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Volatile Profiling of Root-Shoot and Fruits of *Capsicum frutescens* var. Salo Dua from Enrekang, Indonesia

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Abstract

Capsicum frutescens **var. Salo Dua is a local variety cultivated in Enrekang Regency, South Sulawesi. It has unique traits of color transition during fruit ripening and extended post-harvest shelf life. However, the metabolite profiling in this potential variety has not been explored. This was an initial study that aimed to profile the volatile compounds in the root-shoot parts (as vegetative) and in the ripe fruits of Salo Dua variety. The instrument of Gas Chromatography coupled with Mass Spectrometry (GC-MS) was used to separate and characterize the volatile compounds. Our study revealed a higher number of forty-two volatiles in the ripe fruits compared to the twenty-eight volatiles in the shoot-root parts. The five major compositions of the chemical class in ripe fruits were characterized by the formation of alcohols (26%) followed by esters (19%), alkaloids (10%), fatty acids (10%), and ketones (7%). While the abundant volatiles in the root-shoot parts were shown by the presence of esters (29%), alcohols (21%), fatty acids (18%), alkaloids (11%), and heterocyclic (7%). There were nineteen volatiles that only emitted in the ripe fruits. Of which, capsaicin and dihydrocapsaicin were detected in the ripe fruits with an average relative area of 1% and 0.51%, subsequently.**

Keywords: *Capsicum frutescens*, GC-MS, local plant, metabolite profiling, volatiles

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Introduction

Genus *Capsicum* has been commonly used as spices and food additive because chilies contain bioactive compounds such as capsaicinoids, carotenoids, phenols, as well as vitamins and minerals that could be applied to promote and improve a human health (Baenas *et al.*, 2019; de Sá Mendes and de Andrade Gonçalves, 2020). In addition, *Capsicum annum* fruits also contain the highest average of seed oil content by 28.1% compared to other chili speciesand contain fatty acid composition of palmitic acid, stearic acid, oleic acid, and linoleic acid (Jarret *et al.*, 2013). Capsaicinoids are the secondary metabolites that are responsible for chili pungency. In the capsaicinoid components, the two dominant capsaicinoids of capsaicin and dihydrocapsaicin account for 79% and 90% during fruit ripening (Barbero *et al.*, 2014). Capsaicinoids are produced in the vesicles of epidermal cells of the placenta (Palma-Orozco *et al.*, 2021).

Capsicum frutescens var. Salo Dua is a local chili variety from Enrekang, Indonesia, has a height of 130 cm and a color transition of fruit ripening from white-green, purple and red (ripe). The purple color varies from a solid to striped purple. From morphological observation, this plant is similar to the variety of Dewata chilies. Authentically, the surface texture of the Salo Dua fruit peels are rather rough, not shiny, and elongated with a tapered tip compared to hybrid chilies in general. Based on our first observations with local farmers, this plant has a higher pungency, a higher resistance to chili's pathogens, and a longer post-harvest shelf life compared to other chilies. These superior characters make the market price of Salo Dua variety relatively expensive which approximately reaches Rp. 80,000,- even Rp. 140,000,- per kilogram. Its long storage durability attracts consumer needs from various countries. However, the low productivity (with average of 6-7 ton is still a serious concern to meet the market demand.

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Metabolite diversity in chilies of genus *Capsicum* determines the physiological process and quality that is discriminated by plant genotype. Metabolomic approach has been used widely to reveal the metabolite diversity in several chili varieties (Lozada *et al.*, 2023; Mi *et al.*, 2020). Mature fruits of *Capsicum* contain an increase of total phenolics, phenolic acids, ascorbic acid, its derivates as well as macro and micro elements that serve as health beneficial metabolites for dietary agents as consumed at appropriate dose (Sarpras *et al.*, 2019; Xiang *et al.*, 2022). It has been revealed that seeds and fruits of *C. frutescens* consisted of volatile compounds such as heterocyclic, β-diketones that inhibited the activity of pathogens (Gurnani *et al.*, 2016) as antibacterial and antifungal compounds (Sarpras *et al.*, 2019). Furthermore, the compounds of capsaicinoids, peptides, and phenol contained in the *Capsicum* spp. fruits conveys the antimicrobial and antiviral effects (Periferakis *et al.*, 2023; Romero-Luna *et al.*, 2023). The leaves of *C. frutescens* contained compound constituents of alkanol, alkanoic acid, alkanoate and ester, which exhibit a significant antibacterial and antifungal activities (Adepoju *et al.*, 2020). However, comparative studies between fruits and its shoot-root components of the plant remain scarce in the existing literature.

To our knowledge, the metabolite characterization of the local chili variety of Salo Dua which has a high potential to be developed remains unexplored. The study of metabolite markers contained in this variety is an interesting strategy in unraveling the new bioactive compounds as natural constituents for the health-promoting and industry uses. Therefore, this was a preliminary investigation conducted to identify the metabolite profiles in the shoot-root (as vegetative parts) and the ripe fruits of Salo Dua variety. This study provides novel metabolomes that are produced in two different stages of local chili growth. We performed the expected candidate metabolites in ripe fruits that might be responsible for the superior character of long shelf life.

Materials and Methods

Sample Collection and Site Location

The chili plants were collected from local farmers in Salo Dua village located in Maiwa District, Enrekang Regency-South Sulawesi. The chilies were cultivated at 3°48'0.8424"S 119°54' 38.5452" E.

Sample Preparation and Extraction

The samples used in this study were the root-shoot parts (vegetative phase) from 30 days after planting (DAP) and the fresh ripe fruits (Figure 1) to identify the differences in volatile compounds production. The samples were washed, air dried, chopped, and macerated in 96% ethanol (1:3 w/v) following method of Zahra *et al.* (2020). The extraction process was carried out for five days at room temperature. The filtrates were collected and evaporated using a rotary vacuum evaporator at 60 ^{0}C. The extracts were then subjected to a GC-MS analysis to determine the active volatile compounds.

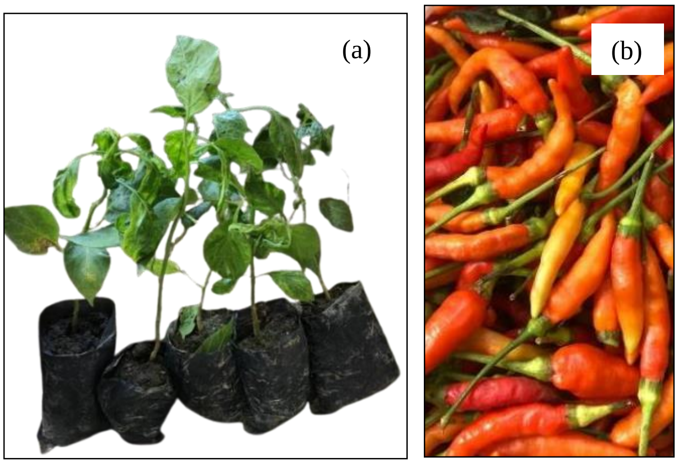

Figure 1. The plants (a) and ripe fruits (b) of Salo Dua variety that used as samples.

Measurement of Volatile Compounds

Identification of volatile compounds was performed using a Gas Chromatography – Mass Spectrometry (GC-MS) system (Thermo Scientific Trace 1310-ISQ 7000). The optimized temperature program used Maokam *et al.*, (2014) method. The initial temperature was set at 150^0C to 280^0C. The helium was used with a flow rate of 1.0 mL/min. A total of 1.0 µL of extract volume was injected using splitless technique. EI mode was performed to ionize the volatiles. In the GC column, the initial temperature was set at 150^0C before being increased to 250^0C at a rate of 20 ^{o}C/min, then set up at 280^oC at a rate of 2^oC/min and held for 2 min. Components of Mass Spectrometry were set at 70 eV in the *m*/*z* range. The data of volatile compounds were characterized by matching fragmentation results with the NIST library version 2017.

Results and Discussion

The representative chromatogram spectra of the root-shoot parts (Figure 2) and ripe fruits (Figure 3) in chili plants of the Salo Dua variety showed the variations of peaks. These were explained by the distinct volatile compounds contained in both samples. Table 1 displayed twenty-eight volatiles which are the highest contents consisted of 9-Octadecenoic acid (Z)-, oxiranylmethyl ester (15.53%); Glycidyl palmitoleate (8.74%); trans-13-Octadecenoic acid (6.79%); Z-(13,14-Epoxy) tetradec-11-en-1-ol acetate (6.45%); and 2-Propanol, 1-methoxy- (6.02%). Furthermore, the fresh ripe fruits showed a higher number of volatiles which comprised of forty-two volatiles compared to the root-shoot parts (Table 2). The highest volatile compounds in these ripe fruits were 9-Octadecenoic acid (Z)-, oxiranylmethyl ester (15.08%); trans-13-Octadecenoic acid (11.43%); Glycidyl palmitate (7.76%); 11-Octadecenoic acid, methyl ester, (Z)- (6.03%); dan 2-Propanol, 1-methoxy (4.23%).

The growing root-shoot parts period and fruit formation as well as fruit ripening might cause a difference of volatiles produced by plants. Emission of volatile compounds is regulated by developmental stages of plants whose variability depends on plant species (Bracho-Nunez *et al.*, 2011). Moreover, the variance and contents of volatile compounds as secondary metabolite are determined by several factors such as genotype, environmental changes, as well as physiological process during developmental stages of plant growth (Rodríguez-Burruezo *et al.*, 2010; Isah, 2019). In general, the difference of metabolites is driven by resource acquisition capacity which allocation costs are increased when the reproduction stage needs a higher resource priority (Barton and Boege, 2017). Growing phases between root-shoot parts and generative of chili from distinct species show the fragmentation patterns which reveal the pinpointed metabolites (Macel *et al.*, 2019). Even between chili varieties, the varied composition of volatile constituents is due to the difference in site location, environmental factors, transport and storage (Ahmad *et al.*, 2022).

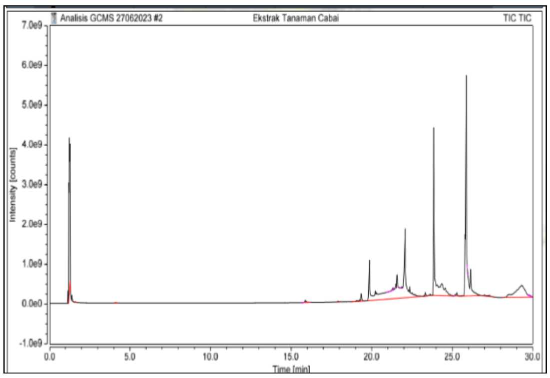

Figure 2. GC-MS chromatogram of the root-shoot parts of *Capsicum frutescens* var. Salo Dua.

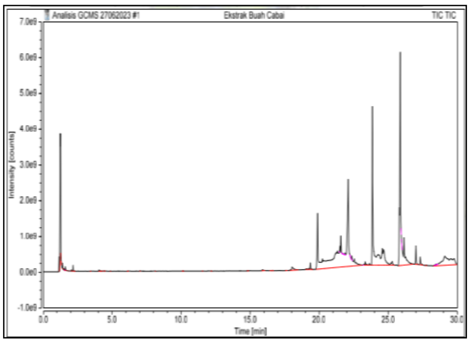

Figure 3. GC-MS chromatogram of the ripe fruits of *Capsicum frutescens* var. Salo Dua.

This study evidenced fourteen diverse classes of volatile compounds detected in ripe fruit compared to nine classes in its root-shoot parts (Figure 4). The main average composition of chemical class in ripe fruits was characterized by the formation of alcohols (26%) followed by esters (19%), alkaloids (10%), fatty acids (10%), ketones (7%), and fatty acid methyl esters/ FAME as well as lactones, flavonoids, each with 5% (Figure 4.b). In addition, the small percentages of chemical classes in ripe fruits were shown by heterocyclic, phenols, amino cyclitol, amines, carbohydrates, and aldehydes, each with 2%. The predominance of alcohols and esters chemical class in our study is following the metabolite profiling of Ahmad *et al.*, (2022). This finding is further supported by the identification of non-derivatized metabolites in various *Capsicum* species, including *C. baccatum*, *C. chinense*, *C. annuum*, and *C. frutescens*, which similarly demonstrated a predominance of esters, followed sequentially by fatty acids, hydrocarbons, capsaicinoids, phytosterols, and alcohols (Aranha *et al.*, 2017).

Whereas in the root-shoot parts, the presence of esters (29%) was the most abundant followed by alcohols (21%), fatty acids (18%), alkaloids (11%), heterocyclic (7%), and ketones as well as hydrocarbons, steroid, and nitrogen oxide, each of 4% was identified (Figure 4.a). Similar with Adepoju *et al.* (2020), the methanol extract of *C. frutescens* var. ijosi, var. sombo, and var. bawa exhibited the predominance of ester, followed by alkanoate, alkanoic acid, and alkanol. However, the total of compounds in our study are relatively abundance than that of previous studies (Adepoju *et al.*, 2020).

In detail, we detected new volatiles that only emitted in ripe fruits (Table 2) and these were absent in its root-shoot growth (Table 1). The new volatiles were 11-Octadecenoic acid, methyl ester, (Z)-; 10-Octadecenoic acid, methyl ester; Capsaicin; l-(+)-Ascorbic acid 2,6-dihexadecanoate; Dihydrocapsaicin; (2-Aziridinylethyl)amine; Propanoic acid, 2-oxo-, methyl ester; Cyclopropanebutanoic acid, 2-[[2-[[2-[(2-pentylcyclopropyl); 2-Propanone, 1-hydroxy-(13,14-Epoxy)tetradec-11-en-1-ol acetate; Methyl 16-hydroxy-hexadecanoate; Silanediol, dimethyl; Propanal, 2,3-dihydroxy-, (S); 2-Bromoethyl methyl sulfide; 2-Hydroxy-gamma-butyrolactone; Cyclohexanone, 2-(2-butynyl)-; 1,5,5-Trimethyl-6-methylene-cyclohexene; Paromomycin; Cyclohexan-1,4,5-triol-3-one-1 carboxylic acid; dan Propyl nitrite.

It was clear that capsaicin and dihydrocapsaicin which were the major compounds from capsaicinoids only being produced in the fresh fruits particularly. About 90% of capsaicin and dihydrocapsaicin is produced in the placenta of fruits. On the other hand, other minor capsaicinoids such as nornordihy drocapsaicin, nordihydrocapsaicin, n-vanillyl-nonanamide, n-vanillyl-decanamide, homo capsaicin, homo capsaicin isomer I and II (Maokam *et al.*, 2014) were not obtained in our study. The difference may be attributable to several such as *Capsicum* sp. varieties, temperature of cultivation, position of fruits on the plant, fruit ripening stages and the light intensity (Alam *et al.*, 2018). For example, flavonoids and capsaicinoids are the main differences between metabolite profiles in Jize and Korean chili peppers (Mi *et al.*, 2020). In addition, fruits of *Capsicum annuum* L. var. Grossum at the maturation stage of green, yellow, and red color did not contain capsaicin compared to other chili varieties (Musfiroh *et al.*, 2013). Furthermore, the capsaicinoid type and contents may be related to the genotype and the stage of fruit maturation.

Table 1. GC-MS detection of volatile compounds of the root-shoot parts of *Capsicum frutescens* var. Salo Dua

No.	Retention time (min)	Relative area (%)	Compounds	Molecular Formula	Classes of Volatile Compounds
1	25.866	15.53	9-Octadecenoic acid (Z)-, oxiranylmethyl ester	$C_{21}H_{38}O_3$	Glycidyl Esters
2	23.852	8.74	Glycidyl palmitoleate	$C_{19}H_{34}O_3$	Esters
3	22.07	6.79	trans-13-Octadecenoic acid	$C_{18}H_{34}O_2$	Monounsaturated Fatty Acids
4	21.499	6.45	Z-(13,14-Epoxy) tetradec-11-en-1-ol acetate	$C1_6H_{28}O_3$	Alcohols
5	1.235	6.02	2-Propanol, 1-methoxy-	$C_4H_{10}O_2$	Alcohols
6	21.57	5.26	trans-13-Octadecenoic acid, methyl ester	$C1_9H_{36}O_2$	Esters
7	1.286	4.73	Ethanol	C_2H_6O	Alcohols
8	19.863	3.74	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	Saturated Fatty Acids
9	1.204	3.34	Nitric oxide	NO	Nitrogen Oxide
10	25.798	2.85	Butyl 9,12-octadecadienoate	$C_{22}H_{40}O_2$	Heterocyclic
11	26.141	2.02	Glycidyl palmitate	$C_{19}H_{36}O_3$	Glycidyl Esters
12	22.009	1.79	Oleic Acid	$C_{18}H_{34}O_2$	Monounsaturated Fatty Acids
13	24.063	1.73	Glycidyl (Z)-9-Heptadecenoate	$C_{18}H_{34}O_2$	Esters
14	24.352	1.64	Z-5-Methyl-6-heneicosen-11-one	$C_{22}H_{42}O$	Ketones
15	29.236	0.97	E,E,Z-1,3,12-Nonadecatriene-5,14-diol	$C_{19}H_{34}O_2$	Alcohols
16	22.366	0.66	cis-13-Octadecenoic acid	$C_{18}H_{34}O_2$	Monounsaturated Fatty Acids
17	19.356	0.39	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	Fatty Acids
18	15.88	0.26	Patchouli Alcohols	$C_{15}H_{26}O$	Alcohols
19	25.281	0.22	9-Octadecenoic acid (Z)-, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{21}H_{40}O_4$	Monoacylglycerols
20	1.17	0.17	Benzeneethanamine, 3-fluoro-ß,5-dihydroxy-N-methyl	$C_9H_{12}FNO_2$	Alkaloids
21	19.25	0.09	Cyclopropaneoctanoic acid, 2-[[2-[(2-ethylcyclopropyl)	$C_{22}H_{38}O_2$	Esters
22	1.405	0.07	2-Ethyl-oxetane	$C_5H_{10}O$	Heterocyclic
23	1.636	0.05	Benzeneethanamine,2,5-difluoro-ß,3,4-trihydroxy-N-methyl	$C_9H_{11}F_2NO_3$	Alkaloids
24	4.075	0.04	Tetraacetyl-d-xylonic nitrile	$C_{14}H_{17}NO_9$	Hydrocarbons
25	19.05	0.04	Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester	$C_{35}H_{68}O_5$	Diacylglycerols
26	1.306	0.02	Isopropyl Alcohols	C_3H_8O	Alcohols
27	1.5	0.01	Imidazole, 2-amino-5-[(2-carboxy)vinyl]-	$C_6H_7N_3O_2$	Alkaloids
28	15.73	0.01	Cholestan-3-ol, 2-methylene	$C_{28}H_{48}O$	Steroid

Table 2. GC-MS detection of volatile compounds of the ripe fruits of *Capsicum frutescens* var. Salo Dua

No.	Retention time (min)	Relative area (%)	Compounds	Molecular Formula	Classes of Volatile Compounds
1	25.869	15.08	9-Octadecenoic acid (Z)-, oxiranylmethyl ester	$C_{21}H_{38}O_3$	Glycidyl Esters
2	22.097	11.43	trans-13-Octadecenoic acid	$C_{18}H_{34}O_2$	Monounsaturated Fatty Acids
3	23.852	7.76	Glycidyl palmitate	$C_{19}H_{36}O_3$	Glycidyl Esters
4	21.567	6.03	*11-Octadecenoic acid, methyl ester, (Z)-	$C_{19}H_{36}O_2$	Monounsaturated FAME
5	1.235	4.23	2-Propanol, 1-methoxy	$C_{10}H_{22}O_3$	Alcohols
6	19.886	3.99	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	Saturated Fatty Acids
7	29.09	2.68	9-Octadecenoic acid (Z)-, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{21}H_{40}O_4$	Monoacylglycerols
8	25.798	2.6	Butyl 9,12-octadecadienoate	$C_{22}H_{40}O_2$	Heterocyclic
9	24.668	2.25	Z-5-Methyl-6-heneicosen-11-one	$C_{22}H_{42}O$	Ketones
10	21.216	1.81	*10-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	Monounsaturated FAME
11	21.495	1.77	Oleic Acid	$C_{18}H_{34}O_2$	Monounsaturated Fatty Acids
12	29.746	1.41	E,E,Z-1,3,12-Nonadecatriene-5,14-diol	$C_{19}H_{34}O_2$	Alcohols
13	26.998	1	*Capsaicin	$C_{18}H_{27}NO_3$	Alkaloids
14	1.204	0.91	Methyl Alcohols	CH_4O	Alcohols
15	20.23	0.63	*l-(+)-Ascorbic acid 2,6-dihexadecanoate	$C_{38}H_{68}O_8$	Phenols
16	18.029	0.62	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	Fatty Acids
17	24.066	0.58	Glycidyl palmitoleate	$C_{19}H_{34}O_3$	Esters
18	27.318	0.51	*Dihydrocapsaicin	$C_{18}H_{29}NO_3$	Alkaloids
19	24.944	0.28	Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester	$C_{35}H_{68}O_5$	Diacylglycerols
20	1.17	0.17	*(2-Aziridinylethyl)amine	$C_4H_{10}N_2$	Amines
21	2.167	0.14	*Propanoic acid, 2-oxo-, methyl ester	$C_4H_6O_3$	Esters
22	15.883	0.13	Patchouli Alcohols	$C_{15}H_{26}O$	Alcohols
23	4.054	0.1	Glycerin	$C_3H_8O_3$	Alcohols
24	1.405	0.08	Acetaldehyde, hydroxy	$C_{46}H_{77}NO_{17}$	Aldehydes
25	19.254	0.07	*Cyclopropanebutanoic acid, 2-[[2-[[2-[(2-pentylcyclopropyl)	$C_{25}H_{42}O_2$	Flavonoids
26	1.612	0.06	*2-Propanone, 1-hydroxy	$C_3H_7O_6P$	Alcohols
27	25.145	0.06	*Z-(13,14-Epoxy)tetradec-11-en-1-ol acetate	$C_{16}H_{28}O_3$	Alcohols
28	19.057	0.04	*Methyl 16-hydroxy-hexadecanoate	$C_{17}H_{34}O_3$	Flavonoids
29	1.636	0.03	*Silanediol, dimethyl	$C_6H_{12}O_4Si$	Alcohols
30	2.051	0.03	*Propanal, 2,3-dihydroxy-, (S)	$C_3H_6O_3$	Alcohols

Table 2. Continued

No.	Retention time (min)	Relative area (%)	Compounds	Molecular Formula	Classes of Volatile Compounds
31	1.514	0.02	*2-Bromoethyl methyl sulfide	C3H_7BrS	Alcohols
32	4.398	0.02	*2-Hydroxy-gamma-butyrolactone	$C_4H_6O_3$	Lactones
33	10.098	0.02	*Cyclohexanone, 2-(2-butynyl)-	$C_{10}H_{14}O$	Ketones
34	12.169	0.02	*1,5,5-Trimethyl-6-methylene-cyclohexene	$C_{10}H_{16}$	Lactones
35	14.802	0.02	*Paromomycin	$C_{23}H_{45}N_5O_{14}$	Amino Cyclitol Glycoside
36	16.601	0.02	Imidazole,2-amino-5-[(2-carboxy)vinyl]-	$C_6H_7N_3O_2$	Alkaloids
37	1.32	0.01	Ethanol	C_2H_6O	Alcohols
38	1.568	0.01	*Cyclohexan-1,4,5-triol-3-one-1-carboxylic acid	$C_7H_{10}O_6$	Ketones
39	1.81	0.01	Benzeneethanamine, 2,5-difluoro-ß,3,4-trihydroxy-N-methyl	$C_9H_{11}FNO_3$	Alkaloids
40	4.874	0.01	*Propyl nitrite	$C_3H_7NO_2$	Esters
41	7.02	0.01	l-Gala-l-ido-octose	$C_8H_{16}O_8$	Carbohydrates
42	11.557	0.01	Pterin-6-carboxylic acid	$C_7H_5N_5O_3$	Esters

Notes: (*) New volatile compounds only detected in the ripe fruits; FAME (Fatty Acid Methyl Esters).

The metabolite profiles indicate the growth and development of chili peppers (Taiti *et al.,* 2019). As this study was the initial record of volatile profiling in chilies of Salo Dua variety, there were important bioactive compounds produced in ripe fruits which may contribute to explain a higher extending shelf life of Salo Dua fruit storage after postharvest. Of which the predominant capsaicinoids of capsaicin and dihydrocapsaicin significantly increase the permeabilization of cell membranes as well as cell walls of bacteria, yeasts and fungi resulting in membrane damage to inhibit infection and invasion of pathogens (Ayariga *et al.,* 2022; Romero-Luna *et al.,* 2023). A 11-Octadecenoic acid, methyl ester, (Z)- accounted for 6.03% in our study is expected to have antimicrobial activity as reported by Octarya *et al.,* (2021). Octadecenoic acid is predicted to play a role as antioxidant, antibacterial, antivirus and anti-inflammatory (Tri Rumanti and Saragih, 2023). Furthermore, the phenol compound of l-(+)-Ascorbic acid 2,6-dihexadecanoate is an antioxidant property to possess anticancer, antibacterial, and wound healing (Begum *et al.,* 2017). The amine compound of (2-Aziridinylethyl)amine has potential as antiviral roperties (Vijayaraj *et al.,* 2022). Cyclohexan-1,4,5-triol-3-one-1-carboxylic acid could be responsible for antibacterial and antifungal activity (Jeyadevi *et al.,* 2013). The presence of paromomycin from aminoglycosides that can be used as biocontrol and protection against various bacterial and fungal pathogens (Elshafie *et al.,* 2023). Overall, the interaction of volatile metabolites in ripe fruit might contribute to keep the fruits from spoilage and maintain the shelf life during storage.

This first database of volatile profiling in *Capsicum frutescens* var. Salo Dua could be used as a primary reference to explore its potential of bioactive compounds. There is a need to prove the antimicrobial screening and isolation of the targeted bioactive compounds that might be beneficial in plant breeding of chilies with long shelf life as the fruit storage techniques.

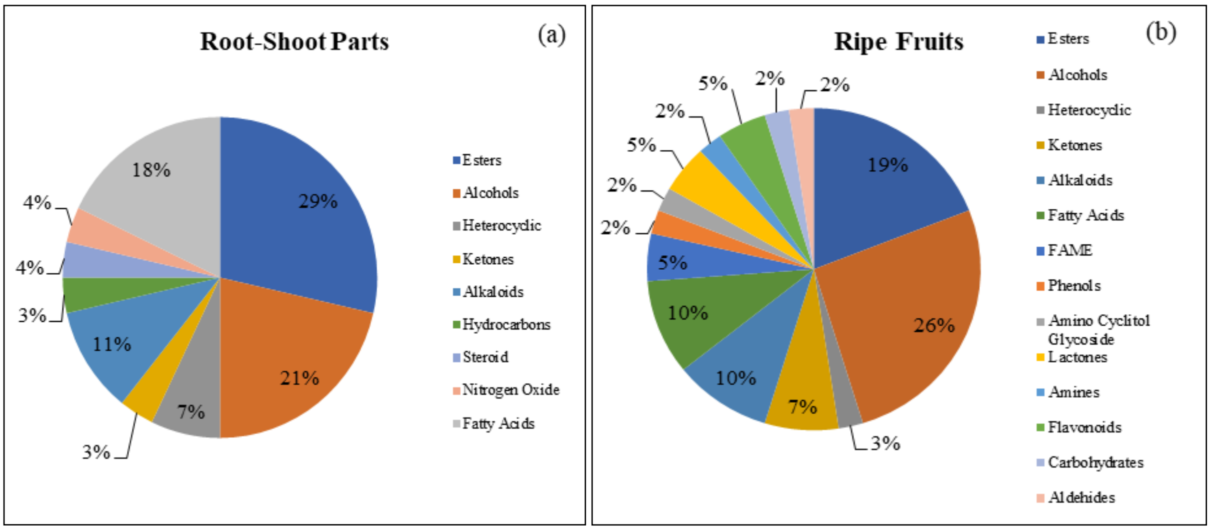

Figure 4. Percentage of compound classes between the root-shoot parts (a) and ripe fruits (b) of *Capsicum frutescens* var. Salo Dua.

Conclusion

This preliminary study revealed the difference of volatile compounds that produced in the vegetative represented by the composite of the root-shoot parts and volatiles in the generative parts from fruits of local chili of *Capsicum frutescens* var. Salo Dua. The root-shoot parts displayed twenty-eight volatiles from 9 chemical classes which esters accounts for a highest chemical percentage by 29%. Ripe fruits contained forty-two volatiles from 14 chemical classes which was occupied dominantly by alcohols for 26%. The compounds that only identified in the root-shoot with the highest relative abundances were Z-(13,14-epoxy)tetradec-11-en-1-ol acetate (6.45%), 2-propanol, 1-methoxy- (6.02%), and trans-13-octadecenoic acid, methyl ester (5.26%). Conversely, the predominant compounds exclusively only presented in the ripe fruits included 11-octadecenoic acid, methyl ester (Z)- (6.03%), 10-octadecenoic acid, methyl ester (1.81%), and capsaicin (1%). The capsaicin (1%) and dihydrocapsaicin (0.51%) were detected as a capsaicinoid components determining chili pungency.

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References

Adepoju, A.O., Omotoso, I.O., Femi-Adepoju, A.G. & Karim, A.B. (2020). Comparative studies on the antimicrobial, chemical and biochemical contents of the foliar extracts of *Capsicum fructescens* L. varieties. *African Journal of Biotechnology* 19(12): 836-845.

Ahmad, R., Alqathama, A., Aldholmi, M., Riaz, M., Abdalla, A.N., Mostafa, A., Al-Said, H.M., Alqarni, A.M., Ullah, R., Asgher, S.S., Amir, M., Shaaban, H. & Ahmad, W. (2022). Gas Chromatography-Mass Spectrometry (GC-MS) metabolites profiling and biological activities of various *Capsicum annum* cultivars. *Plants* 11(8): 1022.

Alam, M.A., Syazwanie, N.F., Mahmod, N.H., Badaluddin, N.A., Mustafa, K. 'Ain, Alias, N., Aslani, F. & Prodhan, M.A. (2018). Evaluation of antioxidant compounds, antioxidant activities and capsaicinoid compounds of Chili (*Capsicum* sp.) germplasms available in Malaysia. *Journal of Applied Research on Medicinal and Aromatic Plants* 9: 46-54.

Aranha, B.C., Hoffmann, J.F., Barbieri, R.L., Rombaldi, C.V. & Chaves, F.C. (2017). Untargeted Metabolomic Analysis of *Capsicum* spp. by GC–MS. *Phytochemical Analysis* 28(5): 439-447.

Ayariga, J., Abugri, D., Amrutha, B. & Villafane, R. (2022). Capsaicin potently blocks *Salmonella typhimurium* invasion of vero cells. *Antibiotics* 11(5): 666.

Baenas, N., Belović, M., Ilic, N., Moreno, D.A. & García-Viguera, C. (2019). Industrial use of pepper (*Capsicum annum* L.) derived products: Technological benefits and biological advantages. *Food Chemistry* 274: 872-885.

Barbero, G.F., Ruiz, A.G., Liazid, A., Palma, M., Vera, J.C. & Barroso, C.G. (2014). Evolution of total and individual capsaicinoids in peppers during ripening of the Cayenne pepper plant (*Capsicum annuum* L.). *Food Chemistry* 153: 200-206.

Barton, K.E. & Boege, K. (2017). Future directions in the ontogeny of plant defence: understanding the evolutionary causes and consequences. *Ecology Letters* 20: 403-411.

Begum, S.M.F.M., Priya, S., Sundararajan, R. & Hemalatha, S., (2017). Novel anticancerous compounds from *Sargassum wightii*: In silico and in vitro approaches to test the antiproliferative efficacy. *Journal of Advanced Pharmacy Education and Research* 7(3): 272-277.

Bracho-Nunez, A., Welter, S., Staudt, M. & Kesselmeier, J. (2011). Plant-specific volatile organic compound emission rates from young and mature leaves of Mediterannean vegetation. *Journal of Geophysical Research* 116: D16304.

de Sá Mendes, N. & de Andrade Gonçalves, É.C.B. (2020). The role of bioactive components found in peppers. *Trends in Food Science and Technology* 99: 229-243.

Elshafie, H.S., De Martino, L., Formisano, C., Caputo, L., De Feo, V. & Camele, I. (2023). Chemical identification of secondary metabolites from rhizospheric Actinomycetes using LC-MS analysis: In silico antifungal evaluation and growth-promoting effects. *Plants* 12(9): 1869.

Gurnani, N., Gupta, M., Mehta, D. & Mehta, B.K. (2016). Chemical composition, total phenolic and flavonoid contents, and in vitro antimicrobial and antioxidant activities of crude extracts from red chilli seeds (*Capsicum frutescens* L.). *Journal of Taibah University for Science* 10(4): 462-470.

Isah, T. (2019). Stress and defense responses in plant secondary metabolites production. *Biological research* 52(1): 39.

Jarret, R.L., Levy, I.J., Potter, T.L. & Cermak, S.C. (2013). Seed oil and fatty acid composition in *Capsicum* spp. *Journal of Food Composition and Analysis* 30: 102-108.

Jeyadevi, R., Sivasudha, T., Ilavarasi, A. & Thajuddin, N. (2013). Chemical constituents and antimicrobial activity of Indian green leafy vegetable *Cardiospermum halicacabum*. *Indian Journal of Microbiology* 53: 208-213.

Lozada, D.N., Pulicherla, S.R. & Holguin, F.O. (2023). Widely targeted metabolomics reveals metabolite diversity in Jalapeño and Serrano chile peppers (*Capsicum annuum* L.). *Metabolites* 13: 288.

Macel, M., Visschers, I.G.S., Peters, J.L., Kappers, I.F., de Vos, R.C.H. & van Dam, N.M. (2019). Metabolomics of thrips resistance in pepper (*Capsicum* spp.) reveals monomer and dimer acyclic diterpene glycosides as potential chemical defenses. *Journal of Chemical Ecology* 45: 490–501.

Maokam, C., Techawongstien, S. &Chanthai, S. (2014). Determination of major and minor capsaicinoids in different varieties of the *Capsicum* fruits using GC-MS and their inhibition effect of the chilli extract on α-amylase activity. *International Food Research Journal* 21: 2237-2243.

Mi, S., Yu, W., Li, J., Liu, M., Sang, Y. &Wang, X. (2020). Characterization and discrimination of chilli peppers based on multi-element and non-targeted metabolomics analysis. *LWT* 131: 109742.

Musfiroh, I.D.A., Mutakin, M., Angelina, T. & Muchtaridi, M. (2013). Capsaicin level of various *Capsicum* fruits. *International Journal of Pharmacy and Pharmaceutical Sciences* 5: 248-251.

Octarya, Z., Novianty, R., Suraya, N. & Saryono. (2021). Antimicrobial activity and GC-MS analysis of bioactive constituents of *Aspergillus fumigatus* 269 isolated from Sungai Pinang hot spring, Riau, Indonesia. *Biodiversitas* 22: 1839-1845.

Palma-Orozco, G., Orozco-Álvarez, C., Chávez-Villeda, A.A., Mixtega-Martínez, A. & Castro-Muñoz, R. (2021). Capsaicin content in red habanero chilli (*Capsicum chinense* Jacq.) and its preservation after drying process. *Future Foods* 4: 100070.

Periferakis, A.T., Periferakis, A., Periferakis, K., Caruntu, A., Badarau, I.A., Savulescu-Fiedler, I., Scheau, C. & Caruntu, C. (2023). Antimicrobial properties of capsaicin: available data and future research perspectives. *Nutrients* 5(19)*:* 4097.

Rodríguez-Burruezo, A., Kollmannsberger, H., González-Mas, M.C., Nitz, S. & Fernando, N. (2010). HS-SPME comparative analysis of genotypic diversity in the volatile fraction and aroma-contributing compounds of capsicum fruits from the annuum-chinense-frutescens complex. *Journal of Agricultural and Food Chemistry* 58: 4388-4400.

Romero-Luna, H.E., Colina, J., Guzmán-Rodríguez, L., Sierra-Carmona, C.G., Farías-Campomanes, Á.M., García-Pinilla, S., González-Tijera, M.M., Malagón-Alvira, K.O. & Peredo-Lovillo, A. (2023). Capsicum fruits as functional ingredients with antimicrobial activity: an emphasis on mechanisms of action. *Journal of Food Science and Technology* 60: 2725-2735.

Sarpras, M., Ahmad, I., Rawoof, A. & Ramchiary, N. (2019). Comparative analysis of developmental changes of fruit metabolites, antioxidant activities and mineral elements content in Bhut jolokia and other Capsicum species. *LWT* 105: 363-370.

Taiti, C., Costa, C., Migliori, C.A., Comparini, D., Figorilli, S. & Mancuso, S. (2019). Correlation between volatile compounds and spiciness in domesticated and wild fresh chili peppers. *Food and Bioprocess Technology* 12: 1366-1380.

Tri Rumanti, A. & Saragih, H. (2023). Ekstraksi dan identifikasi kandungan senyawa bioaktif daun saga rambat (*Abrus precatorius*). *Biota: Jurnal Ilmiah Ilmu-Ilmu Hayati* 8: 59-68.

Vijayaraj, R., Altaff, K., Sri Kumaran, N. & Swarnakala. (2022). Volatile bioactive compounds from marine macro-algae and their pharmacological properties. *Indian Journal of Geo-Marine Sciences* 51: 832-842.

Xiang, Y., Xu, X., Zhang, T., Wu, X., Fan, D., Hu, Y., Ding, J., Yang, X., Lou, J., Du, Q., Xu, J. & Xie, R. (2022). Beneficial effects of dietary capsaicin in gastrointestinal health and disease. *Experimental Cell Research* 417(2): 113227.

Zahra, A.R., Kurniasih, E., Fadilla, I. & Mauliana. (2020). Isolation of capsaicin compounds from cayenne as a food additives material. IOP Conference Series: Materials Science and Engineering 725: 012062.