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Cucumis melo L. 'Gama Melon Parfum' Extract: Volatile Compound Profile, Optimization, Preparation and Perfume Radar

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ABSTRACT

Perfume notes are a sophisticated blend of essential or fragrance oils that give perfumes a distinct scent. Melon notes are highly favored aromatic elements in perfumes. Melon (*Cucumis melo* L. 'Gama Melon Parfum'), known by the local name Gama Melon Parfum (GMP), is a melon breed that has unique phenotypic characteristics: bitter taste, batik-like pattern, and fragrant aroma. GMP has a fresh and fruity melon character, typically used as a top note in the perfume pyramid concept. Our study aimed to develop a perfume derived from GMP volatile extract as a fragrance ingredient. The process included collection, identification, extraction, physicochemical characterization, volatile compound analysis, perfume optimization, preparation, and perfumery radar. GMP can serve as the top note in a perfume formulation. From the D-optimal mixture design, an ideal perfume formula could be created from a mixture of 0.95 mL GMP, 0.55 mL rose, and 0.50 mL vanilla. The composition was found to produce a perfume that met sensory standards: a transparent and uniform liquid without impurities. It also had a unique aromatic scent with a relative density of 0.8102 g/cm3 which fell within the specified range of 0.7000-1.200 g/cm3, viscosity of 0.7931 cps within the required range of 0.7830-1.4030 cps, and a hedonic level of 9.72 cm out of a maximum of 15.00 cm. The perfume radar showed fruity-floral-musk characteristics. Results from this research indicate that enhancing GMP as a fragrance ingredient enables the creation of an optimal perfume that meets the required standards, is well-received, and demonstrates an inclination toward femininity.

Keywords: D-optimal mixture design; Gama Melon Parfum; perfume notes; perfume optimization; perfume radar

INTRODUCTION

Consumer awareness of personal care continues to increase as living standards improve, a factor driving the growth of the global perfume industry. The global perfume market size reached US$35.5 billion in 2022. The market of this industry is expected to reach US$50.4 billion by 2028, exhibiting a growth rate of 6.05% (IMARC, 2023). Nowadays, ethanol-based perfumes are a standard offering in the fragrance industry (Gunawan et al., 2023). Perfumes are a preparation that emits a pleasant odor and are usually liquids made from natural or synthetic ingredients. Based on the concentration of fragrance in the solvent (ethanol), these cosmetic products are classified into *eau de parfum* (10-20%), *eau de toilette* (5-15%), *eau de cologne* (3-8%), and aftershaves (1-3%) (Marcus et al., 2013).

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The term "notes" in perfumes describes the aroma sensed after applying perfumes from the container. The composition of perfume notes generally refers to the concept of a perfume pyramid, which divides notes based on the period of their fragrance spread. Top notes disperse first or during the opening of the container, middle notes disperse after the top notes period, and base notes disperse at the end of the period (most persistent odor) (Rodrigues et al., 2021). Usually, this concept only applies to products that fall into the fine fragrance category (Chisvert et al., 2018). Notes in perfumes are a complex mixture of essential or fragrance oils that give perfumes a unique aroma (Harrison et al., 2018). Essential oils are volatile aromatic liquids obtained from plant materials through steam distillation, while fragrance oils are mixtures of synthetic aroma compounds or natural essential oils diluted with a carrier such as propylene glycol, vegetable oil, or mineral oil (Ríos, 2016).

Melon notes are among the most popular character notes in perfume products. Until now, there are around 150 perfume brands with melon characters as top notes, for example, Acorelle® Absolu Fruits and Zara® Peach (www.fragrantica.com, 2022). The melon notes give a tropical, fresh, and even beach vibe. These notes add depth and a modern side to a fruity or floral scent. Melon notes also take center stage in well-known fragrances such as Prescriptives® Calyx, Claiborne® for Men, and Aramis® New West for Her (Harrison et al., 2018). Other notes commonly used in perfumes products besides melon are rose and vanilla. Rose notes have a fresh lemon scent profile with various powdery, woody, or fruity shades, feminine, clean, and romantic impressions, while vanilla notes in the perfume world are prevalent notes with a strong gourmand character (sweet, cupcake, girly). Examples of perfumes products that combine notes of rose and vanilla include Unic® Rose & Vanilla, Mancera® Roses Vanille, Jo Malone London® Rose Water & Vanilla, and Vera Wang® Embrace Rose Buds and Vanilla (www.fragrantica.com, 2022).

Melon (*Cucumis melo* L. 'Gama Melon Parfum'), known by the local name Gama Melon Parfum (GMP), is a melon breed that has unique phenotypic characteristics, including bitter taste, batik-like pattern, and fragrant aroma (Maryanto et al., 2014). The aromatic characteristics of this cultivar are influenced by volatile compounds 3-pentene 2-ol, hexyl acetate, and 3-hydroxy 2-butanone (Hasbullah et al., 2019). Various studies on GMP have been recently carried out, including the stability of phenotypic and aroma characters (Maryanto et al., 2014), aroma profiles of volatile compounds (Hasbullah et al., 2019), phenotypic characters and biochemical compounds (Saputri et al., 2020), the antioxidant activity of ethanol extract (Zulfikar et al., 2020), aroma-triggering volatile compounds (Hasbullah et al., 2021), phenotypic characters and identification of cyclophilins (CYPs) genes (Wibowo et al., 2021), chemical properties and degradation kinetics thermal (Husnun et al., 2022), as well as computational studies as an inhibitor of epidermal growth factor receptor protein (Wibowo et al., 2022). GMP has a fresh and fruity melon character, commonly used as top notes in the perfume pyramid concept. These notes are generally combined with rose (floral) or pear (fruity) as middle notes and musk (musky) or vanilla (sweet) as base notes (Harrison et al., 2018).

Scientists have extracted volatile compounds from fruits for the flavor and fragrance industries. Several fruits extracted include salak (*Salacca edulis* Reinw) cv. pondoh (Supriyadi et al., 2002), combined fruit juices (orange, peach, apple, apricot, pineapple, mango, banana, and passion fruit) (Barba et al., 2017), omija (*Schisandra chinesis* Baillon) (Kim et al., 2019), GMP melon (Hasbullah et al., 2019), finger limes (*Citrus medica* L. var. sarcodactylis) (Chen et al., 2020), Peruvian pepper (*Schinus molle* L.) (Giuffrida et al., 2020), peaches (*Prunus persica* L.) (Q. Wang et al., 2020), and black cardamom (Ai et al., 2022). Researchers have applied optimal volatile compounds for various extraction methods, including cold maceration (Hasbullah et al., 2019, 2021), solvent-assisted flavor evaporation (SAFE) (Conde-Martínez et al., 2014; Goh et al., 2019; R. Liu et al., 2019; Supriyadi et al., 2002), headspace-stir bar sorptive extraction (HS-SBSE) (Ha et al., 2014; Kaur et al., 2011; Kim et al., 2019; Ríos-Reina et al., 2019), headspace solid phase microextraction (HS-SPME) (Aati et al., 2022; Chen et al., 2020; Mohammadhosseini et al., 2021; Pollo et al., 2022), and vacuum freeze-drying (Silva & Schmidt, 2022; B.-B. Wang et al., 2022; C. Wang et al., 2022; Xu et al., 2021). The cold maceration extraction method has the advantage of minimizing contaminants in the extract and preventing the occurrence of secondary compounds caused by heat during extraction. The maceration process is conducted at -20°C, or freeze-room temperature, for a whole day. After the maceration process, substances such as water, proteins, lipids, and carbohydrates will freeze, preventing them from being included in the extract after decantation (Hasbullah, 2014). Although various sophisticated extraction techniques are available, cold maceration remains an excellent technique due to its simplicity, ease, and low-cost application (Hasbullah et al., 2019, 2021).

The current approach for enhancing the quality of a product is known as quality by design (QBD). The concept highlights that quality cannot solely assessed by product testing but must be established through design. A technique commonly employed in implementing the QBD idea is the design of experiment (DoE). Typically, there are three primary categories of DoE implementation based on the parameters to be researched. These categories include mixture design, factorial design, and a combination of both (Montgomery, 2017). Mixture design (MD) is employed to characterize and optimize a formula. Perfumery ternary diagram® (PTD®) is the most recent technique employed in perfume engineering. PTD® is a derivative of MD used to enhance perfume's scent notes. This approach relies on comparing the structure of the scent pyramid and the engineering of a ternary diagram (Teixeira et al., 2013). A perfume radar can depict the characteristics and

path of a smell. It can be generated by examining panelist evaluations through sensory analysis or odor descriptors of fragrance. A perfume radar classifies scents into three categories: masculine, feminine, and unisex. Meanwhile, perfume smell characteristics are categorized into eight primary groups: citrus, fruity, flowery, green, herbaceous, musk, oriental, and woody. Furthermore, the perfume radar also maps out the structure and essence of perfume fragrances (Teixeira, 2011; Teixeira et al., 2010, 2014). GMP has a fresh melon scent that is suitable for combination with the aroma of roses and the sweet impression of vanilla, which may result in a more feminine perfume radar.

Synthetic or fragrance oil is a common ingredient in most perfumes on the market. Nonetheless, some people frequently experience sensitization, irritation, and allergy due to fragrance oils in cosmetics (Arribas et al., 2013; Reeder, 2020). Although GMP is an inedible melon with an intensely bitter taste, it has a pleasant aroma and the potential to be developed as a natural perfume fragrance safer than synthetic ones. The different outcomes of our preliminary fundamental GMP research confirm this melon cultivar's move towards more practically research in cosmetics, particularly perfume. This research aims to extract GMP, characterize its physicochemical and olfactory profiles, create optimized perfume notes from various combinations of GMP extract, rose, and vanilla essential oils, and ascertain the perfumery radar of the optimized perfume.

MATERIALS AND METHODS

Materials and instruments

The primary materials used in this work included the rind of melon (*Cucumis melo* L. 'Gama Melon Parfum'), hexane, dichloromethane (Sigma®, USA), rose and vanilla essential oils (Darjeling®, Indonesia), and ethanol 96 % (Brataco®, Indonesia). The characterization of the chemical profile of GMP extract was carried out using a gas chromatography-mass spectrometry (GC-MS) instrument, namely GCMS-QP2010S (Shimadzu®, Japan).

Methods

Samples collection and determination of GMP

Samples were harvested from our greenhouse in Mutihan, Yogyakarta, Indonesia. Fruits were harvested sixty days after plantation (DAP) and immediately transported to the laboratory. The fruit's rind was removed from the flesh and stored at -20°C until further use (Hasbullah et al., 2019, 2021). All parts of the plant (roots, stems, branches, leaves, and fruit) were submitted for identification at the Plant Systematics Laboratory, Faculty of Biology, Universitas Gadjah Mada, to ensure the correct identity of the plant (certificate number: 0340/S.Tb./VI/2023).

Extraction of GMP

With some modifications, volatile compounds of GMP were extracted from samples via cold maceration using our previously published method (Hasbullah et al., 2019, 2021). A dry blender homogenized the fruit's frozen rind (50 g). After homogenization, the sample was added with a 120 mL hexane/dichloromethane solvent mixture (2:1, v/v) and then sonicated in the water bath for 15 min. The maceration was continued for 24 h at -20°C to extract the volatile compounds. The extract was decanted, dried, concentrated to a final volume of 5 mL, and stored in a dark glass vial at -20°C until further analysis.

Volatile compound Analysis of GMP

The analysis used GCMS-QP2010S (Shimadzu®, Japan) with a 70-eV electron impact (EI) mode. The capillary column Agilent DB-5MS (30 m x 0.25 mm; film thickness of 0.25) was used for separation. One µL of the sample was split-mode injected with a 1:49 split ratio. The separation was run using temperature programming, specifically with the oven temperature ranging from 70°C and 300°C and increasing at a rate of 5°C/min. Helium was used as the carrier gas at a pressure of 30 kPa, with a total flow rate of 35.6 mL/min. The GCMS-QP2010 detector temperature was adjusted to 305°C, and a spectrum range of 28-600 m/z was performed. The compounds were analyzed by comparing the mass spectra of identified peaks from the sample to those of authentic standards in the Wiley 229 Library, NIST 62 Libraries, and NIST 12 Libraries.

Physicochemical characteristics of fragrance components

GMP volatile extracts, rose, and vanilla essential oils were used as fragrances, and the final product underwent physicochemical characterization, including color, relative density, solubility in 90% ethanol, optical rotation, refractive index, viscosity, surface tension, acid value, and ester value.

Color

A total of 10 mL of sample was pipetted using a pipette with a capacity of 10 mL, then put into a 20 mL test tube, placed on white cardboard, and observed visually at a distance of 30 cm.

A triplicate test was performed on the samples (BSN, 2014).

Relative density

The pycnometer with a capacity of 10 mL was washed with acetone and then dried, along with the interior of the pycnometer and the cover. The empty pycnometer was weighed using an analytical balance at 20°C, then filled with distilled water. Following this, the cover was inserted, and the outside was dried. The same procedure was carried out for the samples. The relative density formula was used to conduct the calculations. Determinations and calculations of the samples were performed in triplicate (BSN, 2014; ISO, 1998a).

Solubility in 90% ethanol

A total of two mL of samples were mixed with 90% ethanol (1:1 volume ratio) in a 10 mL measuring cup with a lid. The mixture was shaken, then determined whether the solution was clear and transparent. The samples were then tested in triplicate (BSN, 2014).

Optical rotation

The light source was lit in the polarimeter using a sodium lamp, producing monochromatic light with a 589.3 ± 0.3 nm wavelength. The blank test was done by reading the polarimeter to an accuracy of 0.5 mrad (± 0.03°). The polarimeter tube was filled with the sample in the tube. The tube was placed in a polarimeter, and then the dextro (+) or levo (-) optical rotation was read on the instrument scale. Optical rotation was expressed in circumferential degrees up to 0.01°. The dextro optical dial was marked (+), while the left is marked (-). The average of the three readings was recorded with a difference of no more than 0.08° (BSN, 2014).

Refractive index

A drop of the sample was placed in the refractometer, then closed tightly. This allowed the light to pass through the sample solution and the prism, causing the light on the screen on the instrument to split into two. The boundary mark was moved by turning the control knob until it reached the intersection point of the two diagonal lines, allowing for the observation and reading of the refractive index scale through the microscope. The samples were tested in triplicate (ISO, 1998b).

Viscosity

Aquadest was pumped to a level above the marking line A on the Ostwald viscometer, and subsequently allowed to flow downwards. When the aquadest reached this marker, the stopwatch was turned on. Once it reached line B, the stopwatch was turned off, and the flow time was recorded. The same procedure was carried out on the samples. The temperature was measured by inserting a thermometer into the viscometer. Calculations for the sample were carried out using the viscosity formula in triplicate (Jain et al., 2012a).

Surface tension

The sample was briefly dipped into a capillary tube marked with a limit mark, allowing it to rise above the marked level, and the increase was measured. Calculations were carried out using the surface tension formula. Determinations and calculations of the samples were carried out in triplicate (Jain et al., 2012b).

Acid value

A total of 4 g ± 0.05 g of sample was weighed on an analytical balance and dissolved in 5 mL of neutral ethanol in a 250 mL capacity saponification flask with a round bottom made of alkali-resistant glass, equipped with a glass tube with a minimum length of one meter and a minimum diameter of one centimeter. Then, five drops of phenolphthalein solution were added as an indicator. This solution was titrated with 0.1 N potassium hydroxide (KOH) until a pink color appeared. Calculations were carried out using the acid number formula. Determinations and calculations of the samples were carried out in triplicate (BSN, 2014).

Ester value

A total of 4 g ± 0.05 g of sample was weighed on an analytical balance, dissolved in 25 mL of 0.5 N potassium hydroxide (KOH) solution in neutral ethanol with several pieces of porcelain in a 250 mL round bottom alkaline saponification flask equipped with a glass tube with a minimum length of one meter and a diameter of at least one centimeter. It was then boiled until cooked, and subsequently five drops of phenolphthalein solution and titrate with 0.5 N HCl were added until a color change was visible. The value was calculated using the ester value formula. Sample determination and calculation were carried out in triplicate (BSN, 2014).

Perfume optimization, preparation, and perfume radar

Perfume optimization refers to a modified perfumery ternary diagram® (PTD®) concept (Teixeira, 2011; Teixeira et al., 2013) using a mixture design assisted by Design Expert®12

software (Statease, 2020) to optimize relative density and viscosity (Abdolmaleki et al., 2019; BSN, 1998) as well as hedonic responses (Meilgaard et al., 2016). Perfume preparation was carried out by taking each fragrance ingredient using a micropipette to a total mixture of 2 mL and then placing it in a glass bottle with a capacity of 20 mL. The resulting mixture was diluted with 96% ethanol to 20 mL, which produced *eau de toilette* type (Marcus et al., 2013). The glass bottle was tightly closed and stored for seven days for the aging process at room temperature and further characterization.

The relative density and viscosity of the perfume mixtures were measured using procedures similar to those described above. Hedonic response measurements were carried out after obtaining ethical clearance from the Medical and Health Research Ethics Committee (MHREC) of Faculty of Medicine, Public Health, and Nursing at Universitas Gadjah Mada - Dr. Sardjito General Hospital (certificate no. KE/FK/0065/EC/2024). The hedonic testing was conducted by exposing 16 perfume formulas with three letters of random codes to 75 participants. Inclusion criteria for the study participants included untrained female panelists aged 18-23 years without neurological diseases or olfactory disorders. Each tested perfume was sprayed on a paper strip twice. Then, the panelists gave a hedonic assessment of the perfume aroma by sniffing and marking a "point" on a 15.00 cm-long horizontal line and a vertical line at both ends. The centimeter (cm) was a unit used to measure the results of hedonic measurements of perfume. The values ranged from 0.00 cm to 15.00 cm, with higher values indicating a greater preference by the panelists (Meilgaard et al., 2016).

The perfume radar was determined from the checklist given to the untrained panelists during the testing, in which they were requested to select from eight fragrance characteristics: citrus, fruity, floral, green, herbaceous, musk, oriental, and woody. Panelists were given absolute freedom to choose from the eight available fragrance character options according to personal interpretation, and then the total number of choices made by the panelists was converted into a radar chart using Canva™.

RESULTS

Phenotypic characteristics of GMP

The samples collected were characterized by a very fragrant fruit aroma like perfume, weighing between 300-500 grams, with an oblate fruit shape, a pistil protrusion at the bottom of the fruit, yellow-brown fruit skin with unique ornaments forming longitudinal lines, white flesh, and no visible netting (Figure 1). Based on these phenotypic characteristics, GMP is a melon cultivar classified as non-edible because of its bitter taste. For this reason, it is typically used as a cosmetic or pharmaceutical raw material (Daryono, 2019; Daryono & Maryanto, 2017; Zulfikar et al., 2020).

Figure 1. Gama melon parfum (GMP)

Determination of GMP

The following results were obtained from the determination carried out at the Plant Systematics Laboratory, Faculty of Biology, Universitas Gadjah Mada (certificate no. 0340?S/Tb/VI/2023).Kingdom : Plantae; Division : Magnoliophyta; Class : Magnoliopsida; Order : Cucurbitales; Family : Cucurbitaceae; Genus : *Cucumis;* Species : *Cucumis melo* L.; Cultivar : Cucumis melo L. 'Gama Melon Parfum'; Local name : Gama Melon Parfum

Based on this identification, the difference between GMP and melons currently exist worldwide is in the cultivar. GMP is a cultivar from crossing the parent melon ♀ NO3 from Turkmenistan (Central Asia) and the parent melon MR ♂ from Japan. The parent melon ♀ NO3 has small size, fragrant aroma, orange skin color, does not have lobes and long lines, and has a bitter taste, while the parent MR ♂ is of medium size, no fragrant aroma, has green fruit skin color, lobes and long lines, and is sweet (Daryono & Maryanto, 2017; Hasbullah, 2014; Hasbullah et al., 2019, 2021; Husnun et al., 2022; Maryanto et al., 2014; Saputri et al., 2020; Wibowo et al., 2021; Zulfikar et al., 2020).

Volatile compound profile of GMP

Forty-one volatile chemicals from GMP extract were identified using GC-MS (Figure 2). The extract consisted of nine esters (29.67%), six alcohols (9.21%), two phenols (18.19%), seventeen hydrocarbons (19.06%), five terpenes

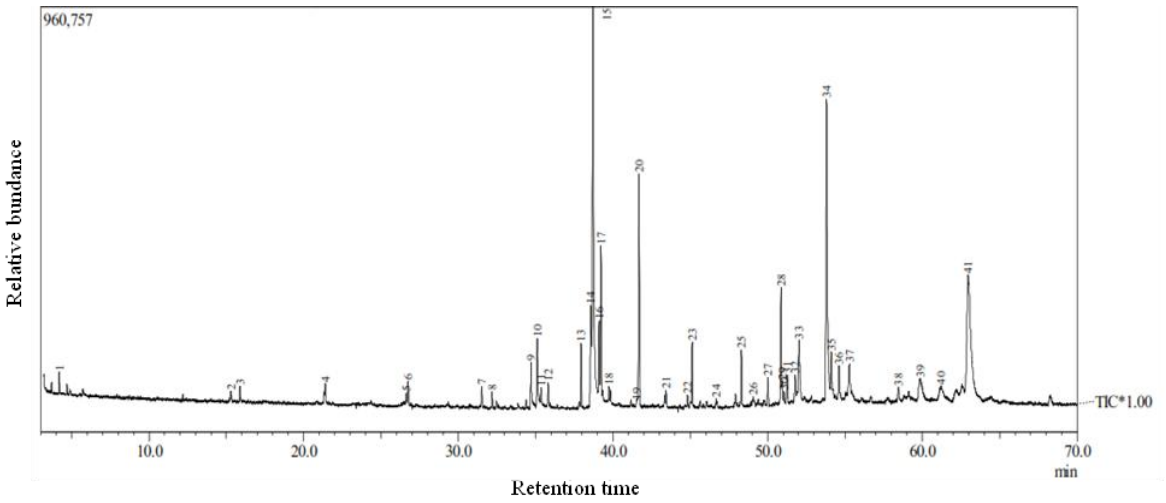

Figure 2. Chromatogram of GMP volatile compound by GC-MS

(19.67%), one ketone (0.47%), and one halide (4.28%). Esters were the most prevalent in the GMP, with terpenes, hydrocarbons, phenols, halides, and ketones following in that order (Table I).

GMP extract profile indicated a high concentration of esters and a lower presence of alcohols. The formation of esters during ripening is likely due to the esterification process between alcohols and acids (Hasbullah et al., 2019). Ester compounds in GMP contributing to its fragrance are hexadecanoic acid (creamy candle waxy nuance) (TGSC, 2023e), octyl ethanoate (floral, herbaceous, and fruity characteristics) (TGSC, 2023h), and ethyl €-hexadec-9-enoate (mild waxy, fruity, creamy milky balsamic, greasy oily traits) (TGSC, 2023h). Ester volatile chemicals are produced when alcohol is esterified by alcohol acetyltransferase (AAT) (W. W. Liu et al., 2012). Mechanism typically involves using a coenzyme A moiety or coenzyme A ester as an acyl donor. The scent of volatile esters is produced when alcohol reacts with short-chain fatty acids, catalyzed by alcohol acylCoAacyl transferase during phospholipid breakdown as the fruit ripens (Hasbullah, 2014).

The alcohol group responsible for the GMP aroma was identified as tetrahydrofuran-2-ylmethanol, which has a moderate, warm, greasy caramel scent (Echemi, 2023). Alcohol dehydrogenase (ADH) catalyzes the reduction of aldehydes to produce volatile alcohol compounds. Additionally, volatile alcohol compounds are generated as by-products of lipid catabolism (Hasbullah, 2014). Delta-tocopherol and gamma-tocopherol are phenolic compounds produced in large quantities but do not contribute significantly to the fragrant character of GMP. Da Silva and Jorge (2014) documented melon's content and gamma-tocopherol levels. While beta- and delta-tocopherols were measured collectively, gamma-tocopherol was the most prevalent form in melon (Da Silva & Jorge, 2014; Shahidi & De Camargo, 2016). The identified hydrocarbon components do not add to the GMP scent profile. Obando-Ulloa et al. (2010) found that the probable fragrance profile of melon is determined by three specific branched alkanes: 2-methylpentane, 3-methylpentane, and methylcyclopentane (Obando-Ulloa et al., 2010). In the terpenes group, 3,7-Dimethyloct-6-en-1-ol contributes to floral, rosy, sweet citrus with green fatty terpene nuances (TGSC, 2023b), while stigmasterol presents sweet odor characteristics (Bakrim et al., 2022). Terpenes are organic compounds consisting of molecules with the formula $(C_5H_8)n$, commonly present in plants.

These molecules are part of the biogenic volatile organic compounds (BVOCs) group, a varied and extensive category of secondary plant metabolites. They are commonly used in the medical, flavor, and fragrance sectors (Kanwal et al., 2022). The chemical 4-Hydroxy-4-methylpentan-2-one, including a ketone group, has a subtle and minty smell (NIOSH, 2019). Ketone volatile molecules can arise from intermediary substances in the production of leucine, valine, and pantothenate, as well as lipid metabolism (Hasbullah,2014). The chlorine-like scent detected is believed to have originated from (9Z,12Z)-octadeca-9,12-dienoyl chloride, residual dichloromethane solvent used during extraction.

Physicochemical characteristics of fragrance

In the following research stage, the following physicochemical properties were determined for GMP volatile extract, rose, and

Table I. Volatile compounds profile in GMP extract

Compound name (IUPAC)	CAS No.	R. time (min)	Area (%)	Odor description references
Esters				
Octyl ethanoate	112-14-1	15.883	0.44	Floral, herbaceous, fruity (TGSC, 2023h)
Propan-2-yl tetradecanoate	110-27-0	32.180	0.43	Faint, oily fatty (TGSC, 2023f)
Ethyl €-hexadec-9-enoate	54546-22-4	35.361	0.52	Mild waxy, fruity, creamy milky balsamic, greasy oily (Chemicalbook, 2023c)
Tetradecyl (Z)-octadec-9-enoate	22393-85-7	49.067	0.40	No data available
[(1S)-2-methyl-4-oxo-3-[(Z)-pent-2-enyl]cyclopent-2-en-1-yl] (1R,3R)-2,2-dimethyl-3-(2-methylprop-1-enyl)cyclopropane-1-carboxylate	4466-14-2	55.289	1.66	No data available
€-Hexadec-9-enoic acid	10030-73-6	34.702	1.46	Smell of the human body (Nakamura, 1999)
Hexadecanoic acid	57-10-3	35.104	2.60	Creamy candle waxy nuance (TGSC, 2023e)
Octadeca-9,12-dienoic acid	2197-37-7	38.570	3.60	Faint fatty (TGSC, 2023g)
(Z)-octadec-9-enoic acid	112-80-1	38.713	18.01	Lard-like odor (FAO, 2023)
Alcohols				
Tetrahydrofuran-2-ylmethanol	97-99-4	26.632	0.44	Mild, warm, oily caramel aroma (Echemi, 2023)
2-[(9Z,12Z)-octadeca-9,12-dienoxy]ethanol	17367-08-7	39.101	2.56	No data available
Hentriacontan-1-ol	544-86-5	50.863	3.39	No data available
Nonacosan-1-ol	6624-76-6	46.673	0.44	No data available
Heptacosan-1-ol	2004-39-9	51.050	0.37	No data available
Docosan-1-ol	661-19-8	54.116	2.01	Characteristic (TGSC, 2023a)
Phenols				
(2R)-2,8-dimethyl-2-[(4R,8R)-4,8,12-trimethyltridecyl]-3,4-dihydrochromen-6-ol	119-13-1	52.038	3.32	Characteristic (TGSC, 2023c)
(2R)-2,7,8-trimethyl-2-[(4R,8R)-4,8,12-trimethyltridecyl]-3,4-dihydrochromen-6-ol	54-28-4	53.809	14.87	Characteristic (TGSC, 2023d)
Hydrocarbons				
Dodec-1-ene	112-41-4	15.295	0.40	Mild and pleasant smell (Jones, 2023)
Tetradec-1-ene	1120-36-1	21.401	0.54	Mild pleasant odor (USCG, 1999)
Pentadec-1-ene	13360-61-7	26.744	0.71	Odorless (Fischersci, 2020a)
Hexadec-1-ene	629-73-2	31.517	0.54	Mild hydrocarbon odor (Chemicalbook, 2023a)
Octadec-1-ene	112-88-9	35.816	0.70	Mild hydrocarbon odor (Chemicalbook, 2023b)
Nonadecane	629-92-5	37.943	1.66	Fuel-like (Chung et al., 1993)
Docos-1-ene	1599-67-3	39.743	0.43	No data available
Cyclotridecane	295-02-3	41.508	0.43	No data available
Heptadecane	629-78-7	41.683	6.02	Fuel-like (Chung et al., 1993)
Octadecane	593-45-3	43.428	0.46	Fuel-like (Chung et al., 1993)
Cyclotetracosane	297-03-0	44.823	0.36	No data available
Octacosane	630-02-4	45.120	1.65	No data available
Hexatriacontane	630-06-8	48.301	1.60	Odorless (Fischersci, 2020b)

Table I. (Continued)

Compound name (IUPAC)	CAS No.	R. time (min)	Area (%)	Odor description references
€-hexacos-9-ene	71502-22-2	50.950	0.49	No data available
Henicosane	629-94-7	51.268	0.93	Odorless (Chung et al., 1993)
Tetratetracontane	7098-22-8	54.613	1.51	No data available
Nonadec-1-ene	18435-45-5	58.459	0.62	No data available
Terpenes				
(6E,10E,14E,18E)-2,6,10,15,19,23-Hexamethyltetracosa-2,6,10,14,18,22-hexaene	111-02-4	50.016	0.72	Faint odor (Cameo, 2023)
3,7-Dimethyloct-6-en-1-ol	106-22-9	51.781	1.08	Floral, rosy, sweet, citrus with green fatty terpene nuances (TGSC, 2023b)
(3S,8S,9S,10R,13R,14S,17R)-17-[(E,2R,5S)-5-ethyl-6-methylhept-3-en-2-yl]-10,13-dimethyl-2,3,4,7,8,9,11,12,14,15,16,17-dodecahydro-1H-cyclopenta[a]phenanthren-3-ol	83-48-7	59.889	1.77	Characteristic of sweet odor (Bakrim et al., 2022)
(1R,3aR,5aR,5bR,7aR,9S,11aR,11bR,13aR,13bR)-3a,5a,5b,8,8,11a-hexamethyl-1-prop-1-en-2-yl-1,2,3,4,5,6,7,7a,9,10,11,11b,12,13,13a,13b-hexadecahydrocyclopenta[a]chrysen-9-ol	545-47-1	61.215	1.08	No data available
(3R,3aR,5aR,5bS,9S,11aS,11bR,13aS,13bR)-3a,5a,8,8,11b,13a-hexamethyl-3-propan-2-yl-1,2,3,4,5,5b,6,9,10,11,11a,12,13,13b-tetradecahydrocyclopenta[a]chrysen-9-ol	1615-94-7	62.966	15.02	No data available
Ketones				
4-Hydroxy-4-methylpentan-2-one	123-42-2	4.193	0.47	Faint, minty odor (NIOSH, 2019)
Halides				
(9Z,12Z)-octadeca-9,12-dienoyl chloride	7459-33-8	39.222	4.28	Chlorine-like (Fischersci, 2008)

vanilla essential oils as fragrance components: color, relative density, solubility in 90% alcohol, optical rotation, refractive index, viscosity, surface tension, acid value, and ester value (Table II).

In the perfumery industry, special attention is given to the performance of fragrance in the composition of perfumes. Solubility in alcohol is the main physical characteristic of fragrances used in perfume formulations because it functions as a solvent, carrier, fixative, and antimicrobial agent (Chisvert et al., 2018; Gut et al., 2020; Miastkowska et al., 2018; Miastkowska & Lasoń, 2020; Sikora et al., 2018). The fragrance ingredients (GMP, rose, and vanilla) used in perfume formulations are entirely soluble in 90% alcohol, thus meeting the requirements to be formulated in perfume. In contrast, the main chemical characteristic of fragrance ingredients is ester value. The ester compound determines the base character of perfumes and defines the "shape" of a perfume based on its fragrance characteristics. Rose has the highest ester number, followed by GMP and vanilla. A higher ester value indicates a more pungent and more complex aroma of fragrances (Niu et al., 2018, 2019, 2020).

Perfume optimization and preparation

A total of 16 runs of mixed fragrances (GMP, rose, and vanilla) resulting from the optimization of the mixture design from Design Expert®12 were produced and met organoleptic requirements, including clear, homogeneous, particle-free liquid and a distinctive fragrant odor (BSN, 1998). D-optimal mixture design optimization produced

Table II. Physicochemical characteristics of fragrance components

Physicochemical characteristics	Volatile extract/essential oil (n=3)		
	GMP	Rose	Vanilla
Color	Yellow	Colorless	Brown
Relative density (20°C)	1.0267 ± 0,0003	1.0134 ± 0.0001	1.0571 ± 0.0001
Solubility in 90% alcohol	1:1 (dissolved)	1:1 (dissolved)	1:1 (dissolved)
Optical rotation (°)	+0.10 ± 0.00	-0.32 ± 0.02	not measurable
Refractive index	1.429 ± 0.000	1.508 ± 0.000	1.424 ± 0.000
Viscosity (cps)	1.760 ± 0.019	1.202 ± 0.008	1.650 ± 0.005
Surface tension (mN/m)	33.23 ± 0,25	29.05 ± 0.07	35.93 ± 0.04
Acid value	0.19 ± 0.00	8.62 ± 0.01	25.48 ± 0.11
Ester value	71.13 ± 0.61	144.45 ± 0.27	38.06 ± 0.16

perfumes with relative densities between 0.8143-0.8301 g/cm^3, viscosities between 0.8048-0.8940 cps, and hedonic responses between 8.84 to 10.37 cm. These optimal responses were obtained from the composition of GMP 0.90-1.10 mL, rose 0.40-0.80 mL, and vanilla 0.30 - 0.50 mL with a dilution of 18 mL of 96% alcohol in each formula (Table III).

The D-optimal mixture design optimization results were then used to determine the optimal formula using previously defined criteria (Table IV) by recreating the formula with three replications, followed by characterization. The requirements for each composition of fragrance or notes (GMP, rose, vanilla) were chosen “in range” because it refers to a modification of the PTD® concept with a range of GMP (top notes) of 45% to 55%, rose (middle notes) of 20% to 40%, and vanilla (base notes) of 15% to 25% diluted with 96% alcohol (Teixeira, 2011; Teixeira et al., 2013). The relative density and viscosity response criteria were deliberately kept minimal in order to facilitate the distribution of the perfume through a sprayer on the bottle. This is because lower values of these two parameters result in faster release of the aroma, meeting the quality requirements for non-aerosol alcoholic liquid perfumes whose distribution mechanism is not assisted by gas pressure (Chisvert et al., 2018). Meanwhile, the hedonic response criteria were maximized because it is the primary response for assessing consumers’ liking toward a perfume (Apaolaza et al., 2014).

Optimization was carried out based on these criteria using Design Expert®12 to obtain an optimal formula with prepared response predictions. The optimal formula was GMP 0.95 mL, rose 0.55 mL, and vanilla 0.50 mL. The aim of formula optimization for cosmetic preparations, including perfumes, is generally to determine the variable levels of solid products with high-quality characteristics that can be produced. The results of the optimal formula are characterized, including relative density, viscosity, and hedonic. The measurement results are then compared with the predicted values obtained from Design Expert®12, and the deviation values are calculated. The result is considered good if the deviation is less than 10%. A comparison of the predicted and experimental values (Table V) shows that the deviation value (% bias) obtained is less than 10%, indicating that the experimental results are close to the predicted results (Syukri & Nugroho, 2020).

The range of relative density and viscosity values will impact the sprayability of the perfume through the bottle's sprayer valve. Perfume with an alcohol composition of 90% (EDT type) requires a relative density and viscosity value range of 0.7000 - 1.2000 g/cm^3 and 0.7830 - 1.4030 cps, respectively, which is expected to produce a perfume that is easy to spray and spreads on the skin in a constant amount. The values obtained in this research were a relative density of 0.8102 g/cm^3 and a viscosity of 0.7931 cps with a clear, light-yellow solution. These results indicate that the perfume produced meets the organoleptic quality requirements for non-aerosol liquid perfume, featuring a clear, homogeneous liquid free of foreign particles and, naturally, having a distinctive fragrant aroma (BSN, 1998; Herráez & Belda, 2004).

Perfume radar

The results of the perfume radar, based on the measurement of the character of the fragrance by 75 untrained panelists across 16 perfume formulas containing GMP, rose, and vanilla (Figure 3), revealed that the predominant character of the perfume was fruity-floral-musk. A possible explanation for this might be due to the role of GMP as top notes with more composition than the other two components. The characteristics of the GMP, like typical melon notes, impart a tropical, fresh, and beach-like ambiance. The notes enhance the complexity and contemporary aspect of a fruity or flowery fragrance. Rose notes are characterized by a fresh

Table III. Optimization design of fragrance mixture in 20 mL perfumes

Run	Fragrance composition (mL)				Responses (n=3)		
	GMP	Rose	Vanilla	Alcohol 96%	Relative density (g/cm^3)	Viscosity (cps)	Hedonic (cm)
1	0.90	0.70	0.40	18.00	0.8300 ± 0.0001	0.8361 ± 0.0143	9.45 ± 3.30
2	1.10	0.40	0.50	18.00	0.8178 ± 0.0001	0.8360 ± 0.0229	9.16 ± 3.55
3	1.05	0.50	0.45	18.00	0.8227 ± 0.0017	0.8566 ± 0.0458	10.37 ± 3.34
4	1.05	0.60	0.35	18.00	0.8202 ± 0.0004	0.8668 ± 0.0245	9.24 ± 3.57
5	0.90	0.60	0.50	18.00	0.8218 ± 0.0005	0.8853 ± 0.0274	9.44 ± 3.14
6	1.10	0.60	0.30	18.00	0.8300 ± 0.0001	0.8581 ± 0.0353	9.20 ± 3.03
7	0.95	0.70	0.35	18.00	0.8217 ± 0.0001	0.8940 ± 0.0260	8.84 ± 3.15
8	0.90	0.80	0.30	18.00	0.8175 ± 0.0001	0.8651 ± 0.0434	9.09 ± 3.28
9	1.00	0.50	0.50	18.00	0.8143 ± 0.0001	0.8070 ± 0.0107	9.55 ± 2.84
10	1.00	0.50	0.50	18.00	0.8151± 0.0003	0.8438 ± 0.0160	9.95 ± 2.60
11	1.10	0.50	0.40	18.00	0.8148 ± 0.0004	0.8092 ± 0.0206	9.17 ± 2.87
12	0.90	0.60	0.50	18.00	0.8261 ± 0.0002	0.8792 ± 0.0187	9.94 ± 2.84
13	1.10	0.60	0.30	18.00	0.8179 ± 0.0010	0.8048 ± 0.0139	9.66 ± 3.02
14	1.00	0.60	0.40	18.00	0.8261 ± 0.0002	0.8167 ± 0.0077	8.99 ± 3.32
15	0.90	0.80	0.30	18.00	0.8200 ± 0.0001	0.8294 ± 0.0035	9.30 ± 3.21
16	1.10	0.40	0.50	18.00	0.8301 ± 0.0002	0.8396 ± 0.0121	10.02 ± 2.74

Table IV. Criteria for optimal perfume formula

Parameter	Criteria	Lower	Upper
GMP	In range	0.90 mL	1.10 mL
Rose	In range	0.40 mL	0.80 mL
Vanilla	In range	0.30 mL	0.50 mL
Relative density	In range	0.7000 g/cm^3	1.2000 g/cm^3
Viscosity	Minimize	0.7830 cps	1.4030 cps
Hedonic	Maximize	0.00 cm	15.00 cm

Table V. Comparison of predicted and observed values

Parameter	Predicted	Observed	Residual	% Bias
Relative density (g/cm^3)	0.8179	0.8102 ± 0.0002	0.0077	0.95
Viscosity (cps)	0.7834	0.7931 ± 0.0092	0.0097	1.22
Hedonic (cm)	9.67	9.72 ± 0.07	0.05	4.67

lemon aroma with powdery, woody, or fruity undertones, giving off a feminine, clean, and romantic vibe. Vanilla notes in perfumery are dominant and have a rich gourmand quality. Combining three notes creates a gentle, musky effect (Ahmad et al., 2020; Harrison et al., 2018; www.fragrantica.com, 2022). The combination was demonstrated to be suitable for this perfume's target, represented by the untrained female panelists aged 18-23 participating in this research.

DISCUSSION

The creation of *Cucumis melo* L. 'Gama Melon Parfum', referred to locally as Gama Melon Parfum (GMP), as a perfume, has not been previously reported. While several studies have documented perfume formulation (Ameh et al., 2021; Gunawan & Rahayu, 2021; Parab et al., 2020), none have addressed GMP optimization related to perfume. This research contributes to the development of this cultivar in the applicable realm, building upon our previous foundational research (Hasbullah, 2014; Hasbullah et al., 2019, 2021; Husnun et al., 2022; Maryanto et al., 2014; Saputri et al., 2020; Wibowo et al., 2021). This research further enhances the existing data on the use of GMP as a key component for fragrance in perfume formulas with a fresh melon scent, and it complements the previous product line of shampoos with GMP active substances that have been introduced.

This research has advantages over other perfume research (Abebe et al., 2021; Yingngam & Brantner, 2015) because it combines hedonic assessments to determine product acceptability. This study also included more panelists than our previous study (Gunawan & Rahayu, 2021), which only involved thirty panelists. The use of a line

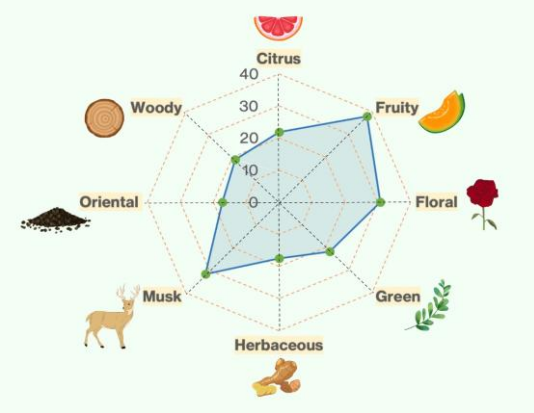

Figure 3. Perfume radar of GMP perfume as top notes

scale in hedonic testing in this study has more advantages compared to the general category scale. It may provide more precise quantitative measurement results because it can reduce the subjectivity factor of panelists in providing assessments on a "middle" or "fair" scale as expected in the use of 9 hedonic scales. The use of two anchors in the research is to prevent the line scale from shifting into a category scale, which triggers a tendency for the data to concentrate in the middle of the line, ultimately resulting in a reduction. The left end of the scale indicates "none" or a zero amount of stimulus, while the right end of the scale indicates a significant or extreme amount of stimulus (Lim, 2011; Sezille et al., 2014; Villanueva et al., 2005; Wichchukit & O'Mahony, 2022; Xia et al., 2020). The results of the hedonic measurement were 9.72 cm, indicating a good level of liking because it is directed towards the right of the anchor from the center point of the line. These results were also supported by the inclusion of 75 untrained panelists, which exceeded the minimum requirement of 30 panelists (Curtis, 2013).

Apart from the optimal perfume formula, this study also visualizes the character of perfume aromas through perfume radar. This visualization will determine the direction of the perfume. In addition, the claim of using natural fragrances becomes a narrative when the product is launched. This claim has significant implications for marketers of perfume products. As can be observed in the market, claims such as ''natural ingredients'' or ''natural origin'' are increasingly popular. This research confirms the effectiveness of such approach. Fragrances labeled as natural will evoke more favorable hedonic sensory experiences in consumers and higher purchase intentions (Apaolaza et al., 2014).

The optimal formula obtained has met the perfume organoleptic standards set by the National Standardization Agency of Indonesia (transparent, homogeneous, particle-free liquid and a distinctive fragrant odor), as well as requirements for relative density and viscosity (BSN, 1998). In the future, the optimal composition of GMP, rose, and vanilla can be used as a fragrance ingredient (oil phase) in the formulation of cosmetic products, for example, solid perfume, deodorant, soap, and lotion.

CONCLUSION

GMP extract can serve as a top note in fragrance formulation. The optimization of the perfume by a D-optimal mixture design yielded an exceptional smell with a composition of 0.95 mL GMP, 0.55 mL rose, and 0.50 mL vanilla for the fragrance components. The mixture produced a fragrance that met sensory criteria: a clear, consistent liquid free of contaminants, with a distinct aromatic smell, a specific gravity of 0.8102 g/cm^3, a viscosity of 0.7931 cps, and a hedonic rating of 9.72 cm. The perfume radar detected fruity, flowery, and musky elements.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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