Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.34622

The imitation and creation of a mango flavor

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Abstract

As one of the major fruits, mango has a very attractive flavor characteristic, and is well known for its exotic flavor. Mango flavor has widespread application in beverages, ice-creams, foods and other products. However, flavor and fragrance formulas are usually trade secrets in flavor and fragrance industries. How to imitate and create mango flavor with the aroma materials has rarely been reported. In this paper, note method was used to imitate and create a mango flavor. The notes to construct mango flavor were identified by tasting and smelling mango fruits. Mango flavor is made up of sweety note, fruity note, milky note, acidic note, green note, floral note, herbal note, and sulfury note. On the basis of these notes, aroma materials were chosen, and an initial mango flavor formula was designed. After numerous adjustments and modifications, the desired mango flavor was successfully created, and the typical mango flavor formula was obtained. The mango flavor obtained has a typical characteristic aroma of natural mango fruit. It smells fresh and harmonious.

Keyword: mango flavor; creation; imitation; formula; odor characteristics.

Practical Application: A typical mango flavor formula was obtained and the desired mango flavor was developed.

1 Introduction

Mango (*Mangifera indica* Linn) belongs to the family Anacardaceae and to the genus Mangifera. China is the fourth largest producer of mangos based on the data published by FAO (Andrade et al., 2000). Mangos were ranked fourth in total production among major fruit crops in the world (Burton-Freeman et al., 2017). Mango not only exhibits excellent flavor with great taste, aroma, color, but also has high nutritional value. Mangos are a rich source of antioxidant, minerals, and vitamins (Prasad et al., 2022). Known as the "apple of the tropics", mango is a commercially important tropical fruit. Because mango has delicious flavor, nutritional value, and unique taste, it is one of the most popular tropical fruits (Cuevas-Glory et al., 2020), and is one of the most consumed fruits in the world (Camatari et al., 2018). Mango can be consumed directly in its fresh form. Its derived products, such as jam, jelly, pulp, juice and nectar, are also popular. Mango jam is well known for its sweet and pleasant flavor and strong yellow color (Martins et al., 2021). Mango peel can be utilized as an ingredient for the preparation of functional foods such as fortified fruit bars because it is a potential source of polyphenols (Safdar et al., 2022). Furthermore, mango peel flour can also be used in the formulation of functional yogurt because of its dietary fiber content (Pérez-Chabela et al., 2022).

Mango is well known for its exotic flavor. The current popularity of mango is mainly due to its unique flavor, aroma and appearance. Especially, flavor is critical to consumer acceptability (Malundo et al., 2001). Therefore, volatile chemicals that contribute to the aroma of mangos have been extensively investigated (Andrade et al., 2000). The volatile compounds identified comprise mixtures of monoterpenes, sesquiterpenes, aldehydes, lactones, volatile fatty acids, alcohols, phenols, esters, ketones, and some carotenoids (Maldonado-Celis et al., 2019). Silva et al. (2022) found 53 volatile compounds, and found that the three major compounds present in all samples of mango pulp were beta-pinene, caryophyllene, and (R)-alpha-pinene. Pino & Mesa (2006) found that ethyl butanoate, ethyl-2-methylpropanoate, (E)-β-ionone, (E,Z)-2,6-nonadienal, methyl benzoate, (E)-2-nonenal, 2,5-dimethyl-4-methoxy-3(2H)-furanone and decanal were potentially most important to mango aroma. Quijano et al. (2007) investigated the volatile ingredients of nine Colombian mango varieties and identified 145 compounds. Among them, terpene hydrocarbons were the major volatiles. Andrade et al. (2000) studied aroma volatile constituents of Brazilian varieties of mango fruit. Three distinguishable aroma groups were identified as: terpinolene, carene, and myrcene. Although these volatile chemicals found previously can make contributions to imitate mango flavor, how to imitate and create mango flavor with the volatile compounds has rarely been reported. Flavor and fragrance formulas are usually trade secrets in flavor and fragrance industries. Furthermore, very few books have been written on the subject of creating flavors (Wright, 2011). To the author's knowledge, there is little information available in literatures about the imitation and creation of mango flavors. However, mango has a very attractive flavor characteristic. If a mango flavor is created, it can be widely used in beverages, ice-creams, foods and other products. Therefore, the imitation and creation of a mango flavor is of great significance.

In this paper, note method (Yu et al., 2022; Zhu & Yu, 2020) was used to imitate and create a mango flavor. The notes to construct mango flavor were identified. A desired mango flavor was successfully prepared and a typical mango flavor formula was obtained.

Received 12 Feb., 2022
Accepted 06 May, 2022
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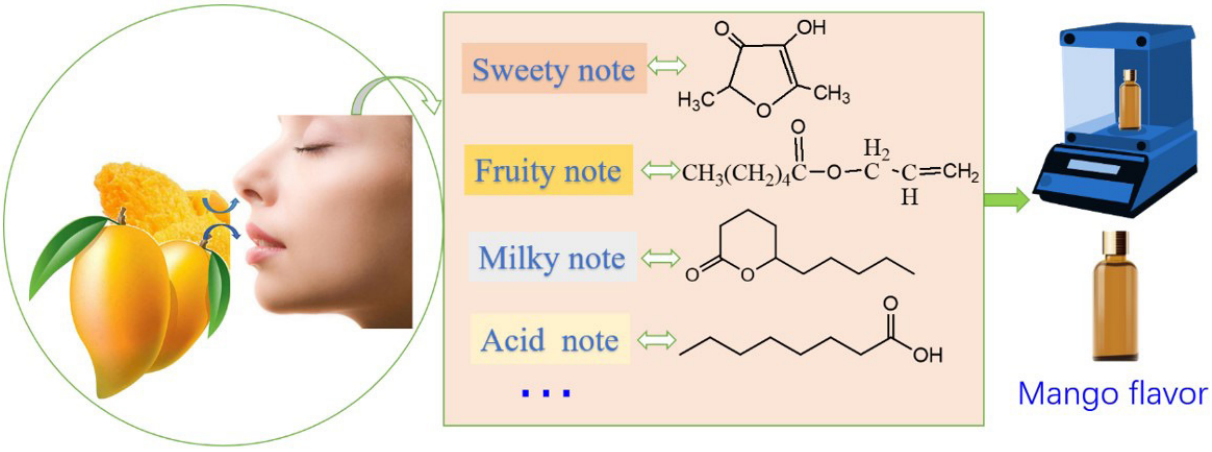

Figure 1. The schematic diagram of the process of the creation of a mango flavor.

2 Materials and methods

2.1 Materials

All the aroma materials to develop mango flavor were food-grade. The natural essential oils were purchased from Shanghai Titan Technology Co., LTD. The synthetic aroma materials can be subdivided by functional group as following: hydrocarbons, alcohols, aldehydes, ketones, acids, esters, oxides, lactones, and sulfur compounds. Ketones, lactones, alcohol and esters used in constructing mango flavor were provided by Pu-Jie Aroma Chemicals (Shanghai) Co., Ltd. The other aroma compounds of synthetic origin came from Guangzhou Levon Flavor and Fragrance Co. Ltd. The natural essential oils and the aroma compounds of synthetic origin were used as received.

2.2 Methods

The note method reported in references (Yu et al., 2022; Zhu & Yu, 2020) was used to create mango flavor in this work. A simple schematic diagram of the process of the creation of a mango flavor is shown in Figure 1. According to odor characteristics, mango flavor was subdivided into various notes which was obtained by smelling and tasting mango fruit. On the basis of the notes identified, corresponding aroma materials were chosen and the proportions of these ingredients were defined to brainstorm an initial mango flavor formula. Based on the initial mango flavor formula, a mango flavor sample was blended, and then was evaluated by olfactory discrimination. The adjustments and modifications of mango flavor formulas were not made, until the desired mango flavor was created and the typical formula was obtained.

3 Results and discussion

3.1 The obtained notes for compounding a mango flavor

A flavor can be divided into different notes. Therefore, these notes can be used to construct the flavor. By smelling and tasting mango fruit, the obtained notes for compounding mango flavor were shown in Figure 2.

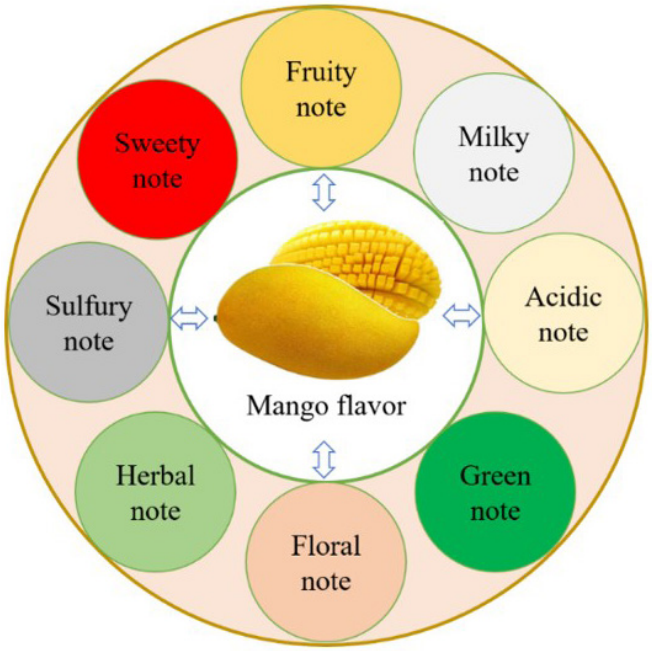

Figure 2. The obtained notes for compounding mango flavor by smelling and tasting mango fruit.

Mango flavor is a very complex flavor. The notes for mango flavor are sweety note, fruity note, milky note, acidic note, green note, floral note, herbal note, and sulfury note as shown in Figure 2. These identified notes can be used to construct the mango flavor, and the corresponding aroma materials can be chosen to design mango flavor formula. Among these notes, fruity note and sweety note are the main notes to create mango flavor. The sulfury note can impart the odor characteristic of tropical fruits, and enhance the authenticity of mango flavor (Hui, 2010; Zhang, 2013).

3.2 The chosen aroma materials for the creation of mango flavor

According to the notes for compounding mango flavor obtained by smelling and tasting mango fruit, aroma materials with the corresponding odor characteristics were chosen to create the mango flavor.

The sweet nectar of mango plays an important role in the authenticity of mango flavor (Wright, 2011). The aroma materials often used to display sweety note in flavors and fragrances are furaneol, ethyl maltol, and maltol. Maltol and ethyl maltol have sweety note suggestive of candy. Furaneol has a sweety note reminiscent of strawberry and candy. The three aroma compounds can impart sweety note in flavors such as pineapple and hami melon (Yu et al., 2022; Zhu & Yu, 2020). In the creation of mango flavor, the three aroma compounds can also be adopted to give sweety note. Maltol and ethyl maltol can give a nice effect when they are used in combination with furaneol. They can capture the essence of sweet nectar. Furthermore, β-Damascone and benzyl alcohol can also be chosen to impart sweety note in mango flavor. β-Damascone has a very powerful sweety note reminiscent of rose and plum. Except for giving sweety note, β-damascone can also impart naturalness. (Surburg & Panten, 2006). Benzyl alcohol has a slightly sweet odor and can also be used in mango flavor to impart sweety note. It can also be adopted as a solvent in flavors due to its relatively weak odor (Burdock, 2010).

The fruity note is complex in mango flavor. The fruity note in mango covers the range from coconut, peach, apple, pineapple, pear, banana, grape, and citrus fruit (Wright, 2011). The fruity note in mango flavor can be achieved using these complex fruity odors. Esters and lactones usually have fruity odor. The lactones and esters adopted to impart fruity note in mango flavor were as follows: γ-heptalactone, γ-octalactone, γ-nonalactone, γ-decalactone, γ-undecalactone, ethyl acetoacetate, ethyl 3-hydroxybutyrate, ethyl 2-methyl butyrate, diethyl malonate, ethyl acetate, ethyl butyrate, allyl hexanoate, allyl 3-cyclohexylpropionate, allyl heptanoate, hexyl acetate, isoamyl acetate, amyl acetate, and isoamyl hexanoate. The coconut note and peach note are made up of a combination of lactones. γ-Heptalactone, γ-octalactone, and γ-nonalactone have a fruity odor reminiscent of coconut. γ-Decalactone and γ-undecalactone can provide peach-like fruity note. Especially, γ-undecalactone, often called peach aldehyde, have a strong peach-like fruity odor. Ethyl 2-methyl butyrate has a fruity note suggestive of apple. Ethyl acetoacetate has an ethereal fruity odor suggestive of green apples. Allyl hexanoate, allyl 3-cyclohexylpropionate, and allyl heptanoate have strong fruity odor reminiscent of pineapple. Ethyl butyrate is a fruity smelling liquid with pineapple undertone. Isoamyl acetate and amyl acetate have intense banana-like fruity odor. Compared with isoamyl acetate, the odor of amyl acetate is slightly harsh. Isoamyl acetate is key to banana. Hexyl acetate has a pleasant pear-like fruity odor and taste. Ethyl 3-hydroxybutyrate has a fruity odor reminiscent of fresh grape. Diethyl malonate has a pleasant, faint, fruity odor. At 50 ppm, it has fruity taste characteristics with pineapple and apple nuances. Ethyl acetate has an ethereal fruity odor with a rum-like, brandy-like note. It can enhance the diffusive and fresh aroma, and is often used as the top note in flavors and fragrances (Zhu et al., 2021). Isoamyl hexanoate has a sweet, green, fruity odor reminiscent of apple and pineapple. Citral and some natural essential oils such as orange oil, lemon oil, and mandarin oil can be used in mango flavor to impart citrus fruity characteristics. Citral has a fruity odor suggestive of lemon. Citral has been widely used in blending citrus flavors due to its strong lemon odor. Orange oil has a characteristic, fruity, orange-peel-like odor, and is widely used in beverages and confectioneries. Lemon oil has a fresh, fruity odor, reminiscent of lemon peel. Lemon oil can be used to enhance the freshness of fruity odor. Mandarin oil has a characteristic fruity odor, suggestive of mandarin peel. It can be used to enrich the fruity note in fragrances and flavors (Burdock, 2010; Surburg & Panten, 2006).

δ-Lactones often make a significant contribution to the milky odor characteristics in flavors (Zhu & Xiao, 2017). Therefore, δ-undecalactone, δ-decalactone, and δ-nonalactone can be chosen to impart milky note in mango flavor. δ-Undecalactone is a colorless to pale yellow liquid with a milky, creamy odor. It also has somewhat fruity odor reminiscent of peach. At 10 ppm, δ-undecalactone has milky, creamy taste characteristics. δ-decalactone has a milky, oily, creamy-coconut, peach-like odor. δ-nonalactone has a milky-creamy, fatty taste and a mild, nut-like aroma. Except for these δ-lactones, acetoin also has strong buttery, creamy, and milky aroma characteristics. It also has butter-like, dairy and creamy taste characteristics. As a flavor ingredient, acetoin is often used in milk, butter, strawberry, and yogurt flavors (Burdock, 2010; Surburg & Panten, 2006).

Aliphatic acids are good at low levels in many fruit flavors. The organic acids often provide a sharp, sour taste and odor to a product. In flavor compositions, acids can be used to accentuate fruity notes (Surburg & Panten, 2006). The acids to impart acidic note in mango flavor can be selected as following: acetic acid, isobutyric acid, butyric acid, hexanoic acid, and octanoic acid. Acetic acid, with a strongly pungent, penetrating odor, is one of most important of the carboxylic acids in foods. It is useful in a wide range of fruity flavors. Isobutyric acid is a colorless liquid with a strong penetrating odor reminiscent of rancid butter. It has an acidic, sour dairy taste characteristics on dilution. Butyric acid is a colorless liquid with a penetrating, persistent odor similar to isobutyric acid. Butyric acid exhibits a burning, acid taste. Hexanoic acid is a colorless to pale yellow oily liquid with a sour, fatty, cheesy odor and an acrid taste. Octanoic acid is a colorless oily liquid with a fruity-acid odor. It has a slightly sour taste (Burdock, 2010). These acids can be used in flavors to enhance fruity notes.

The aroma materials to present green note in mango flavor were chosen as follows: cis-3-hexenol, cis-3-hexenyl acetate, cis-3-hexenyl butyrate, cis-3-hexenyl caproate and hexanol. cis-3-Hexenol has a freshly cut grass characteristic aroma and has green, fresh, raw fruity taste characteristics. The fresh green leafy characteristics of cis-3-hexenol has uses in fruity and vegetable-like flavors. cis-3-Hexenol is often adopted to impart green top note in flavors and fragrances. cis-3-Hexenyl acetate, with a green fruity odor, has been found in a lot of fruits. cis-3-Hexenyl acetate has a green, fruity taste with fresh tropical nuances on dilution. cis-3-Hexenyl butyrate smells green-fruity.

At 20 ppm, cis-3-hexenyl butyrate has green, leafy, fruity taste characteristics with a tropical nuance. It is often used in flavors to create freshness. cis-3-Hexenyl caproate is a colorless to pale yellow liquid with a strong fruity-green odor. On dilution, cis-3-hexenyl caproate also has green, fruity, waxy taste characteristics with a tropical nuance. Hexanol has a mild, green, fruity odor. At 20 ppm, hexanol has apple-skin, oily, green taste characteristics. These aroma materials can enhance the freshness of mango flavor (Burdock, 2010; Surburg & Panten, 2006; Zhu & Xiao, 2015).

The aroma materials to impart floral note in mango flavor were chosen as follows: linalool, linalyl acetate, and β-caryophyllene. As one of the mostly frequently used fragrance substances, linalool has a pleasant flowery-fresh aroma. It is often used in perfumery for a lot of flowery fragrance compositions such as lavender, neroli, and lily of the valley. Linalool can present naturalness to top notes due to its relatively high volatility. Linalyl acetate has a typical bergamot-lavender aroma. At 5 ppm, it has floral, green taste characteristics. Linalyl acetate has been widely used in blending fragrances such as lavender, bergamot, neroli, linden, and lilac. β-Caryophyllene is a colorless to slightly yellow oily liquid with a clove-like, floral, woody, spicy odor (Burdock, 2010; Surburg & Panten, 2006).

The aroma materials to present herbal note in mango flavor were chosen as follows: β-pinene, diphenyl oxide, myrcene, and ocimene. β-Pinene is a colorless mobile liquid with a pine-like, turpentine-like odor. Diphenyl oxide has a harsh, geranium, floral-green odor, and has odor characteristic of mango. Myrcene has a vegetative, woody, citrus fruity taste with a tropical mango nuance on dilution. Ocimene is a colorless to straw-colored mobile liquid with a warm herbaceous odor, and also has odor characteristic of mango. At 40 ppm, ocimene has tropical, green, woody taste characteristics. β-Pinene, diphenyl oxide, ocimene, and myrcene have odors characteristic of mango (Burdock, 2010; Surburg & Panten, 2006).

The aroma materials to give sulfury note in mango flavor were chosen as follows: para-mentha-8-thiolone, ethyl-2-methylthioacetate, methyl thiobutyrate, methy (2-methyl-3-furfuryl) disulfide, and dimethyl sulfide. With a black currant odor, para-mentha-8-thiolone has a buchu-like, fruity taste characteristics with a green tropical nuance. Ethyl-2-methylthioacetate has a pungent, fruity odor with sulfury note. Methyl thiobutyrate can impart sulfury, ripe aroma and the feeling of juiciness. Methy (2-methyl-3-furfuryl) disulfide can give sulfury, meaty odor. Dimethyl sulfide has a cabbage-like, wild radish odor. It has sulfureous, vegetative taste and aroma characteristics on dilution (Burdock, 2010; Surburg & Panten, 2006).

3.3 The obtained typical mango flavor formula

On the basis of the notes and the chosen aroma materials, the initial formula of mango flavor was designed. A mango flavor was prepared in the light of the initial formula. After sensory evaluation of the product, the initial formula was modified and adjusted numerous times. The desired mango flavor was obtained and its formula was shown in Table 1.

The sweety note is essential for the authenticity of mango flavor. In the mango flavor formula, benzyl alcohol, β-damascone, furaneol, maltol and ethyl maltol were used to provide sweet note as shown in Table 1.

Fruity note is the main note to construct mango flavor. Saturated esters often have a range of fruity odors, and are frequently crucial components of fruit flavors. In the mango flavor formula, ethyl acetoacetate, ethyl 3-hydroxybutyrate,

Table 1. The obtained typical mango flavor formula.

No.	Flavor ingredient	wt %
1	Maltol	0.21
2	Ethyl maltol	0.91
3	10% Furaneol	0.8
4	10% β-Damascone	0.01
5	Benzyl alcohol	0.5
6	γ-Heptalactone	0.02
7	γ-Octalactone	0.04
8	γ-Decalactone	0.26
9	10% Ethyl acetoacetate	0.05
10	10% Ethyl 3-hydroxybutyrate	0.05
11	Ethyl 2-methyl butyrate	0.02
12	10% Diethyl malonate	0.06
13	Ethyl acetate	0.13
14	Ethyl butyrate	0.18
15	Allyl hexanoate	0.35
16	Allyl 3-cyclohexylpropionate	0.15
17	Allyl heptanoate	0.02
18	10% Hexyl acetate	0.02
19	Isoamyl acetate	0.02
20	Amyl acetate	0.01
21	10% Isoamyl hexanoate	0.05
22	Orange oil	0.21
23	γ-Nonalactone	0.05
24	γ-Undecalactone	0.04
25	10% δ-Decalactone	0.06
26	10% Acetoin	0.24
27	10% Acetic acid	0.01
28	Isobutyric acid	0.02
29	Butyric acid	0.02
30	Hexanoic acid	0.18
31	Octanoic acid	0.45
32	cis-3-Hexenol	0.16
33	cis-3-Hexenyl acetate	0.03
34	10% Hexanol	0.01
35	10% Linalool	0.03
36	10% Linalyl acetate	0.01
37	10% β-Caryophyllene	0.4
38	beta-Pinene	0.01
39	Diphenyl oxide	0.01
40	Ocimene	0.01
41	1% Para-Mentha-8-thiolone	0.06
42	10% Dimethyl sulfide	0.63
43	Mango base	2
44	Ethyl alcohol	10
45	Propylene glycol	71.5
46	Total	100

ethyl 2-methyl butyrate, diethyl malonate, ethyl acetate, ethyl butyrate, allyl hexanoate, allyl 3-cyclohexylpropionate, allyl heptanoate, hexyl acetate, isoamyl acetate, amyl acetate, and isoamyl hexanoate were used to impart fruity note of mango flavor. Ethyl butyrate is one of the main ester components in mango (Suyanto et al., 2022). The rum-like, brandy-like note of ethyl acetate can convey a ripe fruity aroma. Except for these saturated esters, γ-lactones also make a significant contribution to the fruity note of mango favor. In the formula, γ-heptalactone, γ-octalactone, γ-nonalactone, γ-decalactone, γ-undecalactone were adopted to present fruity note. Orange oil, a natural essential oil, was also used in the formula to impart fruity note. Furthermore, orange oil can enhance the naturalness of mango flavor (Burdock, 2010; Surburg & Panten, 2006).

In the mango flavor formula, δ-decalactone and acetoin were adopted to impart milky note (Zhu & Xiao, 2017). Furthermore, δ-decalactone and acetoin can bring harmony to fruity note in the mango flavor formula.

Acetic acid, isobutyric acid, butyric acid, hexanoic acid, and octanoic acid were used in the mango flavor formula to provide acidic note. These acids can accentuate fruity note in mango flavor (Surburg & Panten, 2006).

In the mango flavor formula, hexanol, cis-3-hexenyl acetate and cis-3-hexenol were adopted to impart green note. These aroma materials with green note can improve the freshness of mango flavor. Green note, in combination with acidic note, can also be used to imitate the odor characteristics of the degree of ripeness of mango fruit.

Linalool, linalyl acetate, and β-caryophyllene were used to display floral note in mango flavor. Most of mango fruits exhibit a certain of floral aroma when they are mature. Therefore, the addition of a proper amount of aroma materials with floral note can increase the authenticity of mango flavor.

In the mango flavor formula, β-pinene, diphenyl oxide, and ocimene were used to impart herbal note. Ocimene and diphenyl oxide have special odor characteristic of mango fruit. Wright (2011) reported that mango character recognition was derived from the combination of ocimene (herbal, mango), ethyl butyrate (fruity), and γ-decalactone (peach, milky).

In the mango flavor formula, para-mentha-8-thiolone and dimethyl sulfide were used to display sulfury note. These aroma materials can provide the odor characteristics of tropical fleshy fruit, and can enhance the feeling of juiciness and the authenticity of mango flavor (Zhang, 2013).

On the basis of Table 1, a desired mango flavor was prepared. The mango flavor obtained has a typical characteristic aroma of natural mango fruit. It smells fresh and harmonious, and can be widely used in beverages, ice-creams, foods, and other products.

4 Conclusion

This work concentrated on the creation and imitation of a mango flavor with the note method. By tasting and smelling mango fruit, the notes to construct mango flavor were identified. Mango flavor is made up of sweety note, fruity note, milky note, acidic note, green note, floral note, herbal note, and sulfury note. On the basis of these notes and the chosen aroma materials, a typical mango flavor formula was obtained. A desired mango flavor was successfully prepared. The mango flavor obtained has a typical characteristic aroma of natural mango fruit. It smells fresh and harmonious, and can be widely used in beverages, ice-creams, foods, and other products.

Acknowledgements

The authors thank Shanghai Alliance Program (LM201844) for providing the financial support.

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