Agriculture and Food

AIMS Agriculture and Food, 8(1): 198–213.
DOI: 10.3934/agrfood.2023011
Received: 19 September 2022
Revised: 04 January 2023
Accepted: 02 February 2023
Published: 14 February 2023

http://www.aimspress.com/journal/agriculture

Research article

Effects of household-scale cooking on volatile compounds, sensory profile, and hypotensive effect of Kenikir (*Cosmos caudatus*)

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Abstract: Kenikir (*Cosmos caudatus*) can be used in the preparation of raw and cooked vegetables in some Indonesian dishes. The cooking process may affect the appearance, chemical properties, and flavor of kenikir. This study aims to determine the effect of household scale cooking on the volatile compounds, sensory profiles, and hypotensive activity of kenikir. Fresh kenikir samples and samples boiled or steamed at 100 °C (for 3 and 5 minutes) were analyzed for volatile compounds compositions (solid-phase microextraction-Gas chromatography-mass spectrometry, SPME-GCMS), sensory profiles by free choice profiling, and in-vivo study by using stroke-prone spontaneously hypertensive rats (SHRSP)—a model of spontaneous hypertension. The GCMS analysis identified 30 volatile compounds from 5 compound groups, namely alcohols (2 compounds), benzenes (3 compounds), esters (3 compounds), monoterpenes (10 compounds), and sesquiterpenes (12 compounds). Several compounds, namely (Z)-3-hexenol, α-cadinol, and 3-carene were only detected in fresh kenikir, whereas β-myrcene and β-elemene compounds were only identified after cooking. The principal component analysis of sensory attributes associated fresh kenikir with bright color and minty taste, steamed kenikir with floral aroma, and boiled kenikir with juicy, moist, tender, and smooth texture. Furthermore, a hypotensive effect was shown in the water extract of kenikir after 2 and 4 hours of single oral administration in SHRSP. In summary, the heating process (boiled and steamed) of kenikir has changed its volatile compound composition, which can affect its sensory profiles. In addition, the water extract of kenikir can diminish hypertension in SHRSP.

Keywords: cooking; hypotensive effect; kenikir (*Cosmos caudatus*); sensory profile; volatile compounds

1. Introduction

Kenikir belongs to the genus Cosmos in the flowering plant family Asteraceae. Kenikir is a shrub, which is a type of plant that grows close to the ground. The plant is usually 75-100 cm high, with erect stems, purplish-colored segments, and many branches. The leaves are compounded with a pointed tip [1].

Kenikir leaves can be consumed as raw vegetables (such as in Trancam dishes), or cooked vegetables (such as in Urap and Pecel dishes in Java). The leaves can also be used as a food flavoring and are also often added to traditional medicinal herbs. Kenikir leaves have a unique taste and aroma that diversifies cuisine flavors [2].

The vegetables can be cooked by blanching, boiling, steaming, frying, or microwaving [3]. The cooking process can alter the level of phytochemicals in vegetables through a variety of mechanisms such as thermal breakdown, oxidation, leaching, and matrix degradation. Moreover, the phytochemical degradation could be minimized by applying appropriate cooking methods [4]. The contents of fresh Kale in all cooking procedures (boiling, steaming, microwaving, pressure cooking, and vacuum cooking) resulted in the loss of antioxidant activity, total flavonoids, organic acids, and minerals [5]. The best way to maintain the antioxidant capability and bioactive substances was found to be steaming. The boiling of 15 Brassica cultivars decreased the content of aldehyde and alcohol compounds and increased the concentration of isothiocyanates [6].

The potential antidiabetic activity (α-glucosidase inhibitors) of kenikir leaves for the treatment of diabetes mellitus [7,8] and decrease systolic blood pressure in Wistar rats after being treated with adrenaline and sodium chloride [9]. Similar to several Southeast Asian herbal plants, kenikir exhibits antioxidant, antibacterial, and cytotoxic activity due to the presence of essential oils [10]. Boiling kenikir leaves for 5 minutes significantly reduced the total phenolic content (TPC), whereas steaming for 5 minutes or microwaving for 1 minute unchanged the TPC [11]. In addition, boiling kenikir leaves for 5 minutes reduced both the caffeic acid and ferulic acid content, whereas steaming for 5 minutes or microwaving for one minute increased the caffeine acid, but it did not change the ferulic acid content [11]. The cooking process may influence the kenikir's appearance and odor or flavor. However, published papers on the profile of volatile compounds and aroma characteristics present in kenikir leaves after undergoing household-scale cooking are limited. Thus, this study aimed to identify and compare volatile compounds, sensory profiles, and hypotensive activity of kenikir leaves (Cosmos caudatus) by boiling and steaming them at the household level.

2. Materials and methods

2.1. Sample preparation

The materials used in this study are fresh kenikir leaves (*Cosmos caudatus*) harvested from a home yard in the Cijantung, Jakarta, Indonesia. They were cleaned, and fresh, whole, and undamaged leaves were selected. Leaves and stems of the kenikir plant were used in this study (Figure 1). The leaves were then weighed for treatments: boiling for 3 and 5 minutes (100 °C), steaming for 3 and 5 min (100 °C), and control (fresh/raw).

Figure 1. Fresh Kenikir sample. Note: the black line in the picture shows the cutting limit of the kenikir used in these studies.

2.2. Heating method

The heating method used in this study was based on our previous study [11] with slight modifications. For boiling treatment, 5 grams of kenikir leaf samples were boiled (100 °C) in 500 mL of water. This process was carried out for 3 and 5 minutes after the water boiled. For the steaming treatment, 5 grams of kenikir leaf samples were steamed (100 °C) for 3 and 5 minutes after the water boiled. Then, all samples were drained with dry tissues before being prepared for further processing. Each treatment was repeated 3 times.

2.3. Solid phase microextraction (SPME)

The volatile compounds extraction was conducted through the SPME method using a divinylbenzene/carboxen/ polydimethylsiloxane (DVB/CAR/PDMS) fiber with a thickness of 50/30 m and a length of 2 cm. The fresh, boiled or steamed samples were put into 22 ml vials, and dodecane

(Sigma-Aldrich, Saint Louis, MO, USA) (internal standard, IS) was added. For fresh samples, 0.2 µL of 0.001% dodecane was added, while for samples with heating, 0.6 µL of 0.0001% dodecane was added. The amount of dodecane in the fresh samples was higher than in the steamed and boiled samples to make its peak (or concentration) comparable to most peaks in the fresh samples. The extraction vial was then closed with a silicone septum and extracted over a water bath at 50 °C for 30 minutes.

2.4. Gas Chromatography-Mass Spectrometry (GC-MS)

The volatile compounds in kenikir leaves were separated and analyzed using GC-MS Agilent 7890A-5975C. The separation was carried out using a DB-5MS capillary column with a length of 30 m, a diameter of 0.25 mm, and a thickness of 0.25 m. The operational conditions were as follows: helium as carrier gas at a rate of 0.8 mL/minute and a pressure of 60 kPa, injector with splits mode at 250 °C, and an oven temperature of 40 °C for 2 minutes, raised to a temperature of 230 °C in increments of 3 °C/minutes. The standard series of C8–C20 alkanes (Fluka) were injected into the GC-MS under the same conditions as the sample to determine the LRI components of the experiment. The volatile compounds were identified by comparing the mass spectra pattern to the NIST 2005 library database. Furthermore, the LRI values of compounds in the experiment were compared to the LRI values in the relevant literature. The relative number of volatile compounds was calculated by comparing the area of the compound in the sample with the area of the internal standard (IS) of dodecane added.

2.5. Sensory analysis

The sensory analysis was conducted using free-choice profiling (FCP) method with untrained panelists [12]. The FCP testing was carried out through two sessions; in the first session, panelists described the attributes of kenikir leaves freely, and in the second session, panelists rated the intensity of those attributes in all kenikir samples. The panel consisted of 20 untrained panelists (8 males and 12 females) in each testing session, with an age range of 18–23 years. Kenikir leaf samples were prepared as in the previous steps. Five samples of kenikir leaves (1 fresh, 2 boiled, and 2 steamed leaves) were transferred into a plastic glass container and then closed to maintain the aroma until later given to the panelists. The first session was carried out simultaneously with 20 panelists at the same time. The testing process took place in a closed room with sufficient lighting. Each panelist was given 5 plastic containers containing 5 samples, a bottle of drinking water, one pen, and research questionnaires. After the first session, quantitative calculations were carried out for each attribute described by the panelists in the first session. The attribute with the highest frequency was then taken for a rating in the second session. In the second session, like the previous session, there were 20 untrained panelists. Each panelist was given 5 plastic containers containing 5 samples and a bottle of drinking water. In this session, the panelists were given a digital questionnaire in the form of a google form to minimize preparation and facilitate research archives.

2.6. Animal study

The 13th of male SHRSP/Izumo strain (Japan SLC, Shizuoka, Japan) was used in this study. The rats were housed in individual stainless-steel cages in a controlled atmosphere (temperature, 23 ± 2 °C; humidity, 50 ± 10%; 12 h light-dark cycle) as per a previous study [13]. The Animal Research-Animal

Care Committee approved the experimental plan for the present study of Tohoku University (2019 noudou-011-01). The water extract of kenikir (40 mg kg/body weight) was used to determine the hypotensive effect in the SHRSP. The extract was prepared based on Amalia et al., 2012 [9] with slight modifications. The extract was prepared by boiling 5 g of dry kenikir leaf in 100 ml distilled water (60 ℃, 5 minutes); it was then filtered through Whatman filter paper and stored at −20 ℃). Before use, the extract was thawing at room temperature. The number of animals used in this study, the concentration of the sample in the treated groups and the control groups were similar to our previous study [14]. The blood pressure measurement was by the tail-cuff method with a BP meter as described in the previous study [13].

2.7. Data analysis

The volatile compounds analysis was performed in three replicates and analyzed using one-way ANOVA. In case of a significant difference, Duncan's test is used with a significance level of $p < 0.05$. The data is presented as a mean and standard deviation. The sensory data was analyzed using Generalized Procrustes Analysis (GPA), while to observe the dominant volatile compounds in each sample, principal component analysis (PCA) was performed. The Anova, Duncan's, and PCA analyses were done by XLSAT 2021.

3. Results and discussions

3.1. Cooking and extraction (SPME)

The cooking treatments carried out on kenikir were boiling, steaming, and no heating (fresh). The process of boiling and steaming kenikir is shown in Figure 2, and the boiled and steamed kenikir in Figure 3. The cooking process, particularly boiling, changed the kenikir's color from bright green to olive-brown.

Chlorophyll is the pigment responsible for giving plants their green color. Chlorophyll is formed from carbon and nitrogen atoms, together with magnesium ions [15]. Cooking treatments can lead to the formation of pheophytin (pheophytin) as magnesium in chlorophyll can be easily replaced with two hydrogen atoms [4,16]. In processed foods, the loss of chlorophyll can cause a color shift from bright green to olive-brown. Factors such as pH, temperature, presence of salt, and active surface ions affect the stability of chlorophyll [16,17]. The color change caused by heat treatment can be preceded by an increase in the green color followed by a decrease. The initial increase in green coloration is associated with the loss of air around the fine hairs on the plant surface and between cells [18].

Drying at 40 ℃ produced the best results to maintain the kenikir quality [19]. Considering the morphological appearance, the trichome glands on the kenikir leaf surface began to be damaged at 40 ℃, resulting in a slight difference when compared to fresh kenikir. Furthermore, kenikir leaves dried at 40 ℃ had a higher TPC than kenikir leaves dried at 60 ℃ and 80 ℃ [19].

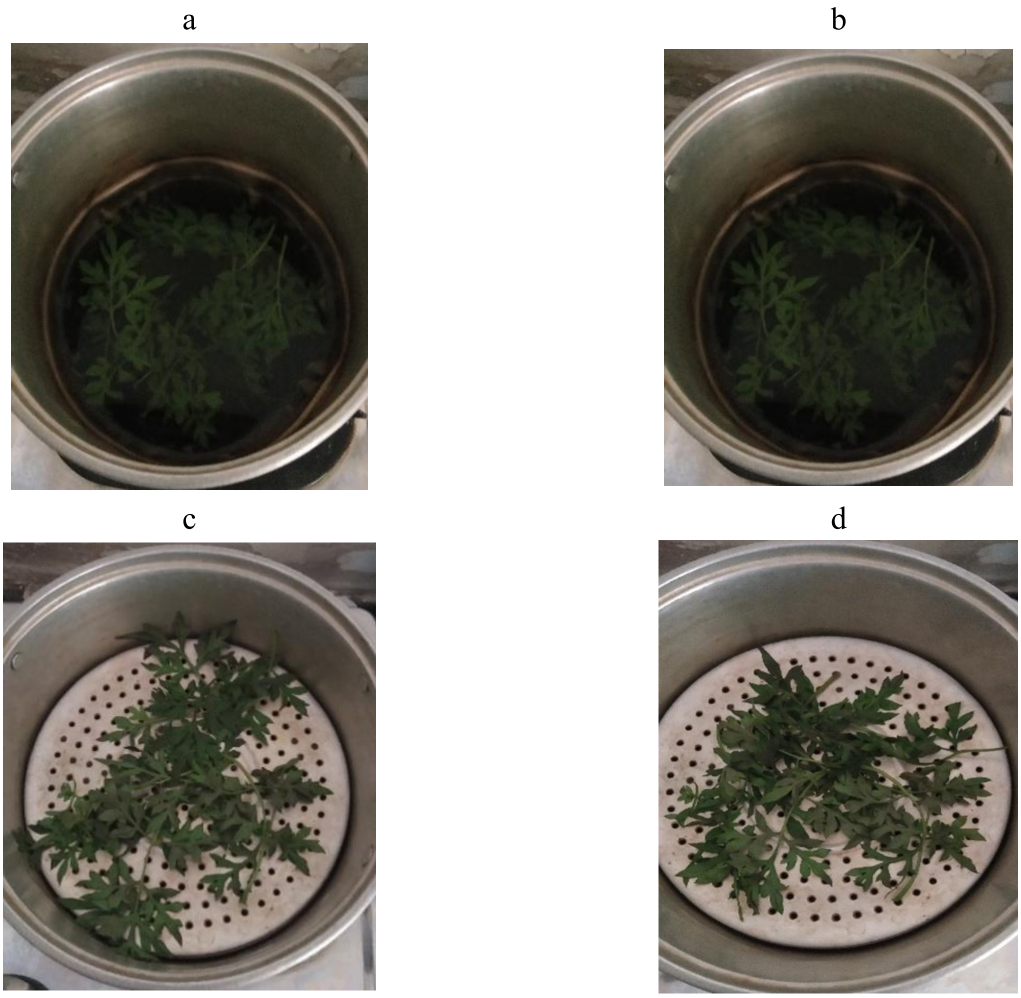

Figure 2. The heating process of kenikir. a) boiled for 3 minutes; b) boiled for 5 minutes; c) steamed for 3 minutes; d) steamed for 5 minutes.

Figure 3. Kenikir after warming up. In a row from left to right: fresh kenikir, boiled kenikir for 3 minutes, boiled kenikir for 5 minutes, steamed kenikir for 3 minutes, steamed kenikir for 5 minutes.

3.2. Volatile compounds analysis of Kenikir

The relative amounts of volatile compounds in fresh, boiled, and steamed kenikir were presented in Table 1. In fresh kenikir, 28 volatile compounds were identified, while in boiling and steaming, 27 and 25 volatile compounds were identified, respectively. These compounds were divided into seven groups, namely alcohols (2 compounds), benzenes (3 compounds), esters (3 compounds), monoterpenes (10 compounds), and sesquiterpenes (12 compounds).

The fresh, boiled and steamed kenikir had more identified volatiles than the kenikir essential oil [10]. This may be due to the difference in the plant part samples and extraction method. The fresh, boiled, and steamed kenikir volatile profiles were similar to essential oils of *Artemisia argyi*, *Centella asiatica*, *Polygonum hydropiper* [10], *Chromolaena odorata* (L.) [20], *Uvaria hamiltonii,* and *Fissistigma kwangnsiensis* [21]. Most of the volatiles of essential oils from Psidium species were monoterpenes and sesquiterpenes [22]. (Z)-β-ocimene, germacrene D, α-thujene, and α-muurolene were the major compounds, in decreasing order, in kenikir volatiles. The major compounds in kenikir essential oil were γ-cadinene, caryophyllene, α-farnesene, and (E)-ocimene [10].

(Z)-3-hexenol and α-cadinol were detected in fresh kenikir and were not detected in the steamed and boiled kenikir. This was thought to be caused by the oxidation of alcohol in the cooking process. (Z)-3-hexenol is one of the compounds belonging to the group of green leaf volatiles (GLVs). GLVs, which have a characteristic 'green' aroma [23], consist of E-2-hexenal, Z-3-hexenal, n-hexanal, E-2-hexenol, Z-3-hexenol, n-hexanol, E-2-hexenyl acetate, Z-3-hexenyl acetate, and n-hexenyl acetate [24]. Plants tend to release GLV when under stress, for example, in case of tissue damage. The formation of (Z)-3-hexenol is influenced by the enzymes lipoxygenase (LOX), hydroperoxide lyase (HPL), and alcohol dehydrogenase (ADH), which convert essential fatty acids, linoleic, and linolenic into aldehydes (such as hexanal and (Z)-3- hexenal) and alcohols (such as 1-hexanol and (Z)-3-hexenol) [25,26]. (Z)-3-hexenol is thought to give a grassy and fresh aroma [27].

α-Cadinol belongs to the sesquiterpenoid alcohol group where cadin-4-ene binds to the hydroxy substituent at position 10. α-cadinol acts as a plant metabolite and fungicide (PubChem). α-cadinol is thought to give an herbal aroma (The Good Scents). α-cadinol identified from *Phaseolus vulgaris* L. through in vitro and in silico analysis showed a potential ACE-inhibitory volatile compound [18].

The volatile compounds of the benzene group detected in the samples included p-xylene, naphthalene, and 1-methylnaphthalene (Table 1). The abundance of compounds in this group tends to decrease during cooking. Compounds in this group give an unpleasant aroma. The volatile compounds of benzenoids were generally from phenylalanine derivatives; p-xylene gives a green and pungent aroma, while naphthalene gives a phenolic aroma, and 1-methylnaphthalene provides a camphor-like aroma [28,29].

Volatile compounds detected in the ester group include cis-3-hexenyl isovalerate, (Z)-3-hexenyl butyrate, and (Z)-3-hexenyl 2-methyl butanoate (Table1). The concentration of ester volatiles decreased during cooking and some were not even detected after 5 min of steaming or boiling. This group of compounds belongs to the fatty acid ester group, which is a type of ester compound produced from a combination of fatty acid compounds and alcohol. This group of compounds was produced through the biochemical conversion of several fatty acid compounds, one of which is linoleic acid through oxidation [29,30]. The compounds of this group give a fresh, green, and fruity aroma to the kenikir leaves.

The monoterpenes detected in the kenikir samples were α-thujene, β-phellandrene, β-myrcene, β-pinene, (E)-β-ocimene, (Z)-β-ocimene, γ-terpinene, 1,3,8-p-menthatriene, (E,E)-cosmene, Allo-ocimene, and ylangene (Table 1). Meanwhile, the sesquiterpenes identified included β-elemene, α-cubebene, α-gurjunene, aromadandrene, α-humulene, epi-bicyclosesquiphellandrene, germacrene D, α-muurolene, α-farnesene, and α-calacorene. Almost all the monoterpenes and sesquiterpenes were detected int both fresh and cooked, except for β-elemene, which was not detected in fresh kenikir. This indicated that β-elemene was generated by cooking. β-elemene was identified in potato leaf [31] and the leaf of Litsea acutivena [32]. β-elemene is well known for its anticancer activity against a variety of cell lines [33].

Monoterpenes and sesquiterpenes are usually associated with the flavor of citrus, spices, and herbs. Mono- and sesquiterpenes are the main group of terpenoid compounds. Monoterpene, sesquiterpene, and diterpene precursors are geranyl diphosphate, farnesyl diphosphate, and geranylgeranyl diphosphate, respectively. Sesquiterpenes are further converted to triterpenes by metabolism, whereas diterpenes react to form tetraterpenes [34].

Vegetable volatiles is dynamic and complex, making it difficult to compare results across studies because volatile compound amounts are reported as relative concentrations. Each factor is supported by evidence from the major compounds and flavor-active compounds. The vegetable volatiles vary primarily due to (1) the availability of substrates and specific enzymes, (2) enzymatic activities (stability and optimum conditions), and (3) the approachability of enzymes and substrates [34].

The effect of cooking on the volatile compounds is summarized by PCA (Figure 4). The first two principal components (F1 and F2) explained 93.3% of the total variance. F1, which account for 78.61%, described the cooking effect. The cooking treatments separated fresh kenikir (F) and kenikir boiled for 3 min (B3) in the same quadrant (upper right) and kenikir boiled for 5 min (B5), steamed for 3 (S3) and 5 min (S5) in the same quadrant (lower right). The compounds associated with F and B3 were (Z)-β-ocimene (Mt6), ylangene (Mt12), α-cubebene (St2), aromadandrene (St4), α-humulene (St5), epi-bicyclosesquiphellandrene (St6), germacrene D (St7), α-muurolene (St8), and α-farnesene (St9). While the compounds associated with B3, S3, and S5 included β-myrcene (Mt3), β-pinene (Mt4), (E)-β-ocimene (Mt5), (E,E)-cosmene (Mt10), allo-ocimene (Mt11), and β-elemene (St1).

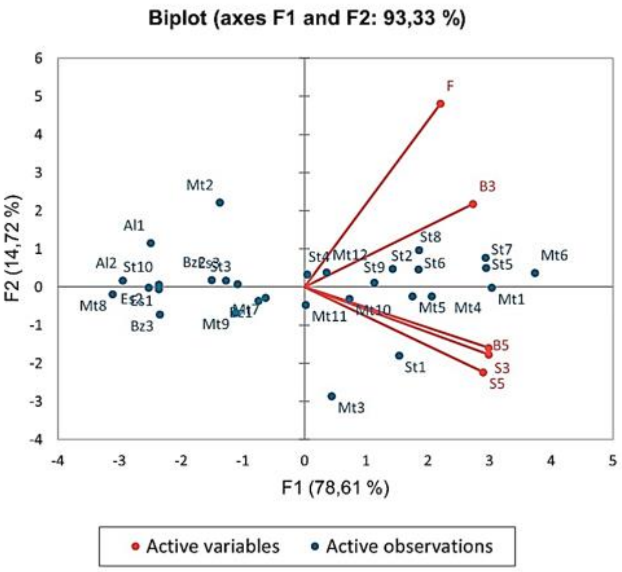

Figure 4. Biplot from PCA of volatile compounds. F (Fresh) = Segar; S (Steamed); S3 = steamed for 3 minutes; S5 = steamed for 5 minutes; B (Boiled); B3 = boiled for 3 minutes; B5 = boiled for 5 minutes. The identifiers are available in Table 1.

3.3. Sensory profile

The free choice profiling (FCP) test of kenikir samples was performed in two sessions using untrained panelists. In the first session, the panelists freely described their impressions (attributes) in terms of appearance, taste, aroma, and texture. In the second session, the panelists rated the intensity of previously determined attributes, namely the most frequent attributes, which were (1) moist and (2) bright for the appearance, (3) smooth, (4) tender, and (5) juicy for the texture, (6) floral and (7) grassy for the aroma, and (8) bitter and (9) minty for the taste.

The effect of cooking on the sensory profile of kenikir leaves is summarized by PCA (Figure 5). The first two principal components (F1 and F2) explained 85% of the total variance. F1, which accounted for 60.1%, described the cooking effect. The PCA separated fresh (F), boiled (B3 and B5), and steamed kenikir leaves (S3 and S5) in different quadrants. Fresh kenikir (F) was associated with bright and minty attributes. This was probably because (Z)-3-hexenol gave a green-type flavor, while α-cadinol gives an herbal odor (The Good Scents Company). (Z)-3-hexenol and α-cadinol were not detected in the cooked kenikir (Table 1).

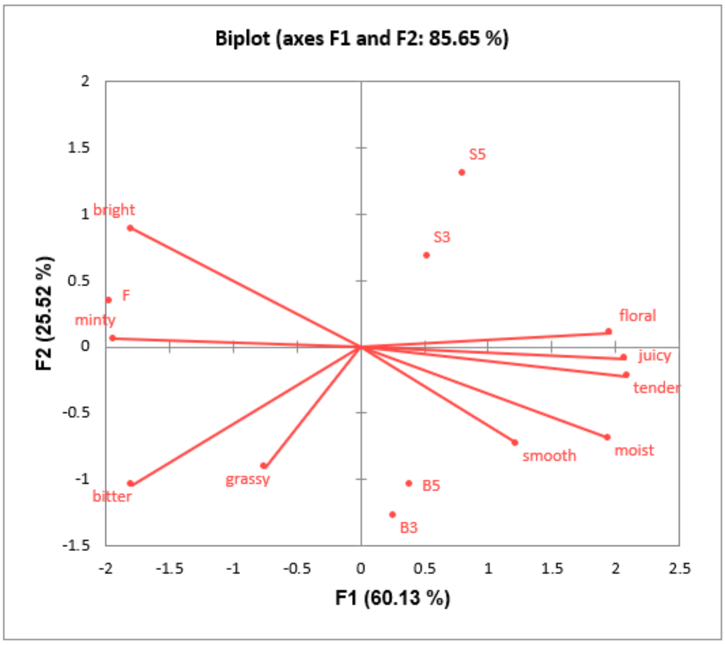

Figure 5. Biplot from PCA of sensory attributes in all kenikir samples. F (fresh); S (steamed); S3 = steamed for 3 minutes; S5 = steamed for 5 minutes; B (boiled); B3 = boiled for 3 minutes; B5 = boiled for 5 minutes.

Steamed kenikir (S3 and S5) was characterized by a higher floral aroma (Figure 5). This was most likely related to the compounds (Z)-β-ocimene and allo-ocimene (Table 1). The relative amounts of allo-ocimene and (Z)-β-ocimene compounds in steamed kenikir was the highest among samples. Meanwhile, bitter and grassy attributes were in the lower left quadrant, which was in contrast to both of the steamed kenikir's quadrants. This may indicate that both attributes were absent or have no relationship with both of the steamed kenikir.

Table 1. Volatile compounds in fresh, boiled, and steamed Kenikir.

Compound	Code	LRI experiment	LRI literature	Approximate concentration (µg/Kg)					Aroma description
				Fresh	Boiled		Steamed		
					3 minutes	5 minutes	3 minutes	5 minutes	
(Alkohols)									
(Z)-3-hexenol	Al1	854	859[b]	2.9 ± 0.8	nd	nd	nd	nd	*grassy, fresh*[j]
α-Cadinol	Al2	1652	1655[d]	0.3 ± 0.1	nd	nd	nd	nd	*herbal*[k]
(Benzenes)									
p-Xylene	Bz1	867	884[a]	0.5 ± 0.2	0.3*	0.4*	0.1*	0.4*	*green, pungent*[j]
Naphthalene	Bz2	1177	1182[f]	0.9 ± 0.1	0.1 ± 0.03	0.1 ± 0.02	0.1 ± 0.02	0.07*	*phenolic*[h]
1-Methylnaphthalene	Bz3	1286	1289[h]	0.045*	0.06 ±0.02	0.04 ± 0.001	0.07± 0.02	0.03 ± 0.01	*naphtyl-like, campor-like*[j]
(Esters)									
cis-3-Hexenyl isovalerate	Es1	1236	1240[f]	0.3 ± 0.3	0.2 ± 0.05	nd	0.1*	0.01*	*green, fruity*[j]
(Z)-3-Hexenyl butyrate	Es2	1188	1188[e]	0.2*	0. 1*	nd	0.1*	nd	*fresh, green*[k]
(Z)-3-Hexenyl 2-methylbutanoate	Es3	1233	1292[b]	0.8*	0.3*	0.1 ± 0.01	0.2*	0.05*	*green, fruity*[k]
(Monoterpens)									
α-Thujene	Mt1	930	931[a]	16.7 ± 3.2	9.2 ± 2.5	10.4 ± 0.5	1.0 ± 1.0	12.45*	*woody, spicy*[j]
β-Phellandrene	Mt2	974	1003[b]	6.4*	7.5*	nd	nd	nd	*turpentine, minty*[j]
β-Myrcene	Mt3	994	990c	nd	nd	4.0*	3.5 ± 1.1	0.0047*	*woody, musty*[j]
β-Pinene	Mt4	998	980[c]	0.0054*	4.7 ± 0.9	4.5 ± 0.2	2.4 ± 0.8	4.4 ± 0.05	*herbal, piney*[k]
(E)-β-Ocimene	Mt5	1040	1051[a]	3.7 ± 1.3	3.4 ± 1.5	2.6 ± 0.2	3.1*	3.4 ± 0.4	*citrus, sweet*[j]
(Z)-β-Ocimene	Mt6	1075	1041	509.3 ± 29.8	655.5 ± 70.6	517.8 ± 29.4	655.4 ± 139.4	606.4 ± 82.9	*floral*
γ-Terpinene	Mt7	1061	1062[a]	0.8 ± 0.1	0.3 ± 0.05	0.4 ± 0.08	0.3*	0.5 ± 0.05	*gasoline, turpentine*[m]
3-carene	Mt8	1067	1048	0.2 ± 0.1	nd	nd	nd	nd	*citrus*[k]

Continued on the next page

Compound	Code	LRI experiment	LRI literature	Approximate concentration (μg/Kg)					Aroma description
				Fresh	Boiled		Steamed		
					3 minutes	5 minutes	3 minutes	5 minutes	
1,3,8-p-Menthatriene	Mt9	1081	1114[d]	0.2 ± 0.05	0.3*	0.3 ± 0.1	0.3 ± 0.01	0.2 ± 0.02	*terpenic, woody*[k]
(E,E)-Cosmene	Mt10	1093	1130[e]	1.2 ± 0.2	1.3 ± 0.09	1.1 ± 0.3	1.5 ± 0.2	1.1 ± 0.2	-
Allo-ocimene	Mt11	1142	1132[d]	0.7 ± 0.03	0.7 ± 0.05	0.7 ± 0.06	0.6 ± 0.1	0.9*	*floral*[k]
Ylangene	Mt12	1370	1372[g]	2.9 ± 0.4	1.9 ± 0.2	1.1 ± 0.3	0.4 ± 0.1	0.5 ± 0.2	-
(Sesquiterpens)									
β-Elemene	St1	1393	1392[a]	nd	22.0 ± 2.1	9.0 ± 5.8	3.2 ± 2.0	2.2 ± 2.2	*herbal*[k]
α-Cubebene	St2	1396	1351[g]	9.0 ± 1.3	6.6 ± 0.5	3.2 ± 0.8	1.1 ± 0.2	1.2 ± 0.2	*herbal*[k]
α-Gurjunene	St3	1408	1409[a]	0.7 ± 0.09	0.6 ± 0.06	0.3 ± 0.1	0.1*	0.045± 0.005	*woody*[k]
Aromadandrene	St4	1437	1440[i]	2.0 ± 0.5	1.2 ± 0.2	1.3 ± 0.8	0.3*	0.4 ± 0.05	*wood*[j]
α-Humulene	St5	1452	1455[i]	28.4 ± 6.5	26.9*	7.2*	4.5 ± 1.6	4.2 ± 0.4	*woody*[k]
Epi-bicyclosesquiphellandrene	St6	1462	1490[a]	9.1 ± 2.1	8.2 ± 0.5	3.4 ± 0.9	1.2 ± 0.4	1.6 ± 1.4	*ashy, sulfur*[l]
Germacrene D	St7	1479	1480[a]	236.0 ± 76.3	113.1 ± 5.6	52.2 ± 46.6	49.6 ± 20.2	1.1 ± 0.1	*woody, spice*[j]
α-Muurolene	St8	1507	1499[a]	19.3 ± 10.5	22.5*	2.5 ± 0.6	1.2 ± 0.2	1.4 ± 0.4	*wood*[m]
α-Farnesene	St9	1516	1504[c]	1.8 ± 0.02	9.0 ± 2.1	3.6 ± 1.1	0.7 ± 0.02	0.7 ± 0.01	*woody, green*[j]
α-Calacorene	St10	1541	1542[a]	0.3 ± 0.2	0.2 ± 0.08	0.1 ± 0.04	nd	nd	*wood*[m]

Note: Presentation of data on the relative number of compounds based on the calculation of the average of 3 replications ± standard deviation. * = components obtained only in 1 replication; tt = not detected. a: [37]; b: [38]; c: [39]; d: [40] e: [41]; f: [42]; g: [43]; h: [28]; i: [27]; j: [26]; k: The Good Scents Company (thegoodscentscompany.com); l: [44]; m: Flavornet (flavornet.org).

Both boiled kenikir, boiled for 3 and 5 min (B3 and B5), had the strongest juicy, tender, moist, and smooth attributes (Figure 5). This was possibly due to the impact of boiling water on fresh kenikir.

Broccoli cooked in a convection steam oven at 125 °C with 90 percent steam saturation for 8 min was the most palatable sensory attribute (overall quality) [35]. In the sensory quality, the broccoli had the highest green color intensity and consistency and the lowest bitter taste intensity. In addition, the broccoli had the highest protopectin content and the greatest firmness.

A quantitative measure of the intensity of sensory attributes, conventional descriptive analysis (CDA) provided more detailed and accurate information on products than free choice profiling (FCP) and Flash Profiling (FP) [36]. However, the panel hours for CDA were longer than those for rapid methods, and FP was able to separate the samples to a greater extent than CDA. This study found that when comparing FCP and FP, ranking-based FP provided a clearer separation of samples than rating-based FCP, but the latter was an easier task for most assessors.

3.4. Hypotensive effect of water extract of Kenikir

This study also examined whether the water extract of kenikir exhibited hypotensive effects after a single dose of oral administration (40 mg/kg body weight) (Table 2). Thirteen-week-old male SHRSP with a systolic blood pressure (sBP) of around 236 mmHg, was used in this study. The outcome revealed that sBP of the control group before and after administration was similar. The sBP showed a significant decrease at 2 h and 4 h (−20.61 and −15.01 changed, respectively) after the administration of kenikir water extract ($p < 0.05$), compared to the control group. This study was consistent with the previous study and used Wistar rats treated with adrenaline and sodium chloride at concentrations of 500−1000 mg/kg body weight [9]. One active compound that contributes as an ACE- inhibitory in kenikir is α-cadinol [18]. This is the first study to demonstrate that water extract of Kenikir has the capacity to diminish high blood pressure by using an animal model that is genetically similar to human hypertension.

Table 2. Time course of systolic blood pressure (mm/Hg) of water extract of Kenikir[a].

Group	0 h	2 h	4 h	6 h
Control	236.00 ± 11.52	229.75 ± 6.02	227.50 ± 20.14	217.25 ± 17.02
Kenikir	226.75 ± 5.38	190.50 ± 8.02*	197.75 ± 14.36*	206.25 ± 10.37
Change (%)	-	−20.61	−15.04	−5.33

Note: [a] Values are given as means ± SD, n = 4. *A significantly different ($p < 0.05$) versus Control. Water extract of Kenikir was administered per oral at 40.0 mg/kg of body weight.

This study demonstrates that kenikir is one of the potential, local sources of functional food that can be efficacious in diminishing hypertension by an animal model of metabolic syndrome-related diseases. Future studies are required to detail the mechanism of kenikir's hypotensive capacity and similar related metabolic diseases.

4. Conclusions

The volatile compound analysis of fresh, boiled, and steamed kenikir detected 30 volatile compounds, including alcohols, benzenes, esters, monoterpenes, and sesquiterpenes. Some compounds, such as (Z)-3-hexenol, α-cadinol, and 3-carene, were found in fresh kenikir, whereas β-myrcene and β-elemene compounds were discovered after cooking. The following kenikir sensory attributes were determined by FCP: bright and moist (appearance), smooth, tender, and juicy (texture), floral and grassy (aroma), and bitter and minty (taste). Furthermore, the water extract of kenikir exhibited hypotensive effects in SHRSP.

Acknowledgments

This work was supported by grants from the Ministry of Education, Culture, Research and Technology for research funding with contract number 240/SPK/LPP-UB/VI/2022 and partially supported by a grant from Fellowship Program for Collaborative Research at Tohoku University.

Conflict of interest

The authors declare no conflict of interest.

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