & Khan, I. A. (2002). Comparison of extraction methods for marker compounds in the essential oil of lemon grass by GC. *Journal of Agricultural and Food Chemistry*, *50*(6), 1345-1349. https://doi.org/10.1021/jf011078h

Shao, Y., Marriott, P., Shellie, R., & Hügel, H. (2003). Solid-phase micro-extraction - Comprehensive two-dimensional gas chromatography of ginger (Zingiber officinale) volatiles. *Flavour and Fragrance Journal*, *18*(1), 5-12. https://doi.org/10.1002/ffj.1133

Shimoda, M., Yoshimura, Y., Yoshimura, T., Noda, K., & Osajima, Y. (2001). Volatile Flavor Compounds of Sweetened Condensed Milk. *Journal of Food Science*, *66*(6), 804-807. https://doi.org/10.1111/j.1365-2621.2001.tb15176.x

Singh, G., Marimuthu, P., Catalan, C., & Delampasona, M. P. (2004). Chemical, antioxidant and antifungal activities of volatile oil of black pepper and its acetone extract. *Journal of the Science of Food and Agriculture*, *84*(14), 1878-1884. https://doi.org/10.1002/jsfa.1863

Sukatta, U., Rugthaworn, P., Punjee, P., Chidchenchey, S., & Keeratinijakal, V. (2009). Chemical composition and physical properties of oil from plai (Zingiber cassumunar Roxb.) obtained by hydro distillation and hexane extraction. *Kasetsart Journal - Natural Science*, *43*(5 Suppl.), 212-217.

Umano, K., Hagi, Y., Shoji, A., & Shibamoto, T. (1990). Volatile Compounds Formed from Cooked Whole Egg, Egg Yolk, and Egg White. *Journal of Agricultural and Food Chemistry*, *38*(2), 461-464. https://doi.org/10.1021/jf00092a028

Viktorová, J., Stupák, M., Řehořová, K., Dobiasová, S., Hoang, L., Hajšlová, J., Van Thanh, T., Van Tri, L., Van Tuan, N., & Ruml, T. (2020). Lemon grass essential oil does not modulate cancer cells multidrug resistance by citral—its dominant and strongly antimicrobial compound. *Foods*, *9*(5), 585. https://doi.org/10.3390/foods9050585

Yeh, H.-Y., Chuang, C.-H., Chen, H.C., Wan, C.J., Chen, T.L., & Lin, L.Y. (2014). Bioactive components analysis of two various gingers (Zingiber officinale Roscoe) and antioxidant effect of ginger extracts. *LWT*, *55*(1), 329-334. https://doi.org/10.1016/j.lwt.2013.08.003