THESIS APPROVAL

GRADUATE SCHOOL, KASETSART UNIVERSITY

Doctor of Philosophy (Agro-Industrial Product Development)

DEGREE

Agro-Industrial Product Development — **FIELD**

Product Development — **DEPARTMENT**

TITLE: Studies on Development of Mafai Jeen [*Clausena lansium* (Lour.) Skeels] Products

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THESIS

STUDIES ON DEVELOPMENT OF MAFAI JEEN [*Clausena lansium* (Lour.) Skeels] PRODUCTS

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A Thesis Submitted in Partial Fulfillment of

the Requirements for the Degree of

Doctor of Philosophy (Agro-Industrial Product Development)

Graduate School, Kasetsart University

2006

ISBN 974-16-2691-6

Pratheung Chokeprasert, Acting Capt. 2006: Studies on Development of Mafai Jeen [*Clausena lansium* (Lour.) Skeels] Products. Doctor of Philosophy (Agro-Industrial Product Development), Major Field: Agro-Industrial Product Development, Department of Product Development. Thesis Advisor: Associate Professor Chintana Oupadisskoon, Ph.D. 134 pages.
ISBN 974-16-2691-6

Mafai Jeen is a minor member of the Rutaceae and common name called wampee, grown mostly in Nan Province. Dried Mafai Jeen is a well known preserved product. The objectives of this research are to study aroma compound and the effect of drying method on the qualities of Mafai Jeen, study the intensity of astringent taste and also to develop new Mafai Jeen products.

Analysis of the aroma compounds from Mafai Jeen fruit using gas chromatography-mass spectrometry (GC-MS) obtained the four most abundant aroma compounds, sabinene, α-pinene, α-phellandrene, and myrcene. The drying time of Mafai Jeen to reach 14 % (wb) moisture content was 17, 32, 42, and 50 h by hot air drying at 60 °C, sun drying, hot air drying at 45 °C, and vacuum drying at 45 °C, respectively. The total changes in product color, ΔE, were observed to be 21.49, 13.72, 12.75, and 6.61 by hot air drying at 60 °C, hot air drying at 45 °C, sun drying, and vacuum drying at 45 °C, respectively.

The intensity of astringent taste was experimented in Mafai Jeen fruits using time-intensity method. Twelve samples of dried Mafai Jeen, varying in the rate of sucrose from 0, 10, 20 to 30 g/100 g of fruits and varying in the rate of ascorbic acid from 0, 1 to 2 g/100g of fruits were prepared. Solution of tannic acid 1 g/l both in water at 7 and 25 °C were tasted same astringent. The interaction between astringency and sweetness was investigated. Maximum intensity, time to maximum and total duration for astringency decreased significantly with increasing sucrose concentration. Raising ascorbic acid increased astringent intensity and duration significantly.

The develop Mafai Jeen fruit product for target consumer, which are aware of their health. A focus group discussion indicated healthy natural Mafai Jeen candy product was required. The product should contain natural color or no artificial flavors, the least sucrose content smooth mouth feel, and moderately sour taste. Three thickening agents; maltodextrin, pectin, and CMC were studies. Descriptive sensory evaluations of the three Mafai Jeen fruit candy revealed that they were different among one another. Glossy, chewiness, cohesiveness, and toothpack were discriminating attributes. Consumer test and purchase intent were done with 135 consumers using 9-point hedonic scale. Different thickening agents added to the Mafai Jeen fruit candy caused a significant difference in the consumer responses. 1.5% pectin and 1.0% CMC added in Mafai Jeen fruit candy were well accepted which overall liking scores 6.3 and 5.9 (like slightly), and 2.0% maltodextrin was least accepted which score 4.6 (Neither like nor dislike). Consumer purchase intent of Mafai Jeen fruit candy was positively influenced after the consumers known that promoted health benefits. Processing steps to produce Mafai Jeen candy involved blending Mafai Jeen for 6 min, heating 58.5% of Mafai Jeen puree over gas stove at 95 °C for 20 min, 35% (w/w) of sucrose were added and continue heating for 20 min, added 5% of glucose syrup and 1.5% of pectin, continue heating until the total soluble solid reached 75 °Bx.

Pratheung Chokeprasert ______ Chintana Oupadisskoon Oct / 25 / 2006

Student's signature ______ Thesis Advisor's signature

ACKNOWLEDGEMENTS

This dissertation would have not been finished without support. At this special moment, I would like to express my sincere appreciation to Assoc. Prof. Dr. Chintana Oupadisskoon for her advice, encouragement, and especially for giving me the opportunity to think independently. Thanks also to my committee members, Assoc. Prof. Sombat Khotavivattana, and Prof. Dr. Tzou-Chi (George) Huang, NPUST for providing their time, valuable advice, support, and their guidance throughout the study and in the preparation of this dissertation. I would like to thank Assoc. Prof. Dr. Thongchai Srinophakun, Department of Chemical Engineering for serving as the Graduate School representative. Thanks to everyone who helped make this project successful.

I would like also to extent my acknowledgements to: the Ministry of University affairs of Thailand and Graduate School, Kasetsart University for supporting dissertation granted. Maejo University-Phare Campus, Thailand for supporting my Ph.D. study leave programmed; the Dept. of Product Development, Kasetsart University, Bangkok, Rajamangala University of Technology Lanna – Nan Campus and Dept. of Food Science, National Pingtung University of Science and Technology (NPUST), Taiwan R.O.C. for providing research facilities; Kai Hsin Sue and Kan Ie Fun, for their assistance in carrying out the GC-MS analysis and Albert Linton Charles for friendship throughout my research conducted in NPUST, Taiwan; Nopparat Chanchai for facilitating recruitment panelists in descriptive tests and time-intensity test, Wattana Yod-Ard for providing raw material; and all respondents who participated in the consumer surveys and also all panelists who participated in sensory tests.

I also thank Mr. Adrian Hillman for his assistance in reading through the manuscript and making appropriate amendments.

Pratheung Chokeprasert

October 2006

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STUDIES ON DEVELOPMENT OF MAFAI JEEN [*Clausena lansium* (Lour.) Skeels] PRODUCTS

INTRODUCTION

Mafai Jeen (*Clausena lansium*)Lour(. Skeels) is originally cultivated in the southern China and in the northern to central Viet Nam. It was introduced into Thailand by Chinese since 1897 (Anonymous, 2001), where it was predominantly grown in Nan province, the northern Thailand. Mafai Jeen fruit was known of having medicinal functions for stomach upset, indigestion and coughing (Stuart, 1977). In the Philippines, folkloric group used Mafai Jeen for influenza, colds and abdominal colic pains. All parts of Mafai Jeen were proved to be useful, the fruits were used as herb medicine for stomach upset and indigestion, the leaves were used as medicine for the treatment of coughing, asthma and gastro-intestinal diseases, the seeds were used for gastro-intestinal diseases such as acute and chronic gastro-intestinal inflammation, ulcers, etc. (Lin, 1989; Kan, 1972). The roots were used to treat bronchitis (Kan, 1972) and were used as an anti-malarial (Kong *el al.,* 1983).

In 2006, the cultivated area of Mafai Jeen in Nan province is 1,000 rais or 400 acres. Mafai Jeen fruits season is from begin of May to the end of July. The fresh Mafai Jeen must be preserved into other product, the pulp can be add to fruit cups, gelatins or other desserts, or made into pie, jam or jelly. Carbonated beverage resembling champagnes is made by fermenting the fruit with sugar (Morton, 1987), the most popular product is in dried form. Mafai Jeen dry preserve fruit, candy, wine, and juice products contain unique flavor and benefits to local medicinal treatment. The governor of Nan province proposed to promote dried Mafai Jeen product to be in the program of one tumbon one product (OTOP). At present in 2006, the fresh fruits are sold at a price of approximately 70 USD/ton.

Objectives

The scope of this dissertation are:

1. To identify the aroma compounds of Mafai Jeen.
    a. Aroma compounds of fruits, seeds, and leaves by headspace sampling.
    b. Aroma compounds of Mafai Jeen fruits by HS-SPME analysis.
2. To study effect of drying methods on Mafai Jeen.
    a. Effect of drying conditions on qualities of dried Mafai Jeen.
    b. Aroma components of Mafai Jeen fruit treated by different drying condition.
3. To study the intensity of astringent taste of Mafai Jeen.
4. To develop Mafai Jeen candy with shelf life study.

The major contribution of this dissertation is the development of Mafai Jeen candy product and study on shelf life. Additional contributions include, the identification of aroma compounds of Mafai Jeen for further use and study the effect of drying methods on Mafai Jeen. Finally, study the intensity of astringent taste of Mafai Jeen. These contributions can be seen from the contents and will be summarized in the final conclusions.

LITERATURE REVIEW

1. Mafai Jeen

Mafai Jeen (*Clausena lansium* (Lour.) Skeels) is a minor member of the Rutaceae and a distant relative of citrus fruits, it travelled sufficiently to acquire many vernacular names, mostly derived from the Chinese *huang-p'i-kuo, huang p'i ho, huang p'i kan,* or *huang-p'i-tzu.* In Malaya, it is known as *wampi, wampoi,* or *wang-pei;* in the Philippines, *uampi, uampit, huampit* or *galumpi;* in Vietnam, *hong bi,* or *hoang bi.* In Thailand, it is called *Mafai Jeen (มะไฟจีน)* , and the common English name is wampee (see appendix Figure A1). In this dissertation, the name Mafai Jeen will be used. It is a highly valued backyard tree in southern China and Southeast Asia. It is an attractive tree with grapelike fruits, but the pulp is scant and the seeds is large (Morton, 1987).

Mafai jeen fruits has outside appearance alike regular Mafai fruits (*Baccaurea ramiflora* Lour.) harvesting in May to July for it season. Mafai Jeen is a native and commonly cultivated in southern China and the northern part to Central Vietnam. It is introduced to Thailand with Chinese immigration in 1897. Mafai Jeen is grown only in Nan province, especially Meung Nan district and nearby Nan river. Mafai Jeen is a second economic fruits of Nan province after Sri-Thong orange (*Citrus reticulata*). Mafai Jeen was growing in the Philippines before 1837 and was reintroduced in 1912. In India and Ceylon, Mafai Jeen was grow in a small area. Chinese people in southern Malaya, Singapore and elsewhere in the Malaysian Archipelago grow the tree at their backyard. It is cultivated to a limited extent in Queensland, Australia and Hawaii. In 1908, the record showed the growing in a few Hawaiian gardens for many years but was not in general cultivation. It was brought to Florida as an unidentified species in 1908. The United States Department of Agriculture received seed from Hong Kong in 1914; from Canton in 1917 and from Hawaii in 1922. Mafai Jeen tree was grown by Dr. David Fairchild at 'Kampong' in Coconut Grove, Miami, and a small cottage near it was named the 'Wamperi' (Morton, 1987).

The Mafai Jeen trees are medium shrub, evergreen habit and can grow up to 10 meters in height. The tree can be grown either fast or slow, depending on its physiology and environments, flexible branches, and gray-brown bark rough to the touch. The leaves are dark green ruffled pinnate compound consisting of 4-7 leaflets, elliptic or elliptic-ovate leaflets 2 3/4 to 4 inch (7-10 cm) long, oblique at the base, waxy-margined and shallowly toothed; thin, minutely hairy on the veins above and with yellow, warty midrib prominent on the underside. The petiole also is warty and hairy. The inflorescence is a many branched panicle. It bears hundreds of small whitish or yellowish flowers which give off a mild, pleasant odor when the tree is in full bloom. The number of fruit maturing on a panicle may vary from 1 to 30, or more, hairy panicles 4 to 20 inch (10-50 cm) long. The fruits, on 1/4 to 1/2 inch (0.6-1.25 cm) stalks, hang in showy, loose clusters of several strands. The Mafai Jeen fruits may be round, or conical-oblong, up to 1 inch (2.5 cm) long, with 5 faint, pale ridges extending a short distance down from the apex. The thin, pliable but tough rind is light brownish-yellow. It is easily peeled and too resinous to be eaten. The flesh, faintly divided into 5 segments, minutely hairy and dotted with tiny, brown oil glands. They are very juicy with a translucent pulp similar to a grape. The fruits are highly aromatic, the taste has a good deal of the grapelike fruits, accompanied with a peculiar flavor, being very grateful to the palate, mucilaginous, juicy, pleasantly sweet, subacid, or sour depending on the variety and ripeness. There may be 1 to 5 oblong, thick seeds 1/2 to 5/8 inch (1.25-1.6 cm) long, bright-green with one brown tip. The fruit is borne in clusters, resembling, when ripe a diminutive lemon. It contains 1 to 3 seeds which nearly fill the interior. We eat with a peel as same as kamquat. Florida-grown fruits have shown 28.8 to 29.2 mg/100 g ascorbic acid (Morton,1987).

Mafai Jeen grown in Thailand was divided into 2 different varieties. 1) Sweet-sour flavor; round shape or chicken-heart and brown skin. 2) Sweet flavor; conical-oblong shape or long-chicken-heart and yellow-skinned.

Mafai Jeen cultivation is done in the similar procedure as for the other citrus trees. A sunny, well drained site with plenty of water and organic matter should be managed for these trees. The crop is borne solely on the tips of branches, so the less pruning the better production. Very few problems have been observed with pest and diseases other than occasional infestations of aphids. The fruits ripen in May to July in Nan province. Mature trees may yield 100 kg of fruits in a season. A grafted Mafai Jeen will produce fruit in around 3-4 years. A fully ripe, peeled Mafai Jeen, of the sweet or subacid types, is agreeable to eat out-of-hand, discarding the large seed . The fruit pulp can be added to fruit cups, gelatins or other desserts, or made into pie or jam. Jelly can be made only from the acid types when under-ripe. The Chinese serve the seeded fruits with meat dishes. In Southeast Asia, carbonated beverage resembling champagne is made by fermenting the fruit with sugar and straining off the juice, but the most popular product is dried Mafai Jeen. The process method are secret they known only the Chinese group.

Dried Mafai Jeen were originated in China. Mafai Jeen fruits were dried with pericarp and heating was introduced in this process become the product with dark in color. The dried Mafai Jeen fruits can be kept for a long time. The process of drying Mafai Jeen fruits can be done by following method show in Figure 1.

2. Medicinal Uses

The fruit was used as a medicine for stomach upsets, indigestion, and coughs. Folkloric uses in the Philippines were for influenza, colds and abdominal colic pains (Stuart, 1977). The leaves have been used as a folk medicine for the treatment of coughs, asthma and gastro-intestinal diseases, while the fruits are used for digestive disorders, and the seeds for gastro-intestinal diseases such as acute and chronic gastro-intestinal inflammation, ulcers, etc (Lin, 1989; Kan, 1972). Its roots are used in folk medicine to treat bronchitis (Kan, 1972) and as an anti-malarial (Kong *et al.,* 1983). The leaves, roots and fruits have been used as a folk medicine in Taiwan (Li *et al.,* 1991) and China (Yang *et al.,* 1988) for treatment of certain dermatological diseases such as, for instance, acute and chronic viral hepatitis.

Dried Mafai Jeen process

Fresh fruit

⇩

Wash

⇩

Soak in 3 – 4% brine for 6 h

⇩

Hand split to remove seeds

⇩

Mix with sugar, 35% by wt. for 2 h

⇩

Sun dry, 4 –5 days

⇩

Dried Mafai Jeen

Figure 1 Dried Mafai Jeen process
Source: Anonymous (2001)

Eating Mafai Jeen will will counteract the bad effects of eaten too many lychees. Lychees should be eaten when one is hungry, and Mafai Jeen only on a full stomach.

The halved, sun-dried, immature fruit is a Vietnamese and Chinese remedy for bronchitis. Thin slices of the dried roots are sold in Oriental pharmacies for the same purpose. Indicdactone compound was found in the Mafai Jeen leaf. The leaf decoction is used as a hair wash to remove dandruff and preserve the color of the hair. (Perry, 1980)

Three novel cyclic amides was isolated from the leaves of *C. lansium*, the boiled water extract of its leaves is used in folk medicine for the treatment of certain dermatological diseases and of acute and chronic viral hepatitis. Heptaphylline and dehydroindicolactone and lansamide-I have been isolated from the roots and leaves of the plant (Yang *et al.,*1988).

Cinnamamide derivatives was extracted from the seed (Lin, 1989).

The characterization of dehydroindicolactone (Kong *et al.,* 1983) and coumarins (Kumar *et al.,* 1995) from the root bark; Carbazole alkaloids was isolated from the root (Li *et al.,* 1991).

The homodimeric trypsin inhibiter with a molecular mass of 54 kDa was isolated from the seed (Ng *et al.,* 2003). It was found to possess antifungal and HIV reverse transcriptase-inhibitory activity.

3. Drying

Food drying is one of the oldest methods of preserving food for later use. It is a complex operation involving heat and mass transfer which may cause changes in product qualities. Physical changes that may occur included shrinkage, puffing and crystallization. In some cases, desirable or undesirable chemical or biochemical reactions may occur leading to changes in color, texture, odor or other properties of the food product (Maskan *et al.,* 2002). Drying occurs by vaporization of the liquid by supplying heat to the wet material. Heat may be supplied by conduction (contact or indirect dryers), by convection(direct dryers), by radiation or volumetrically by placing the wet material in a microwave or radio frequency electromagnetic field. Over 85% of industrial dryers are of convection type with hot air or direct combustion gases as the drying medium (Devahastin, 2000). Drying of agricultural products has always been of great importance to the preservation of food by human being. Sun drying is still the most common method used to preserve agricultural products in most tropical and subtropical countries(Yaldiz *et al*., 2001).

4. Aroma Compounds

Aroma or volatile compounds are the most sensitive components in the process of food drying. The effect of drying on the composition of volatile constituents of various aromatic plants and vegetables has been the subject of numerous studies, which show that the changes in concentrations of the volatile compounds during drying depend on several factors, such as the drying method and parameters that are characteristic of the product subjected to drying (Venskutonis, 1997).

Volatile compounds must be isolated and concentrated to suitable concentration prior to analysis by Gas Chromatography. Essential oils and aqueous sample can be easily directly injected after diluting or concentrating. For complex food samples, extraction technique is the most appropriate. Extraction techniques for aroma in food are base on two different properties of their volatile constituents. They are volatility and affinity toward non-polar solvents or polymer. Distillation and headspace trapping use volatility to selectively remove volatile components from food matrix. Solvent extractions and adsorptions polymers use their hydrophobicity for the same purpose (Etievant, 1996). The extraction method must be represented the original flavor present in the matrix and avoided the formation of any artifact during sample preparation (Chaintreau, 1999). Chaintreau (2001) classified the extraction methods into three main categories (Table 1). Various extraction methods have been widely used for the analysis of volatile components of fruits.

4.1 Distillation

Several techniques of distillations have been used to extract aroma components from foods. Steam distillation is among the oldest techniques used to separate volatile from non-volatile material. Aroma extracts can be obtained very fast and simply by steam distillation.

4.2 Headspace Extraction

Steam distillation, solvent extraction or solid phase extraction (SPE) techniques allow quantitative data to be obtained, but are often labor-intensive

Table 1 Main extraction methods of aroma compounds.

Solubility	Volatility	Miscellaneous
-Soxhlet	-Steam distillation	-Simultaneous distillation-extraction (SDE)
-Liquid-liquid extraction	-Vacuum transfer	-Distillation-membrane extraction
-Supercritical fluid extraction (SFE)	-Headspace (HS)	-Simultaneous distillation-adsorption
-Solid phase extraction (SPE)		
-Solid phase micro-extraction (SPME)		

Source: Chaintreau (2001)

(Dumont and Adda, 1979; Nijssen, 1991; Saxby, 1982). Besides, chromatographic signals of trace substances may be obscured by high concentrations of low-volatile compounds (Bonino *et al*., 2003). Headspace analysis may overcome these disadvantages, allowing analysis of the volatile fraction only.

Headspace extraction is the method for monitoring the gaseous headspace above a liquid or solid in a sealed container and suitable for aroma analysis. It is a non-destructive technique of mild conditions and easy sample preparation. This technique is divided into three broad categories: static headspace, dynamic headspace, and purge & trap. The fundamental principle of each technique is the same. Volatile analyzes from a solid or liquid material are sampled from the atmosphere adjacent to the sample. In static headspace techniques, a small sample of the atmosphere is sampled and injected directly onto a GC column. In dynamic headspace techniques, the organic analyzes from the headspace are first concentrated and then transferred to GC. The term dynamic headspace is usually used when refer to the analysis of solid materials and the term purge & trap generally refers to the analysis of liquid samples by bubbling the purge gas through system (Wampler, 1997). The gas flow entrains the analyzes on to adsorbent trap, where they remain until the trap is heated to desorb the analyzes into the carrier gas stream (Hinshaw, 2000). Dynamic headspace extraction involves the adsorption of organic molecules swept by an inert gas on an organic polymer. There are many types of available polymers such as Tenax, Porapak, Chromosorb, and charcoal. The trapping step may involve adsorption onto a high surface sorbent material or cold trapping by condensing or freezing (Wampler, 1997)

Among headspace sampling techniques, headspace solid phase microextraction (HS–SPME) has specific advantages over conventional static, dynamic and purge and trap techniques: it is economic, faster and requires little manipulation of the sample (Elmore *et al*., 1997; Jelen *et al.,* 1998; Stevenson and Chen, 1996; Xiaogen and Pepard, 1994).

Solid-phase micro-extraction (SPME) is an innovative, completely solvent free sample preparation method. It can be used to concentrate flavors and fragrances that significantly reduced the time and cost required for sample preparation. This technique can be used to concentrate volatile organic compounds from liquid samples by immersion SPME or headspace above a liquid or solid sample by HP-SPME. The analysis from sample are concentrated on fused silica fiber coated with a polymer film. The equilibrium distribution of analyzes is established between the stationary phase (the microfibers) and the aqueous or gas phase (sample). Once equilibrium has been established, the concentrated compounds are thermally desorbed in the injector of a gas chromatograph and transfer to the capillary column. The different polar phase films for SPME fibers are available for extracting organic compounds from various sample matrices e.g. PDMS (polydimethylsilosane), PA (polyacrylate), PDMS/DVB (polydimethylsilosane/divinylbenzene), CW/DVB (carbowax/ divinylbenzene), Carboxen-PDMS (carboxen-polydimethylsilosane), and DVB-carboxen (divinyl-benzene/carboxen) (Werkhoff *et al*., 2002). The accuracy of SPME for quantitative analysis is highly dependent on experimental conditions, sample matrix, analyze characteristics, the type of fibers and calibration techniques (Hinshaw, 2000 and Marsili, 2002).

SPME has been used for the analysis of a wide range of food products, such as; coffee (Bicchi *et al*., 1997; Ryan *et al*., 2004), cheese (Chin *et al*., 1996), beef (Soo–Yeun and Eunice, 2004), pork (Elmore *et al*., 2001; Fernando *et al.,* 2003), sausages (Marco *et al*., 2004), hops (Field *et al*., 1996), cinnamon (Miller *et al*., 1996), wine and other alcoholic beverages (Evans *et al*., 1997; Fischer and Fischer, 1997; Gandini and Riguzzi, 1997; Ong and Acree, 1999; Sala *et al*., 2002; Demyttenaere *et al*., 2003), apple (Matich *et al*., 1996; Jun-Song *et al*., 1997; Barbara *et al*., 2004), and strawberry (Ulrich *et al*., 1997).

Since its introduction by Arthur and Pawliszyn (1990), the technique of solid phase microextraction (SPME) has been widely used for the extraction and pre-concentration of an extensive range of analyzes in a variety of samples. Flavors and fragrances are samples for which SPME has been extensively used.

The application of SPME coupled to GC–MS to detect and quantify aroma-related heterocyclic compounds generated by the Maillard reaction was addressed by ColemanIII (1997) with detection limits as low as $\mu m\ 1^{-1}$. HS–SPME was also applied to determine sulfur-containing compounds in onion (Jarvenpaa *et al*., 1998) and wine aromas(Mestres *et al.,* 1998). Several fruit juices and pulp aromas also have been studied with SPME coupled to GC: orange (Steffen and Pawliszyn, 1996), tomato and strawberry (Song *et al*., 1998), avocado (Lopez *et al*., 2004) and mango (Malundo *et al*., 1997), among others.

Previous studies on *C. lansium* included the characterization of many compounds from the roots, seeds, and leaves. However, despite the many studies that have elucidated the non-volatile composition, there is little research on the volatile compounds responsible for the intense aroma of Mafai Jeen, although Zhao *et al.* (2004) analyzed the essential oil of the leaf, flower, sarcocarp and seed of

C. lansium. The dominant constituents identified were β-santalol, α-santalol, methyl santalol, bisabolol and ledol.

5. Gas Chromatography-Mass Spectrometry (GC-MS) Analysis

Gas chromatography is the separation technique of a mixture of volatile components, following vaporization in an injection port and transfer into a narrow bore capillary column (typically, 0.25-0.32 mm i.d.). Separation is occurred by differential portion of analyzes between an inert carrier gas, such as helium, which is continuously flowing through the column and polymeric stationary phase (of selected polarity). The inside of the column is coated or chemically bound. The column is housed in a temperature programmed. Then, the analyzes are detected sequentially as they elute from the column by detector (Peppard, 1999). Only those materials that can be vaporized without decomposition are suitable for GC (Kitson *et al*., 1996)

GC-MS is the combination of two powerful analytical techniques. The gas chromatograph separates the components of mixture in time and the mass spectrometer provides information that aids in the structural identification of each component (Kitson *et al*., 1996). Flavor extracts are separated into their individual components by GC and a characteristic mass spectrometer. Individual components of mixtures are identified by comparing their mass spectra (and GC retention time or indices) to those of authentic compounds. Different molecules can be broken up into fragments in a consistent and repeatable manner when subjected to high-energy electron bombardment (typically 70 eV). It occurs within the ion source of a mass spectrometer operated in electron impact mode. The results of electrically charged fragment may then be separated according to their mass/charge (m/z) ratio; subsequent detection of this ions yields a mass spectrum characteristic of the original molecule. It is depended on the type of compound involved. In addition, mass spectra may be searched against huge libraries of spectra, including commercial and much more important in the case of many flavor analysis laboratory and proprietary libraries (Peppard, 1999).

6. Astringency

Astringency, chemically defined as the ability to precipitate proteins (Bate-Smith, 1954), is often described as dryness, puckering and rough-mouthfeel. The sensation of astringency is often associated with polyphenolic substances (Joslyn and Goldstein, 1964), which also elicit bitterness (Robichaud and Noble, 1990). Although sourness is the major sensation of organic acids, dryness or astringency of acids has also been reported (Rubico and McDaniel, 1992). Generally astringency is considered to be a tactile rather than gustatory stimulus, as recently illustrated by Breslin *et al.* (1993). However, interaction with gustatory stimuli has been shown to affect perception of astringency. Raising acidity (and perceived sourness) increased astringent intensity (Guinard *et al*., 1986) and duration (Fischer, 1990). Both mouth dryness and bitterness of tannic acid were attenuated by the addition of sweeteners to test stimuli (Lyman and Green, 1990). Similarly, the astringency elicited by alum was decreased by sucrose (Breslin *et al*., 1993)

The astringency belongs to mouthfeel sensations, particularly important in beverages, such as fruit juices, tea or wine. The sensory evaluation of astringency does not give a satisfactory information on the sensation as the sensation of astringent taste lasts relatively long time even after swallowing the draught. Therefore, time-intensity technique was applied for the measurement of astringency (Lee and Lawless, 1991). Time-intensity (TI) is a descriptive sensory technique in which the intensity of one or more sensory characteristics is rated in real time. TI has been widely used as a tool to study the dynamics of flavor release (Piggott *et al*., 1998) The TI procedure was found better than the use of category scales (Lundahl, 1992) The application of TI procedure was found particularly useful in evaluation of astringency and bitterness of wine (Noble, 1995). Trained judges rated the astringency and bitterness of catechin, gallic acid, grape seed tannins and tannic acid in white wine (Robichand and Noble, 1990). The selection and training of panelists for TI requires understanding of complex abstract concepts and well adapted motor skills. Accepted training methods identify suitable panelists as those who can focus on a single sensory attribute, and record changes in sensation as they occur (ASTM, 1998).

7. Sensory Analysis

Sensory analysis is a scientific discipline used to evoke, measure, analyze, and interpret reactions to characteristics of foods and materials perceived by the senses of sight, smell, taste, touch and hearing (Meilgaard *et al.,* 1999). Sensory analysis methods are used in quality control, product development, storage change on the perceived sensory properties of food products, marketing research, and development applications. Sensory analysis provides marketers with an understanding of food product quality, directions for product quality, profiles of competing products, and evaluations of product reformulations from a consumer perspective (Stone and Sidel, 1993). The primary goal of sensory analysis is to conduct valid and reliable tests in producing data for which important and sound decisions can be made (Meilgaard *et al.,*1999). Lawless and Heymann (1999) identified the two primary areas of sensory analysis to be analytical and affective tests.

Analytical tests consist of discrimination tests, threshold determination, and descriptive analysis (Lawless and Heymann, 1999; Meilgaard *et al.,* 1999). Discrimination tests consist of three different sub-categories all of which are based on the perceived differences between two or more food products, e.g., paired-comparison, triangle testing, and duo-trio testing (Stone and Sidel, 1993; Lawless and Heymann, 1999). Discrimination tests are to be used when there is a slight or minimal difference between samples (Chambers and Wolf, 1996) and is applicable in product reformulation, product positioning, ingredient changes, and cost reduction changes (Chambers and Wolf, 1996; Marketing Research Methodological Foundations, 2003). Threshold testing is a method to determine the strength or concentration of a stimulus required to produce effects on four different levels (Chambers and Wolf, 1996). The four different levels include detection threshold, recognition threshold, difference threshold, and terminal threshold (Chambers and Wolf, 1996). These methods are used in determining product acceptability, detecting product contaminants, and to assist in product formulation (Chambers and Wolf, 1996; Stone and Sidel, 1993). Descriptive analysis has been widely used to characterize in detail aroma, flavor, and oral texture attributes of food products. Descriptive analysis is the description of both qualitative and quantitative sensory aspects of a product using trained panelists (Meilgaard *et al*., 1999). Qualitative aspects involve selecting the characteristics in a product (appearance, flavor, aroma and/or texture). Quantitative aspects involve intensity ratings of the characteristics of a product. The panelists are used as an instrumentation source. Panelists are screened, selected, (approximately 6-15 people), and then trained. Descriptive panels usually require 50-100 hours of training prior to collecting and using panel data (Meilgaard *et al.,* 1999). After an extensive training, panelists have the expertise to evaluate aspects of a food product qualitatively and quantitatively. Descriptive sensory techniques include Quantitative Descriptive Analysis (QDA®), Flavor Profile Analysis (FPA), Texture Profile Analysis (TPA), Spectrum ™ Descriptive Analysis, Free Choice Profiling, and Time-Intensity Descriptive Analysis.

Affective tests can help the sensory scientist to understand the behavior of different consumers groups (Piggott, 1988), and therefore to understand potential buyers of the product and in which way such a product can be inserted into the food market. Data obtained from consumer affective tests represent key information in studies of product development, quality control, food product acceptance, and food service evaluation (Piggott, 1988). There are two types of affective tests, quantitative and qualitative. Qualitative tests (i.e., focus group interviews, focus panel, one-on-one interviews) measure subjective responses of a small group of representative consumers to the sensory properties of products by having them talk about their feelings in an interview or group setting (Meilgaard *et al.,* 1999). Quantitative tests consist of preference tests and acceptance tests, determine the responses of a large group of consumers to a set of questions regarding preference, liking, sensory attributes, etc. (Meilgaard *et al.,* 1999). Affective tests typically use consumers or untrained panelists for a particular product evaluation.

Food companies regularly use sensory tests, such as descriptive analysis and consumer affective tests, to study ingredient effects, processing variables and storage changes on the perceived sensory properties of their products.

8. Shelf Life

In the product development of any food product, one considerable aspect is the knowledge of the shelf life. Shelf life is defined as the period between manufacture and retail purchase of a food product during which the product is of satisfactory quality (IFT, 1974). It can be defined as the time between the production and packaging of the product and the point at which it becomes unacceptable under given conditions (Ellis, 1994).

The Institute of Food Technologists' Expert Panel on Food Safety and Nutrition (IFT, 1981) indicated dried foods to be shelf-stable foods. Development of foods with long shelf life normally requires data on shelf life of the product in a shorter time than it takes for the full shelf life study in order to meet product launch schedules. Accelerated shelf life testing (ASLT) procedures are often used. To achieve results in a shorter time-frame, accelerated shelf life testing implies any method that is capable of evaluating product stability, based on data that is obtained in a significantly shorter period than the shelf life of the product (Mizrahi, 2000). Storage studies to predict shelf life are an important part of every product development (Dethmers, 1979; Waletzko and Labuza, 1976). It is also often assume that accelerated deterioration can be achieved by raising the storage temperature, using an Arrhenius model (Labuza and Schmidl, 1985). The shelf life plots are useful in incorporating the effect of temperature on changes in food quality (Singh, 2000).

Chemical, physical and microbiological changes may occur during storage and result in a decrease of the sensory qualities of a food product (Labuza and Schmidl. 1985; Singh, 2000; Blackburn, 2000). At favorable temperature, such as room temperature, many enzymatic reactions proceed at rapid rates altering the quality attributes of foods (Singh, 1994). Color is one important of food quality that can be used for analyses of quality changes as a result of storage (Giese, 2000). Color deterioration has been reported as follow a first-order reaction (Steet and Tong, 1996). Changes in all the different sensory characteristics: appearance, odor, flavor and texture changes can occur all though the shelf life of foods.

According to Labuza and Riboh (1982), shelf life is not a function of time alone, rather it is a function of the environmental conditions and the amount of quality change can be allowed. The environmental conditions often relate to the temperature of food products during storage and distribution (Labuza and Szybist, 1999). Physical, chemical and sensory quality changes of shelf-stable foods are roughly proportional to their storage temperature (IFT, 1974). The effect of temperature on the rates of chemical reactions were studies in many recent researches (Trezza and Krochta, 2000; Ahmed and Shivhare, 2001; Ahmed and Shivhare, 2002; Cardelli and Labuza, 2001; Lee and Krochta, 2002; Gills and Resurreccion, 2000; Grosso and Resurreccion, 2002; Uddin *et al.,* 2002). To determine shelf life, either consumer acceptance or trained panel assessment can be used (Dethmers, 1979; Ellis, 1994; Kilcast, 2000; Cardelli and Labuza, 2001). Resurreccion (1998) stated that acceptance tests are necessary to obtain the shelf life of a product. Several shelf life studies used consumer acceptance to determine the end of shelf life (Dethmers, 1979; Duyvesteyn *et al*., 2001; Cardelli and Labuza, 2001; Grosso and Resurreccion, 2002; Hough *et al.,* 2002).

9. Fruit Candy

Fruit candy is made primarily of sugar, glucose syrup, and fruit puree. Sometimes an additional natural thickening agent is used in order to improve smoothness and prevent separation. The qualities of fruit candy depends mainly upon ingredients used in the mix, which include water, sugar, glucose syrup, fruit, and a thickening agent. Ingredients interact with each other and create a delightful taste. The thickening agents play an important role in the production of fruit candy, improve product consistency and stabilization, reduce the number of crystals or the size of crystals or both during the production period and also retard melting at the consumption stage. Their primary purpose is to produce smoothness in body and texture, reduce crystal growth during storage, extend shelf life, and provide uniformity of product and resistance to melting (University of Guelph, 2005). Polysaccharide gums are used widely as thickening agents in food.

MATERIALS AND METHODS

1. <u>To Identify the Aroma Compounds of Mafai Jeen</u>

1.1 The Aroma Components of Fruits, Seeds, and Leaves by Headspace Sampling

The objective in this study was to determine the headspace volatile components of Mafai Jeen fruits, seeds and leaves to reveal the volatile compounds that are responsible for its intense aromatic profile.

1.1.1 Plant Materials

The fruits, seeds, and leaves of Mafai Jeen were collected in July 2004 from the Horticultural Research Station, Department of Agriculture, Nan Province, which is located in the northern part of Thailand. The plant (Forest Herbarium No. BKF 135985) was identified and deposited at the Forest Herbarium (BKF), National Park, Wildlife and Plant Conservation Department, Ministry of National Resources and Environment, Bangkok 10900 Thailand. All Mafai Jeen fruits used came from the same batch. Fully ripe fruit were used in the study; ripeness is determined when the fruit turns yellow and has a thin, sometimes brittle skin, somewhat like paper.

1.1.2 Sample Preparation and Headspace Sampling

An Agilent 7694 (Agilent Technologies, Inc., Wilmington, DE 19808, USA.) was used for headspace sampling. Samples of 50 g were cut and immediately crushed in a blender, then 1 g of all samples used in this study were placed into 25 ml vials; they were then crimped and equilibrated for 20 min at 80 $^{\circ}$C before headspace sampling, following the method of Alasalvar *et al.* (1999)

1.1.3 Gas Chromatography-Mass Spectrometry (GC-MS)

GC-MS was performed on an Agilent 6890 GC Plus equipped with a HP-5973 mass-selective detector (Agilent Technologies). A fuse silica capillary column, HP-5-MS, with 5%-Phenyl methylpolysiloxane as non-polar stationary phase (30 m x 0.25 mm i.d. x 0.25 μm film thickness, Agilent Technologies), was utilized for analysis of volatiles obtained from Mafai Jeen. The injection port temperature was 250 °C. The column temperature program started at 40 °C upon injection. The temperature was increased at a rate of 3 °C /min to 100 °C, and then at a rate of 5 °C/min to 230 °C, and held there for 2 min. Purified helium gas at a flow rate of 1 mL/min was used as the GC carrier gas. The mass spectrometer was operated in the electron impact (EI) mode with an electron energy of 70 eV; ion source temperature, 230 °C; quadrupole temperature, 150 °C; mass range *m/z* 35-400; scan rate, 0.25 s/scan; EM voltage, 1423 V; and the GC-MS transfer line was set to 280 °C.

1.1.4 Qualitative and quantitative analyses

Most constituents Identification of volatile components was performed by matching their mass spectra with reference spectra in the Wiley 275 Mass Spectral Library (Revision C.00.00) and the National Institute of Standard and Technology (NIST) 98 Mass Spectral Library (Revision D.01.00/Search Program v.1.6d), both purchased from Agilent Technologies. Quantitative analysis of each volatile component in percent was performed by peak area normalization measurement.

1.2 Aroma Compounds of Mafai Jeen Fruits by HS-SPME Analysis

In this work, manual HS–SPME–GC–MS was employed to isolate and identify the main constituents of the aroma of Mafai Jeen fruits. The objective of this study was to compare the sample preparation, i.e., PDMS, PA, and

DVB/CAR/PDMS, used for determination of the aroma compounds in Mafai Jeen fruit.

1.2.1 Fruit Pulp Sample

Fresh Mafai Jeen fruits were collected in May 2004 from Nan Province in northern Thailand. The sample was homogenized in a blender for ca. 2 min and the resulting slurry was immediately transferred to a 50-ml glass syringe, which had its tip sealed with a silicone cap, and was completely filled. The syringe containing the slurry was kept refrigerated at 8 °C when not in use to minimize the loss of the most volatile compounds (Augusto *et al*., 2000).

1.2.2 SPME Fibers

Three SPME fiber coatings (Supelco, Bellefonte, PA, USA) were evaluated and used for the extraction procedures: 100 μm polydimethylsiloxane (PDMS, non-bonded) cat. No.57300-U, 85 μm polyacrylate (PA, bonded) cat. No. 57304, and 50/30 μm divinylbenzene/carboxen/PDMS (DVB/CAR/PDMS, bonded) cat. No.57328-U. Fibers were conditioned prior to use according to supplier's prescriptions and the contaminated fiber cleaned at 20 °C below its recommended maximum temperature for 1 h.

1.2.3 Headspace Extraction Procedure

In each extraction, 2.00±0.1 g of the pulp slurry was transferred from the syringe to a 40-ml clear screw top vial with hole cap PTFE/silicone septa (Supelco cat. No. 27089-U) and the system was kept at 50 °C with magnetic stirring to achieve the partition equilibration of the analysis between the sample and the headspace. After 15 min a SPME fiber was exposed to the headspace for 15 min. The sample transfer to the GC column was accomplished by keeping the SPME fibers for

5 min in the heat chromatograph injector. This headspace extraction procedure was performed in duplicate for each sample using the SPME fibers listed above. Blank runs with the used fibers were conducted between extractions, to check the absence of carry over which would cause memory effects and misinterpretation of results.

1.2.4 GC–MS System

The extracts were analyzed with an Agilent 6890GC Plus equipped with a HP-5973 mass-selective detector (Agilent Technologies, Inc., Wilmington, DE 19808, USA.). A fused-silica capillary column, HP-5MS, with 5%-Phenyl methylpolysiloxane as nonpolar stationary phase (30 m x 0.25 mm i.d. x 0.25μm film thickness, Agilent Technologies) was utilized for analysis of volatile compounds and a split-splitless injector was operated in the splitless mode for all chromatographic runs.

The injection port temperature was 250 °C. The column temperature program started at 40 °C upon injection. The temperature was increased at a rate of 3 °C /min to 100 °C, and then at a rate of 5 °C/min to 220 °C, and held there for 2 min. High purity helium gas at a constant flow rate of 1 ml/min was used as the GC carrier gas. The mass spectrometer was operated in the electron impact (EI) mode with an electron energy of 70 eV; ion source temperature, 230 °C; quadrupole temperature, 150 °C; mass range *m/z* 35-400; scan rate, 0.25 s/scan; Electron multiplier (EM) voltage was obtained from autotune, 1423 V. and the GC-MS transfer line was set to 280 °C. Compounds were identified by matching their mass spectra with reference spectra in the Wiley 275 Mass Spectral Library (Revision C.00.00) and the National Institute of Standard and Technology (NIST 98) Mass Spectral Search Program v.1.6d, both purchased from Agilent Technologies. Quantitative analysis of each volatile component in percent was performed by relative area normalization measurement.

2. To Study Effect of Drying Methods on Mafai Jeen

2.1 Effect of Drying Conditions on Qualities of Dried Mafai Jeen

The purpose of this study was to evaluate the effect of four drying methods; hot air drying at 60 °C, hot air drying at 45 °C, vacuum drying at 45 °C and sun drying, on qualities of dried Mafai Jeen fruits.

2.1.1 Plant Material

The fresh Mafai Jeen fruits were collected in May 2004 from Nan Province located in the northern part of Thailand. The experiments were carried at Bangkok (13 ° 45 ’ N, 100 ° 31 ’ E) Thailand. All Mafai Jeen fruits used for experimental were from the same batch.

2.1.2 Preparation of Dried Mafai Jeen

Fresh Mafai Jeen
⇩
Wash
⇩
Soak in 3% brine
⇩ 6 h
Hand split to remove seeds
⇩
Mix with sucrose, 35% by wt.
⇩ 2 h
Dry
⇩
Dried Mafai Jeen

Figure 2 Flow chart of dried Mafai Jeen process.

Flow chart for dried Mafai Jeen production was shown in Figure 2. The first step was washing of Mafai Jeen to remove dirt, leaves, and foreign materials. Then, the Mafai Jeen was soaked in 3% brine for 6 h. The fruits were separated from the branched panicle and deseeded manually. The flesh with peel was then mixed with 35% sucrose by weight and they were left for 2 h until sucrose impregnated as flesh followed by drying later.

2.1.3 Drying

The Mafai Jeen fruits were dried in a hot air dryer (BWS, B.W.S. Trading, Thailand. Overall dimensions: 1.92 m height, 1.22 m width, and 0.80 m depth), vacuum dryer (VD53, Binder, Germany. Overall dimensions: 0.75 m height, 0.63 m width, and 0.55 m depth), or sun-dried. The initial moisture content of the samples was 72% (wet basis). Drying conditions for hot air drying were temperature 45 °C or 60 °C, air flow 1.2-1.5 m/s, and tray load 4.00-4.50 kg/m^2; for vacuum drying, temperature 45 °C and vacuum 300-400 mbar abs, and for sun drying, the samples were dried under direct sunlight, starting at 8:00 a.m. and continuing till 5:00 p.m., with temperature 38.2 ± 4.5 °C, the per cent relative humidity of air 52 ± 6.2, and air velocity 0.53 ± 0.22 m/s (these values are the average values, ± standards deviation). Tray loading in vacuum and sun drying were kept the same as in hot air drying. Moisture loss was recorded for determination of drying curves by scale balance at 60 min intervals for hot air and sun drying and 120 min intervals for vacuum drying. The samples were dried until equilibrium was reached (no weight change).

2.1.4 Color Analysis

Color analysis was carried out on Mafai Jeen samples using a tristimulus colorimeter (Chromameter CR-200, Minolta, Osaka, Japan) to obtain the color values (CIE -*L** *a** *b** values). L* represents lightness, *a** represents greenness (-) to redness (+) while *b** represents blueness (-) to yellowness (+) values

(Minolta, 1999). The changes in each individual color parameter were calculated as follows:

$$\Delta L^* = L^* - L_o^* \quad (1)$$

$$\Delta a^* = a^* - a_o^* \quad (2)$$

$$\Delta b^* = b^* - b_o^* \quad (3)$$

The subscript '*o*' refers to the target value or the initial color parameters of each product at the beginning of the drying experiments. The total color difference (ΔE) was then determined using the following equation (Nsonzi and Ramaswamy, 1998):

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \quad (4)$$

At least fives measurements were carried out on each sample.

2.1.5 Proximate Analysis

Proximate analysis were determined by the methods of Association of Official Analytical Chemists (A.O.A.C, 1990)

2.1.6 Sensory Analysis

Preference tests of dried Mafai Jeen products were done with a 50 panel. All panelists were experienced with hedonic scale sensory test. The samples were randomized and coded with a three-digit number chosen from a table of random numbers. A 9-point hedonic scale (Meilgaard *et al.*, 1999) was used to assess the acceptance of various aspects (such as overall acceptance, appearance, aroma, flavor, and texture) of the products.

2.2 Aroma Components of Mafai Jeen Fruit Treated by Different Drying Condition

Dried whole Mafai Jeen is a unique product, consumed mainly in the northern part of Thailand. However, no reports were available on systematic drying of Mafai Jeen fruit, nor on the changes that occur in its aroma profile as a result of processing, though the fruit is valued mainly for its flavor and aroma. The objectives in this study are; to determine the changes in volatile aroma components of dried Mafai Jeen fruit, using different types of driers.

2.2.1 Plant Material

The fresh Mafai Jeen fruits were collected in May 2004 in Nan Province located in the northern part of Thailand. The initial samples were divided into five batches. One was stored frozen at –18 °C for fresh analysis. The remaining batches were dried by using one of the following different drying methods test: (a) sun drying at ambient temperature (30-39 °C) ; (b) drying in a hot air oven at 45 °C; (c) drying in a hot air oven at 60 °C; (d) drying in a vacuum oven at 45 °C. The samples were dried until moisture content reached approximately of 16% dry basis (calculation based on initial moisture content and weight loss, mass of moisture/mass of dry solid x 100).

2.2.2 Extraction of Volatiles

The Clevenger-type apparatus (Clevenger, 1928) hydro-distillation extraction was used for extraction and concentration of volatiles. The Mafai Jeen fruit samples, 500 g with fresh fruit or 200 g dried fruit was put into a round bottomed flask with 500 ml of distilled water. Five drops of silicone were added as antifoam. The distillation process was carried out for 6 h. The distillate was dried over anhydrous sodium sulfate. Dried distillate was concentrated under a stream of nitrogen and stored in 2 ml vial at –18 °C until analysis. The extraction of each sample to be submitted to gas chromatography-mass spectrometer (GC-MS) analyses.

2.2.3 GC-MS Analysis

A GC-MS (Agilent 6890 and HP 5973 mass-selective detector, Agilent Technologies, Inc., Wilmington, DE 19808, USA.) equipped with a fuse silica capillary column, HP-5MS, with 5%-Phenyl methylpolysiloxane as non-polar stationary phase (30 m x 0.25 mm i.d. x 0.25 μm film thickness, Agilent Technologies) was utilized for analysis of volatiles obtained from distillation of Mafai Jeen fruits. The samples (1 μL) were injected with a split ratio of 10:1. The injection port temperature was 250 °C. The column temperature program started at 40 °C upon injection. The temperature was increased at a rate of 3 °C/min to 100 °C, and then increased at a rate of 5 °C/min to 230 °C, and hold for 2 min. Purified helium gas at a flow rate of 1 mL/min was used as the GC carrier gas. The mass spectrometer was operated in the electron impact (EI) mode with an electron energy of 70 eV; ion source temperature, 230 °C; quadrupole temperature, 150 °C; mass range *m/z* 35-400; scan rate, 0.25 s/scan; EM voltage, 1423 V the GC-MS transfer line was set to 280 °C.

2.2.4 GC-MS Data Analysis

Identification of volatile components was performed by matching their mass spectra with reference spectra in the Wiley 275 Mass Spectral Library (Revision C.00.00) and the NIST 98 Mass Spectral Library (Revision D.01.00/1.6d), both purchased from Agilent Technologies. Quantitative analysis of each volatile component in percent was performed by peak area normalization measurement.

3. **To Study the Intensity of Astringent Taste of Mafai Jeen**

The objectives in this study are; To explore the use of Time-intensity (TI) in the measurement of astringent taste, to study astringent taste in Mafai Jeen fruits and studied the effect of sucrose and ascorbic acid on the intensity of astringent taste.

3.1 Material

Tannic acid powder pure (Merck); citric acid, chemically pure for food use; sucrose, pure for food use; dried Mafai Jeen

3.2 Methods

The procedure used for the sensory analysis was in agreement with requirements of the international standard (ISO, 1985), performed in a standardized test room provided with 8 test booths. The room temperature varied between 20-25 °C, the relative moisture content between 40–70%

Seventeen volunteers (seven man and ten woman, ranging in age from 20 –36 years) were chosen from the pool of staff at the Rajchamungala Institute of Technology , Nan campus, based on their lack of food allergies, tolerance of astringent flavors and availability on the training and sample testing days. Nine panelists were screened from this by their ability to rank order of differing taste content correctly. The training took place individually for each panelist over three sessions.

On the first session, the overall goals of the research project were described and panelist were given an overview of the procedure they would be carrying out. On the second and the third session of training, assessors were familiarized with astringent taste, and the technique of TI scaling especially aimed at evaluation of astringent taste. Then, they were asked to taste the standard reference of tannic acid solution 1 g/l. An unstructured line scale with descriptors ‘low astringency’ and ‘high astringency’, left to right respectively, 150 mm in length. The data were collected every 10 second.

Samples were presented in randomly 3 digit coded white plastic cups, not more than four samples were served in the random order, in interval of 2-3 min after disappearance of astringent taste. Samples were evaluated in triplicate and presented at ambient temperature. Between sample, water and unsalted cracker were served for mouth washing.

Twelve samples of dried Mafai Jeen, varying in the rate of sucrose from 0, 10, 20 to 30 g/100g. of fruits and varying in the rate of ascorbic acid from 0, 1 to 2 g/100g. of fruits as shown in Table 2, were prepared by the following process;- The fresh fruits of Mafai Jeen in fully ripe, collected from the local orchard in Nan province were washed and soak in 4% of brine for 6 h, deseed by squeezing with hand, mix with sucrose and ascorbic acid, varying of concentration by treatment and holding for 2 h, drying with hot air dryer at 50 °C, for 36 h**,** and then store in cool dry place until the samples were use.

Table 2 Composition of the experimental samples and reference standards.

	Sucrose (g / 100 g of fruits)	Ascorbic acid (g / 100 g of fruits)	Tannic acid (g / l)
Samples	0, 10, 20, 30	0	
	0, 10, 20, 30	1	
	0, 10, 20, 30	2	
Reference standard	0		1
solution	30		1

3.3 Data Analysis

Time to maximum intensity (T max), maximum intensity (I max), total duration (T tot) for astringency and sweetness were extracted from TI curves. Each variable was analyzed using SPSS 10.0 for Windows with a custom model analysis of variance in which the treatments and assessors were treated as a fixed factor. Mean astringency TI curve were calculated for low and for high flow subjects by averaging ratings across time and samples.

4. To Develop Mafai Jeen Candy with Shelf Life Study

4.1 Determination of Mafai Jeen Qualities

The same batch of fresh Mafai Jeen fruits with similar ripening stage were collected from Nan province located in the northern part of Thailand. Physical and chemical determination and process development were done at the department of Product Development, Kasetsart University, Bangkok, Thailand. The Mafai Jeen fruits sample were remove seed before blending for 6 min and studied on qualities of color L^* a^* b^* values, pH, %moisture, %total soluble solid, %acidity, and %reducing sugar.

4.2 Preparation of Mafai Jeen Candying

Flow sheet for Mafai Jeen candying production was shown in Figure 3. The first step was washing of Mafai Jeen to remove dirt, leaves, and foreign materials. Then, the fruits were separated from branched panicle and deseeded manually. The flesh with peel obtained was blend for 6 minutes followed by heating Mafai Jeen puree over gas stove at 95 °C for 20 min, adding 35% (by wt) of sucrose and continue heating for 20 min, adding 5% (by wt) of glucose syrup and continue heating until the total soluble solid increasing to 75 °Bx. Samples obtained were rest overnight till it cool. Then, cutting into 0.5 x 0.5 x 0.5 inch and transparency plastic (oriented polypropylene, OPP film) was wrapping, thus obtained samples according to the candy process.

Fresh Mafai Jeen

⇩

Wash

⇩

Hand split to remove seeds

⇩

Blend for 6 min

⇩

Heating Mafai Jeen puree over gas stove at 95 °C for 20 min

⇩

Adding 35% (w/w) of sucrose and continue heating for 20 min

⇩

Adding 5% (by wt) of glucose syrup and continue heating until the total soluble solid reached 75 °Bx

⇩

Rest overnight

⇩

Cutting into 0.5 x 0.5 x 0.5 inch and wrapping with transparency plastic sheet

⇩

Mafai Jeen candy

Figure 3 Flow sheet of Mafai Jeen candy process.

4.3 Development of Mafai Jeen Candy

4.3.1 Focus Group Discussion (FGDs)

Focus groups: a practical guide for applied research by Krueger and Casey (2000) was used as the basis for development of Mafai Jeen fruits candy instead of individual interviews because it was felt that participants would be more responsive and spontaneous in an informal. FGDs tend to facilitate considerable interaction on given topics in a limited space of time (Kidd & Parshall, 2000). Three sessions of FGDs were conducted; two of the three sessions were 18-29 and 30-55 years old, held at Nan Province (see appendix Figure C 3) whereas Mafai Jeen was grown, and one session was 18-29 years old, held in Bangkok (see appendix Figure C 4). All FGDs were audio tape-recorded and lasted approximately between one to two hours. The sessions were held between 10 June 2005 and 20 August 2005. Groups were of mixed gender with 4–8 participants per group.

Data were collected in a systematic approach by asking semi-structured, open-ended questions and a socio-demographic questionnaire prior to commencing each focus group. This information complemented the discussion findings gained from the tape recorded sessions. Each focus group began with a general discussion on attitudes to foods, which allowed the respondents to relax and feel at ease. The questions were designed to explore issues related to implementation of the new product idea. The first series of questions were on Mafai Jeen fruit products selection, costs, packaging and benefits. And the second series of questions were on barriers to implementation and the suggestions for improving product and package.

4.3.2 Study on Sucrose and Glucose Syrup Concentration in the Recipe

The aim of experiment was to examine the effect of sucrose concentration and glucose syrup concentration on physical and sensory acceptability of Mafai Jeen fruit candy. The experiment was conducted as a 3 x 5 factorial arrangement of treatment with 3 levels of glucose syrup concentration (0%, 5%, and 10% based on the total weight of the ingredients) and 5 levels of sucrose concentration (20%, 25%, 30%, 35%, and 40% based on the total weight of the ingredients, respectively). Mafai Jeen fruit candy were prepared follow as Figure 3, sucrose were added after Mafai Jeen puree was heated for 20 min and continue stirring and heating for 20 min, then adding glucose syrup and continue stirring and heating until the total soluble solid increased to 75 ^{o}Bx and they were left over night, then cut the samples into 0.5 x 0.5 x 0.5 inches and wrapped with transparency plastic sheet. A total of fifteen Mafai Jeen fruit candy samples were made, each was prepared in duplicate (two experimental replication).

The texture profile characteristics of Mafai Jeen fruit candy were analyzed using the Lloyd Texture Analyzer (Lloyd TA 500, Intro Enterprise Co., Ltd. UK). The texture analyzer was equipped with a 50 kg load cell and a 50 mm diameter compression cell. The test speed was set at 50 mm/min and the distance to compress sample was 60% strain. The hardness (N) of the samples were recorded an standard of 10 measures was reported. (Vijayanand *et al.,* 2000)

The moisture content of Mafai Jeen fruit candy was determined by the methods of Association of Official Analytical Chemists (AOAC, 1990).

The water activity of Mafai Jeen fruit candy was determined at 25 °C using Thermoconstanter (Novasina, MLK, Switzerland), equipped with a temperature-controlled system which allow to have a temperature stable sampling environment. The equipment was calibrated with saturated salt solution in the a_w range of 0.43 – 0.75 (Favetto *et al.*, 1983). For each determination, five replication were obtained and the average reported; under these conditions reliability of this meter is about ±0.003 a_w.

Colorimetric measurement of Mafai Jeen fruit candy were determined in triplicate at the product surface using a spectrophotometer (CM 3500d, Minolta Camera Co., Ltd, Tokyo, Japan). The CIE – L^* a^* b^* uniform color space, where L^* indicates the lightness (0 = black, 100 = white), a^* indicates chromacity on a green (-) to red (+) axis, and b^* chromacity on a blue (-) to yellow (+) axis.

For consumer acceptance, two piece of each of the 15 Mafai Jeen fruit candy samples were evaluated by 30 untrained panelists. Panelists were asked to evaluate 3 sets of samples, each set composed of five samples and took a 10 min break between the set evaluated. They individually evaluated the samples in partitioned booths under fluorescent light at temperature 25 °C. A 9-points hedonic scale (1= dislike extremely; 5= neither like nor dislike; 9= like extremely) was used to evaluate acceptability of the product attributes (color, taste, sweetness, texture, and overall acceptance).

The effect of white sugar concentration and glucose syrup concentration on physical and sensory acceptability of Mafai Jeen fruit candy were determined using a 3 x 5 factorial arrangement in completely randomized block design (RCBD) following the analysis of variance (ANOVA, SPSS version 10.0.1) method. Significant difference of treatment means were determined by Duncan's Multiple Range Test (DMRT). Statistical significant difference was established at $p < 0.05$.

4.3.3 Study on Thickening Agent for Mafai Jeen Fruit Candy

Fruit candy is made of sugar, glucose syrup and fruit puree only, and sometime additional natural thickening agent will be used to improve the smoothness and prevent separation. The purpose of this study was to investigate by sensory evaluation an appropriate thickening agent for the Mafai Jeen fruit candy product.

Mafai Jeen fruit candy were prepared follow as Figure 3, with concentration of sugar from the resulted of 4.3.2. A variety of thickening agents were tested in the study including; maltodextrin DE 10 (Staley, Tate & Lyle, USA), pectin (150grade /USA-SAG type B, Rapid set, GENU®, CP Kelco, Denmark), and CMC (PM 7, China north chemical, China) with various concentration of 0.5%, 1.0%, 1.5%, 2.0%, and 2.5% (based on the total weight of the ingredients) were added simultaneous with glucose syrup during stir and then heating until the total soluble solid increasing to 75 ^{o}Bx and they were left for over night, then cut the samples into 0.5 x 0.5 x 0.5 inch and wrapped with transparency plastic sheet. The fifteen samples were evaluated by ranking of preference with 30 panelists. Each subject receive one type of thickening agent at a time, five samples coded with three-digit numbers and served in random order.

A non-parametric Friedman's test was performed to determine differences among the five samples. Fisher's analog of LSD_{rank} was applied to accomplish all paired-wise comparisons of the five Mafai Jeen fruit candy. The first rank in this study was used to study the sensory descriptive analysis.

The T value is calculated as follows:

$T = \{[12 / bt(t+1)] \,.\, \Sigma X_{.j}^2\} - 3b(t+1);\ j = 1 \text{ to } t$ ……………………..…..….(5)

b = no. of panelists (blocks)

t = no. of samples

$X_{.j}^2$ = square of the rank sum of sample j

A two-tailed test

Ho: all sample are same

Ha: not all sample are same

At a specified α level (0.05), if T value is greater than $\chi^2(\alpha, df = t-1)$, then reject Ho. df = 4 when 5 samples tested.

If Ho is rejected, then do analog Fisher's LSD

Analog Fisher's $LSD_{rank} = t(\alpha/2, \infty) \,.\, [bt(t+1)/6]^{1/2}$ ………………………..(6)

$t(\alpha/2, \infty)$ is the upper α probability points of the student's t-distribution.

Two samples are declared to be significantly different at the α level if their rank sum differs by more than the value of LSD_{rank}

4.3.4 Descriptive Sensory Analysis of Mafai Jeen Fruit Candy

a. Sample Description

First rank of preference of Mafai Jeen fruit candy added 3 type of thickening agent; maltodextrin, pectin, and CMC from 4.3.3 were used for descriptive sensory analysis. Each candy weighs 3.5 ±0.23 g the product was wrapped with transparency plastic sheet and packaged in an aluminum pouch for protection from light, humidity and foreign odors.

b. Panel Selection and Training

Fourteen panelists were recruited from Kasetsart University. They were pre-selected on the basis of good health conditions, time availability, no allergy to fruit candy products, interest in participating, available for all sessions, and able to verbally communicate about the product. Descriptive analysis test procedures as described by Meilgaard *et al.* (1999) were used to train the panelists. Panelists evaluated the samples using a “hybrid” descriptive analysis method (Grosso and Resurreccion, 2002) consisting of the Quantitative Descriptive Analysis (Tragon Corp., Redwood City, Calif., U.S.A.) and the Spectrum™ Descriptive Analysis (Sensory Spectrum, Inc., Chatham, N.J., U.S.A.) methods.

Panelists were then subjected to preliminary acuity tests to investigate their ability to recognize basic taste in solution, basic aromas, and to describe basic attributes related to Mafai Jeen fruit candy products. After the screening process eight panelists were selected. Five panelists were female and three were male in the range of 22-45 years old of age. Training consisted of: (1) Initial orientation session where panelists received detailed explanation about the descriptive sensory methodology and general description of the Mafai Jeen fruit candy product, (2) group meetings for lexicon development and selection of reference standards, and (3) individual training on the developed lexicon. During opening sessions panelists took part in a lexicon-generation exercise. They were provided with the Mafai Jeen fruit candy samples. They were asked to smell and taste them and list as many aromas and flavor terms as possible for each sample and discuss individual results to come up with a consensus. Appendix Figure C 5 illustrates the panel during a group training session. They were seated in a conference-type round table to facilitate communication. Throughout subsequent sessions panelists were exposed to different reference samples and they practiced the lexicon development process. During the last sessions panelists checked the developed lexicon and reduced the number of terms by eliminating redundant ones or those for which panelists could not reach consensus, agreed on precise definitions of the terms, and selected standards needed to describe them. After the final session, panelists had agreed on a list of twenty clearly defined terms(Table 3), the appropriate reference standards and their intensities on the 15-cm intensity line scale (Table 4).

Panelists attained individual training on the different intensities of the developed lexicon using a 15-cm structured line scale. They worked in partitioned booths, with positive airflow, free from distracting noises and odors. They were provided with room-temperature drinking water, unsalted crackers and an expectoration cup to cleanse their palate.

c. Product Evaluation

The eight panelists evaluated three samples Mafai Jeen fruit candy (see appendix Figure C 6) using the developed lexicon, samples were placed in 6 x 8 cm zip locked plastic sachet; two pieces of candy were served for each sample. The panelists evaluated three samples once during a 60-minutes session and the evaluation was repeated two more times. Appendix Figure C 7 shows one of the trained panelists performing the evaluation. Panelists worked in partitioned booths. The panelists were instructed not to swallow the samples, and were asked to rinse their palate well with water between samples. For this purpose, panelists used room temperature drinking water and unsalted crackers. Subjects recorded the intensities of the attributes on the 15-cm structured line scale.

d. Data Analysis

Table 3 Attribute rated by the panel and their definitions used in the descriptive analysis of Mafai Jeen fruit candy.

Attribute	Definition
Appearance	
Glossy	Having a smooth, shiny, lustrous surface of sample
Odor/Aroma	
Pickled lemon	The aroma associated with pickled lemon
Dried preserved mandarin peel	The aroma associated with dried preserved mandarin peel
Pungent	Irritation, burnt and/or penetrating sensation in the interior of the nasal cavity
Caramel	Sweet aromatic associated with characteristic of over heat brown sugar
Tastes	
Sweet	The taste on the tongue associated with aqueous solution of sugar
Sour	The taste on the tongue associated with aqueous solution of acids
Bitter	The taste on the tongue associated with bitter agents such as caffeine or quinine
Astringent	A drying, puckering or tingling sensation on the surface and/or edges of tongue and mouth
Flavor	
pickled lemon	The flavor associated with pickled lemon
Dried preserved mandarin peel	The flavor associated with dried preserved mandarin peel
Texture	
First bite	
Hardness	The force required to compress the sample between the tongue and palate; compress through sample with tongue and palate

(Continued)

Table 3 (Continued)

Attribute	Definition
Masticatory	
Cohesiveness	Amount of deformation undergone by the material before rupture when biting completely through sample using molars; by place sample between molar teeth, compress and evaluate the amount of deformation before rupture
Crumble	The force required to break sample into small fragments or particles with molars
Sandy	A rough to the touch; chew sample 5 times and evaluate
Chewiness	Place sample in mouth and masticate at one chew per two second and at a force equal; evaluate the number of chews required to reduce sample to a state ready for swallowing
Roughness	Degree of abrasiveness of the product's surface as perceived by the tongue; chew sample with molars 8 times and evaluate
Residual	
Bitter	The residual taste on the tongue associated with bitter agents such as caffeine or quinine
Astringent	The residual of drying, puckering or tingling sensation on the surface and/or edges of tongue and mouth
Toothpack	The amount of product packed into the crowns of your teeth after mastication; chew sample up to 8 times, expectorate and feel the surface of the crowns of the teeth with tongue

Table 4 Standard reference intensity ratings used in descriptive tests for Mafai Jeen fruit candy.

Attribute	Reference	Intensity[1] (cm)
Appearance		
Glossy	Warm-up sample[2]	5
	Ka la mae, Savei (Jiraporn, Chiangmai, Thailand)	15
Odor/Aroma		
pickled lemon	Warm-up sample[2]	3
	Pickled lemon 1 cm cube	15
Dried preserved mandarin peel	Warm-up sample[2]	2
	Dried preserved mandarin peel (Jiabao brand, Guangdong Jiabao group Co., Ltd, Guangdong)	15
Pungent	Warm-up sample[2]	5
	Dried Mafai Jeen fruit	10
	3 drop of white vinegar (Thai Q.P. Co., Ltd., Rajburi, Thailand)	15
Caramel	Warm-up sample[2]	0
	Werther's Original chewy toffees (August Storck KG, Berlin)	3
Tastes		
Sweet	Warm-up sample[2]	12
	10.0% sucrose in deionized water	10
	15.0% sucrose in deionized water	15
Sour	Warm-up sample[2]	10
	0.08% citric acid in deionized water	5
Bitter	Warm-up sample[2]	4
	0.05% caffeine in deionized water	12
Astringent	Warm-up sample[2]	3
	0.1% alum in deionized water	5
	Dried preserved mandarin peel (Jiabao brand, Guangdong	6

(Continued)

Table 4 (Continued)

Attribute	Reference	Intensity[1] (cm)
	Jiabao group Co., Ltd, Guangdong)	
	0.15% alum in deionized water	15
Flavor		
pickled lemon	Warm-up sample[2]	5
	Pickled lemon 1 cm cube	15
Dried preserved mandarin peel	Warm-up sample[2]	2
	Dried preserved mandarin peel (Jiabao brand, Guangdong Jiabao group Co., Ltd, Guangdong)	12
Texture		
First bite		
Hardness	Warm-up sample[2]	3
	Marmalade (Best Foods, Malee Bangkok Co., Ltd., Samtuprakarn, Thailand)	2
	5 min boiled egg white	5
	Mint flavor candy (MYMINT brand, Boonprasert conf. Samutsongkharm, Thailand)	13
Masticatory		
Cohesiveness	Warm-up sample[2]	4
	PIPO JELLY, EURO, Pipo brand, variety flavored jelly dessert	2
	Mint flavor candy (MYMINT brand, Boonprasert conf. Samutsongkharm, Thailand)	13
	SUGUS (SUGUS chewy candy, Kraft Jacobs Ltd., Switz.)	15
Crumble	Warm-up sample[2]	1
	Ka nom phing (Cookie Kaset, Institute of Food Research and Prod. Dev. (IFRPD), KU, Bangkok, Thailand)	7
	Coconut sugar cube	12

(Continued)

Table 4 (Continued)

Attribute	Reference	Intensity[1] (cm)
	Tob tub peanut candy (Taveephol product Co., Ltd, Talingchan, Bangkok, Thailand)	15
Sandy	Warm-up sample[2]	3
	Coconut sugar cube	7
	Ka nom phing (Cookie Kaset, Institute of Food Research and Prod. Dev. (IFRPD), KU, Bangkok, Thailand)	10
Chewiness	Warm-up sample[2]	6
	Banana candy (Kleaw Jai, Maeban Nongkasamakkee group, Bungkum, Bangkok, Thailand)	13
Roughness	Warm-up sample[2]	4
	PIPO JELLY, EURO, Pipo brand, variety flavored jelly dessert	0
	Hawthorn piece (Guan Du Qu Qian Wei Ying Xia, 157 Kun Ming, Yun Nan)	6
Residual		
Bitter	Warm-up sample[2]	4
	0.05% caffeine in deionized water	12
Astringent	Warm-up sample[2]	2
	0.1% alum in deionized water	5
	Dried preserved mandarin peel (Jiabao brand, Guangdong Jiabao group Co., Ltd, Guangdong)	6
	0.15% alum in deionized water	15
Toothpack	Warm-up sample[2]	2
	Banana candy (Kleaw Jai, Maeban Nongkasamakkee group, Bungkum, Bangkok, Thailand)	10

[1]Intensity rating are based on 15-cm structured line scale

[2]Warm-up sample consist of 59% Mafai Jeen puree, 35% sugar, 5% glucose syrup, and 1% pectin and processing step as followed by figure 3.

The data were analyzed using univariate statistical analysis. Analysis of Variance (ANOVA, SPSS version 10.0.1, 2001) was performed to determine significant effects of the attribute intensities in each of the three Mafai Jeen fruit candy.

4.3.5 Consumer Test

Consumers (n = 135) were randomly recruited from Kasetsart University and from a local public area in Bangkok. The criteria for recruitment were: at least 18 years old, not allergic to fruit candy products, and positive attitude. Consumers were instructed on the procedure to be followed. They were informed that each sample was randomly coded with a 3-digit number. These numbers corresponded to those appearing on each of the three pages of the questionnaire. Prior to the product evaluation, participants were asked to complete a demographic and socioeconomic survey, which included questions regarding age, gender, education level, employment status, and household income.

Three samples of Mafai Jeen candy piece added 2.0% maltodextrin, 1.5% pectin, and 1.0% CMC were tasted at room temperature in a random 3-digit number coded in a sequential monadic presentation. Room-temperature drinking water and unsalted crackers were provided to consumers to cleanse their palate between samples evaluation, in order to minimize sensory carryover and/or fatigue effects. Consumers were told to chew at least half of the piece and to evaluate the three samples for acceptability of overall appearance, texture, taste, sweetness and overall liking using a 9-point hedonic scale (1=dislike extremely, 5= neither like, nor dislike, and 9=like extremely) (Peryam and Pilgrim, 1957). Consumers were also asked to rate the sweetness of each Mafai Jeen fruit candy (added 2.0% maltodextrin one, added 1.5% pectin one, and added 1.0% CMC one) on a 3-point “just about right” (JAR) scale with “just about right”= 2, “too weak”=1, and “too strong”=3. Participants evaluated acceptance of the product using a yes/no scale (Moscowitz, 1994). Finally, consumers evaluated purchase intent (yes/no) and purchase intent after additional information about health benefits of the Mafai Jeen fruit candy had been provided.

Data were analyzed using univariate statistical analyses. A Randomized Block Design was followed and Analysis of Variance (ANOVA, SPSS version 10.0.1) was performed to determine differences in acceptability for each of the sensory attributes among the three samples. The Duncan post-hoc test was applied to accomplish all paired-wise comparisons of acceptability of each of the three Mafai Jeen fruit candy.

McNemar test was performed to analyze the change in probability of purchase intent before and after consumers had been informed about the health benefits of the product. The McNemar's test represents a comparison of dependent proportions for binary response variables. It is a two-related sample difference test, that follows a Chi-square distribution with 1 df (Agresti, 1996). Consumers are categorized in two categories, in a "before" condition and then the same consumers are re-categorized in an "after" condition (O'Mahony, 1986). The null hypothesis (H_o: $\pi_{+1} - \pi_{1+} = 0$ or $\pi_{21} - \pi_{12} = 0$) stated that there was no significant difference in the probability of buying the product before and after consumers had been informed about its health benefits. In other words, the question was whether the differences between the probability of those who answered yes after (π_{+1}) and the probability of those who answered yes before (π_{1+}) is significant, or whether it was merely chance. The aim is to know if participants were influenced or not by the fact that they were informed about health benefits of the product, and therefore their opinions changed from a "before" status to an "after" status. To complement this test and obtain more detailed understanding, a 95% confidence interval for the difference of proportions was calculated. The difference of two sample marginal proportions ($p_{+1} - p_{1+}$) estimates the true difference ($\pi_{+1} - \pi_{1+}$ or $\pi_{21} - \pi_{12}$). Equation (7) indicates the formula used to calculate sample proportions, where n_{ij} is the number of subjects making response i at the first question (before), and response j at the second question (after knowing that the product contained health promoting ingredients) and N is the total number of responses. Equation (8) is used to calculate confidence interval of difference of proportions. The term ($p_{+1} - p_{1+}$) indicates the difference between the proportion of participants that answered 1 (yes) after knowing that the product contained health benefits (p_{+1}), and the proportion of participants that answered 1 (yes) before knowing that the product contained health benefits (p_{1+}). Equation (8) is useful to calculate 95% confidence interval of such difference. The term $z_{\alpha/2}$ denotes the standard normal percentile having a right-tail probability equal to $\alpha/2$ (in this case a 95% interval, α=0.05, $z_{\alpha/2}$ =1.96). ASE is the estimated standard error for the proportion difference and was calculated using equation (9); where p_{11}= proportion of subjects that answered 1 (yes) before knowing and 1(yes) after knowing, p_{22}= proportion of subjects that answered 2(no) before knowing and 2(no) after knowing that the product contained health promoting minerals and vitamins. A 95% confidence interval denotes that the calculated difference of proportions is 95% of the time correct, with an alpha level set at 0.05, which correspond to the 5% error allowed. When 0 is included in the confidence interval, then there is no significant difference.

$$p_{ij} = n_{ij} / N \quad \ldots\ldots (7)$$

$$(p_{+1} - p_{1+}) \pm z_{\alpha/2} (ASE) \ldots\ldots (8)$$

$$ASE = [\, p_{1+} x(1- p_{1+}) + p_{+1} x(1- p_{+1}) - 2x(p_{11} p_{22} - p_{12}p_{21}) / N\,]^{1/2} \ldots\ldots (9)$$

4.4 To Study on Shelf Life of Developed Product

The Mafai Jeen fruit candy were cut into 0.5 x 0.5 x 0.5 inch and individual wrapped using oriented polypropylene (OPP) film 25 μm thickness.

To consider the economics of the packaging materials and also the product deterioration characteristics, pouches made of the following materials were selected for shelf life studies; 30 μm OPP film and aluminum laminated foil pouches (Strongpack Public Co., Ltd., Bangkok). A total of 20 candy were packed (≈70 g/bag) in two different types of packaging material with dimensions of 18 cm x 13 cm., hermetically heat sealed on the edges and stored at 25 °C and 40 °C. The Mafai Jeen fruit candy samples were withdrawn periodically in order to monitor;

4.4.1 Moisture Content

Moisture content of the product was measured using the methods of Association of Official Analytical Chemists (AOAC, 1990).

4.4.2 Water Activity (a_w)

The water activity of Mafai Jeen fruit candy was determined at 25 °C using Thermoconstanter (Novasina, MLK, Switzerland), equipped with a temperature-controlled system which allow to have a temperature stable sampling environment. The equipment was calibrated with saturated salt solution in the a_w range of 0.43 – 0.75 (Favetto *et al.*, 1983). For each determination, five replication were obtained and the average reported; under these conditions reliability of this meter is about ±0.003 a_w.

4.4.3 Color Assessment

The color of Mafai Jeen fruit candy was measured with a tristimulus reflectance colorimeter using a spectrophotometer (CM 3500d, Minolta Camera Co., Ltd, Tokyo, Japan). Three replicates of 10 pieces were used for each storage time sample. Color is recorded using a CIE – L^* a^* b^* uniform color space, where L^* indicates lightness on o (black) to 100 (white), a^* indicates chromaticity on a green (-) to red (+) axis, and b^* chromaticity on a blue (-) to yellow (+) axis.

4.4.4 Sensory Analysis

To obtain consumer acceptance of Mafai Jeen fruit candy stored at different temperatures and time, fifty untrained consumers, consisting of employees, students and faculty members, were recruited from the Kasetsart University for the consumer test. Panelists were recruited if (a) they are not allergic to fruit candy, (b) their ages are between 19 and 65 years, and (c) they eat fruit candy products at least once a month. Consumers who participated in one of the consumer tests did not necessarily participate in another test. Consumers recorded their answers on paper ballots in terms of overall acceptance, as well as acceptance of color, taste, and texture, using a 9-point hedonic scale, with 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely (Peryam, 1964).

RESULTS AND DISCUSSION

1. To Identify the Aroma Compounds of Mafai Jeen

1.1 The Aroma Compounds of Fruits, Seeds, and Leaves

In order to detect the “true” fragrance composition experienced by the consumers, a headspace sampling technique was performed in this experiment. Over 72 compounds were isolated and over 60 characterized from their retention index, mass spectra and data from the literature. The aroma compounds of leaves, flesh, skin of fruit and seeds are summarized in Table 5, which shows that these compounds were found in different percentages in the various parts of the plant. The majority of these components were found to belong to the hydrocarbon fraction, with percentages ranging from 50% in the leaves, 77% in the flesh, to 96% in the skin and 99% in the seeds. Among the components of the hydrocarbon fraction, the predominant compounds were found to be sesquiterpenes in the leaves, and monoterpenes in the flesh, skin and seeds.

A total of 39 components were identified in the headspace of leaves, amounting to 86% of the total volatiles. The sample was dominated by the sesquiterpenes (28%), with β-bisabolene, β-caryophyllene, and α-zingiberene as the main components. Monoterpenes were fewer (22%) with sabinene (15%) as the main component. In addition to the hydrocarbons, an ester, 3-hexenyl 2-methylbutanoate (0.19%), along with its alcohol, 3-hexen-l-ol (0.l7%) was characterized in the headspace of leaves. The compounds 3-hexen-1-ol and its acetate were often found in green leaves (Hatanaka, 1993). Sesquiterpenes, β-caryophyllene (7.72%) and humulene (0.39%), and an ester (3-hexenyl 2-methylbutanoate, 0.19%) were released in response to the attack by the insect of *Spodoptera* in cotton plantlets (Loughrin *et al.,* 1994). Camciuc *et al.* (1998) proposed that the biological activity of some of these compounds seems to support the hypothesis of their role in defence against insects. The monoterpenes and esters present in Mafai Jeen leaves may act as solvents and also have a synergic action with molecules having irritant properties. Interestingly, significant amount of *ar*-curcumene (1.27%), α-zingiberene (6.52%) and β-bisabolene (9.88%) were characterized in the headspace of leaves as well. Rani (1999) reported that the essential oil from the rhizomes of *Zingiber officinale* Roacoe contains *ar*-curcumene (20%), α-zingiberene (22%) and β-bisabolene (14%). He postulated that bisabolyl cation may be derived from farnesylpyrophosphate. Bisabolyl cation is the penultimate precursor of *ar*-curcumene, α-zingiberene and β-bisabolene; and two 1,2-hydrogen shifts lead to the formation of α-zingiberene whereas one 1,2-hydrogen shift leads to the formation of *ar*-curcumene. The chemical composition of the essential oil obtained from the rhizomes of *Z. officinale* Roscoe was characterized by the presence of *ar*-curcumene (22.1%), zingiberene (11.7%), beta-bisabolene (11.2%) and cadina-l,4-diene (12.5%). It is reasonable that in Sri Lanka (Kumar *et al.,* 1995) the leaves are used as a substitute for curry leaf in cooking.

Monoterpenes constituted the major part of the fragrance emitted from Mafai Jeen flesh, skin and seed. The monoterpene hydrocarbon fraction (76%) dominated the flesh, with sabinene (50.6%) and 1,4-cyclohexadiene (6.2%) as the main components. The alcohol fraction represented 17.5% of the total volatiles with 3-cyclohexen-1-ol (15%) as the major component.

In the skins, 30 components could be identified, amounting to 96.7% of the total volatiles. The sample was dominated by the monoterpenes (94%), with sabinene (69%), α-phellandrene (10.6%), and α-pinene (9.4%) as the main components.

In the seeds, 26 components could be identified, amounting to 99% of the total volatiles. The sample was dominated by the monoterpenes (98%), with sabinene (84%), α-pinene (4.3%), α-phellandrene (3.1%), and myrcene (2.9%) as the main components.

Table 5 Volatile compounds identified in Mafai Jeen (leaf, flesh, skin of fruit, and seed) using headspace sampler with HP-5MS non-polar column.

No	Compounds	RI	% Relative peak area				ID
			Leaf	Flesh	Skin	Seed	
Monoterpene hydrocarbons							
1.	tricyclene	928	*t*	*t*	0.03	*t*	MS, RI_1
2.	α-thujene	931	*t*	*t*	0.02	0.59	MS, RI_1
3.	α-pinene	939	1.99	2.08	9.41	4.26	MS, RI_1
4.	camphene	945	0.98	*t*	0.47	0.04	MS, RI_1
5.	β-pinene	967	*t*	0.21	0.17	*t*	MS, RI_1
6.	limonene	1026	*t*	0.21	*t*	*t*	MS, RI_1
7.	myrcene	993	1.10	1.70	3.15	2.94	MS, RI_1
8.	α-phellandrene	1001	1.38	5.03	10.63	3.08	MS, RI_1
9.	3-carene	1010	*t*	*t*	0.10	*t*	MS, RI_1
10.	(+) 4-carene	1018	*t*	3.98	0.40	1.13	MS, RI_1
11.	sabinene	973	14.92	50.64	69.07	83.56	MS, RI_1
12.	trans-β-ocimene	1035	*t*	*t*	*t*	0.02	MS, RI_1
13.	1,3,6-octatriene	1039	1.96	*t*	0.06	*t*	MS, RI_1
14.	1,4-cyclohexadiene	1043	*t*	6.19	0.32	*t*	MS, RI_1
15.	γ-terpinene	1057	*t*	*t*	0.04	1.95	MS, RI_1
16.	cyclohexene	1065	*t*	6.50	0.17	0.39	MS, RI_1
	total		22.34	76.54	94.05	97.96	
Sesquiterpene hydrocarbons							
1.	copaene	1373	0.28	*t*	*t*	*t*	MS, RI_1
2.	β-caryophyllene	1417	7.72	*t*	*t*	0.55	MS, RI_1
3.	α-bergamotene	1427	0.71	*t*	0.20	0.03	MS, RI_1
4.	(+)-aromadendrene	1436	0.08	*t*	*t*	*t*	MS, RI_1
5.	isosativene	1441	0.38	*t*	0.07	0.01	MS, RI_1
6.	β-santalene	1444	*t*	*t*	0.02	*t*	MS, RI_1
7.	α-humulene	1447	0.39	*t*	0.02	0.03	MS, RI_1

(Continued)

Table 5 (Continued)

No	Compounds	RI	% Relative peak area				ID
			Leaf	Flesh	Skin	Seed	
8.	ar-curcumene	1475	1.27	0.12	0.87	0.03	MS, RI_1
9.	allaromadendrene	1478	*t*	*t*	0.10	*t*	MS, RI_1
10.	α-zingiberene	1486	6.52	*t*	*t*	0.06	MS, RI_1
11.	bicyclogermacrene	1490	0.37	*t*	*t*	0.01	MS, RI_1
12.	α-farnesene	1494	*t*	*t*	0.95	*t*	MS, RI_1
13.	β-bisabolene	1496	9.88	*t*	*t*	0.15	MS, RI_1
14.	β-sesquiphellandrene	1512	0.70	*t*	0.30	*t*	MS, RI_1
15.	*δ*-cadinene	1524	0.33	*t*	*t*	*t*	MS, RI_1
	total		27.69	0.12	2.22	0.85	
Alcohols							
1.	ethanol		*t*	2.46	*t*	*t*	MS
2.	1-penten-3-ol		1.89	*t*	*t*	*t*	MS
3.	cis 2-pentenol		0.71	*t*	*t*	*t*	MS
4.	3-hexen-1-ol	857	0.17	*t*	*t*	*t*	MS, RI_1
5.	linalool	1086	2.25	*t*	0.16	*t*	MS, RI_1
6.	3-cyclohexen-1-ol	1097	*t*	15.07	0.28	0.51	MS, RI_1
7.	3-cyclohexen-1-methanol	1106	*t*	*t*	0.02	*t*	MS, RI_1
8.	β-fenchyl alcohol	1109	*t*	0.54	*t*	0.06	MS, RI_1
	total		5.02	18.06	0.46	0.57	
Aldehydes							
1.	propanal		1.63	*t*	*t*	*t*	MS
2.	butanal		8.61	*t*	*t*	0.02	MS
3.	hexanal	802	1.55	0.47	0.04	*t*	MS, RI_1
4.	2-hexenal	854	1.46	*t*	*t*	*t*	MS, RI_1
5.	benzaldehyde	958	2.56	*t*	*t*	0.02	MS, RI_1
6.	benzeneacetaldehyde	1037	0.30	*t*	*t*	*t*	MS, RI_1
	total		16.12	0.47	0.04	0.04	

(Continued)

Table 5 (continued)

No	Compounds	RI	% Relative peak area				ID
			Leaf	Flesh	Skin	Seed	
Esters							
1.	bornyl acetate	1286	*t*	*t*	*t*	0.01	MS, RI_1
2.	cis-3-hexenyl 2-methylbutanoate	1218	0.19	*t*	0.01	*t*	MS,RI_1
3.	geranyl acetate	1357	*t*	*t*	0.02	*t*	MS, RI_1
	total		0.19	0.00	0.03	0.01	
Ketones							
1.	2-propanone		3.02	*t*	*t*	*t*	MS, RI_1
2.	ethanone		0.20	*t*	*t*	*t*	MS,RI_1
3.	6-methyl-5-hepten-2-one	976	2.26	*t*	*t*	*t*	MS, RI_1
4.	2-nonanone	1079	3.42	*t*	*t*	0.01	MS, RI_1
5.	2-cyclohexen-1-one	1099	*t*	*t*	0.03	0.01	MS,RI_1
	total		8.90	0.00	0.03	0.02	
Heterocyclics							
1.	2-methylfuran		1.10	*t*	*t*	*t*	MS, RI_1
2.	2-ethylfuran		4.61	*t*	*t*	*t*	MS,RI_1
	total		5.72	0.00	0.00	0.00	
Carboxylic acids							
1.	acetic acid		0.94	2.65	0.08	0.03	MS, RI_1
2.	benzoic acid	1163	0.16	*t*	*t*	*t*	MS,RI_1
	total		1.10	2.65	0.17	0.03	
Hydrocarbons							
1.	styrene	921	0.13	*t*	*t*	*t*	MS, RI_1
2.	(E)-4,8-dimethyl-1,3,7-nonatriene	1089	1.22	*t*	*t*	*t*	MS, RI_1
3.	3-methyl-4-brendene	1095		0.13	*t*	*t*	MS,RI_1
	total		1.35	0.13	0.00	0.00	
	Total		86.18	97.44	96.73	99.42	
60	n		39	16	30	26	

RI = programmed temperature retention indices relative to the homo1ogous series of n-alkanes (C5-C25); RI_1 = retention data in literature; *t* = traces < 0.01%; ID = identification method

It should be noted that 1-phellandrene was abundant in all of the samples examined, α-pinene was more abundant in skin than in seed and flesh, whereas 3-cyclohexen-1-ol was distinctive component in the flesh. Sulfur-containing compounds could not be identified in any part of the samples examined. The composition of the volatile compounds of the leaves and seeds of *C. lansium* was distinctly different from that previously studied from Hainan Island, China (Zhao *et al*., 2004) by the absence of the β-santalol, bisabolol and ledol that represents the major volatile component in the leaves and seeds. The steam distillation procedure was applied in their experiment to obtain the essential oils from the flowers, leaves, sarcocarps and seeds of *C. lansium,* respectively. High boiling point alcohols, such as β-santalol (35.2%), bisabolol (13.7%) and ledol (6.5%) in leaves, were extracted under much higher temperature (boiling point of water) compared to the extraction conditions in this experiment (80 °C).

Sabinene (15%, 51%, 69% and 84% in leaf, flesh, skin and seed, respectively) was the major headspace volatile in Mafai Jeen. Sabinene was found to be extremely abundant in the plant and the fresh fruit essential oil of *Peucedanum verticillare* (Fraternale *et al.,* 2000). The emission of sabinene and limonene (trace amounts; see Table 5) was two to three times higher in the middle of the light cycle than it was in darkness in flowers and leaves of *Brassica napus* in situ (Jackobsen *et al.,* 1972). The essential oils from the leaves of *Clausena anisata* (Willd.) J.D. Hook ex Benth, were isolated and found to contain mainly sabinene (33.0%), germacrene-D (17.0%), Z-β-ocimene (6.0%), germacrene-B (5.5%), (E)-β-ocimene (4.9%) and terpinen-4-ol (4.7%) (Gundidza *et al.,* 1994).

The headspace composition of Mafai Jeen samples gives a better overall representation of the compounds detected by smell as compared with that of the steam distillate. The study successfully isolated and characterized the low-temperature volatile aromatic compounds in Mafai Jeen using the headspace sampling technique.

1.2 Aroma Compounds of Mafai Jeen Fruits by HS-SPME Analysis

The analysis of aroma compounds in Mafai Jeen fruits through solid phase microextraction has not been previously reported. However, the selection of an appropriate fiber depends on the compounds and the food to be analyzed. In this study, three types of coating were chosen: (1) DVB/CAR/PDMS, (2) PA, and (3) PDMS. Identified volatile compounds with their relative peak area are summarized in Table 6. In total, 88 compounds were detected in the Mafai Jeen aroma. The three fibers gave results that differed quantitatively with 27, 44, and 24 compounds absent from DVB/CAR/PDMS, PA and PDMS, respectively. Therefore using DVB/CAR/PDMS or PDMS fibers will give more information on the aroma of Mafai Jeen than PA fiber.

Inspection of Table 6 shows that the chemical classes found were: 15 monoterpene hydrocarbons, 23 sesquiterpene hydrocarbons, 16 alcohols, 5 aldehydes, 10 esters, 6 ketones, 1 sulfur–containing compound, 8 carboxylic acids, and 4 hydrocarbons. The most abundant compound was sabinene (22.5-37.2%). Other major constituents were α-farnesene, isosativene, and trans-β-farnesene. Twenty six of these compounds were found in all extracts. There were, 1S-α-pinene, myrcene, α-phellandrene, sabinene, isosativene, α-bergamotene, 1,4,7-cycloundecatriene, trans-β-farnesene, γ-curcumene, α-farnesene, 1H-3a,7-methanoazulene, trans-γ-bisabolene, linalool L, 2-cyclohexen-1-ol, 3-cyclohexen-1-ol, terpinene-3-ol, nerolidol, 5-isocedranol, cis-α-santalol, santalol, hexanal, α-sinensal, geranyl acetate, ethylic acid, acetic acid, and 2,6-octadienoic acid. Only some compounds were detected by PA; those were α-terpinene, terpinolene, β-santalene, trans-carvyl acetate, 2H-benzimidazol-2-one, methanone, and pentadecanoic acid. DVB/CAR/PDMS and PDMS fibers showed similarity in aroma compounds detected, i.e., camphene, β-pinene, (+)-4-carene, 1,3,6-octatriene, zingiberene, cis-α-bisabolene, α-terpineol, 2-cyclohexen-1-ol, β-santalol, 2-hexanal, cis-3-hexenyl 2-methybutanoate, sabinyl acetate, neryl acetate, 2-nonanone, piperitone isomer, and disulfide.

Table 6 Volatile aroma compounds identified in the Mafai Jeen fruit in order of their retention time (t_R) using SPME with 100 μm polydimethylsiloxane (PDMS), 85 μm polyacrylate (PA), and 50/30 μm divinylbenzene/carboxen/PDMS (DVB/CAR/PDMS) fibers coupled to GC–MS.

No.	Compounds	MW	t_R	% Relative peak area		
			(Min)	DVB/CAR/PDMS	PA	PDMS
Monoterpene hydrocarbons						
1	α-thujene	136	8.649	0.03	-	-
2	α-pinene	136	8.895	0.90	0.59	1.91
3	camphene	136	9.457	0.06	-	0.09
4	β-pinene	136	10.611	0.03	-	0.06
5	myrcene	136	11.328	1.51	0.60	1.28
6	α-phellandrene	136	11.871	4.39	2.10	4.36
7	δ-3-carene	136	12.083	-	-	0.04
8	α-terpinene	136	12.362	-	0.08	-
9	(+)-4-carene	136	12.386	0.52	-	0.31
10	sabinene	136	13.170	32.78	22.50	37.20
11	1,3,6-octatriene	136	13.867	0.10	-	0.04
12	1,4-cyclohexadiene	136	14.276	-	0.20	0.31
13	γ-terpinene	136	14.305	0.43	-	-
14	cyclohexene	136	15.632	0.25	-	-
15	terpinolene	136	15.632	-	0.10	-
	total			41.00	26.16	45.61
	n			11	7	10
Sesquiterpene hydrocarbons						
1	δ-elemene	204	26.250	0.02	-	-
2	zingiberene	204	27.520	0.64	-	0.09
3	isosativene	204	28.424	7.65	4.12	8.43
4	α-bergamotene	204	28.828	2.03	1.59	2.23

(Continued)

Table 6 (Continued)

No.	Compounds	MW	t_R (Min)	% Relative peak area DVB/CAR/PDMS	PA	PDMS
5	β-sesquiphellandrene	204	29.025	0.64	0.55	-
6	β-santalene	204	29.250	-	0.27	-
7	2-methyl-3-methylene	204	29.150	-	-	0.18
8	1,4,7-cycloundecatriene	204	29.318	0.38	0.28	0.33
9	trans-β-farnesene	204	29.448	7.14	4.10	7.90
10	α-longipinene	204	29.684	-	-	0.06
11	γ-curcumene	204	30.020	0.86	0.80	0.95
12	β-cubebene	204	30.083	-	0.10	0.18
13	1,6,10-dodecatriene	204	30.165	-	-	0.09
14	α-farnesene	204	30.833	14.64	11.72	15.11
15	1H-3a,7-methanoazulene	204	30.972	1.59	1.81	0.15
16	trans-γ-bisabolene	204	31.016	0.48	0.25	3.22
17	β-himachalene	204	31.035	2.61	-	-
18	γ-1-cadinene	204	31.194	-	-	0.11
19	cis-α-bisabolene	204	31.655	0.31	-	0.08
20	β-bisabolene	204	31.665	-	1.08	0.47
21	γ-elemene	204	32.809	-	-	0.05
22	α-cedrene	204	33.882	-	-	0.15
23	italicene	204	33.882	-	-	0.06
	total			39.00	26.67	39.81
	n			14	12	20
Alcohols						
1	ethanol	46	1.556	0.05	-	-
2	linalool L	154	16.281	1.78	0.76	0.51

(continued)

Table 6 (continued)

No	Compounds	MW	t_R (Min)	% Relative peak area DVB/CAR/PDMS	PA	PDMS
3	2-cyclohexen-1-ol	154	17.128	0.14	0.45	0.24
4	1-terpineol	154	17.969	0.12	0.16	-
5	3-cyclohexen-1-ol	154	19.729	3.10	1.10	0.84
6	α-terpineol	154	20.340	0.16	-	0.04
7	terpinene-3-ol	154	21.085	0.11	0.15	0.08
8	nerol	154	21.980	0.12	-	-
9	trans-geraniol	154	23.033	0.33	0.21	-
10	2-cyclohexen-1-ol	194	25.904	0.42	-	0.21
11	nerolidol	222	32.160	1.29	1.28	1.13
12	5-isocedranol	220	34.699	0.64	0.89	0.64
13	cis-α-santalol	220	35.324	0.58	0.85	0.80
14	β-santalol	220	35.858	0.16	-	0.22
15	santalol	220	38.277	0.10	3.18	1.60
16	phenol	228	44.784	-	7.36	1.63
	total			9.11	16.38	7.94
	n			15	11	12
Aldehydes						
1	hexanal	100	4.682	0.18	0.06	0.03
2	2-hexanal	98	6.120	0.50	-	0.02
3	nonanal	142	16.440	0.11	-	-
4	decanal	156	19.104	-	-	0.03
5	α-sinensal	218	36.531	0.25	0.51	0.39
	total			1.04	0.57	0.47
	n			4	2	4
Esters						
1	cis-3-hexenyl iso-butyrate	170	18.296	0.07	-	-

(continued)

Table 6 (continued)

No.	Compounds	MW	t_R (Min)	% Relative peak area DVB/CAR/PDMS	PA	PDMS
2	cis-3-hexenyl 2-methybutanoate	184	22.191	0.14	-	0.04
3	sabinyl acetate	194	25.740	0.31	-	0.10
4	trans-carvyl acetate	194	25.899	-	0.12	-
5	neryl acetate	196	26.745	0.61	-	0.28
6	geranyl acetate	196	27.327	1.31	0.34	0.64
7	cis-3-hexenyl benzoate	204	32.338	0.04	-	-
8	sesquisabinene hydrate	222	32.559	-	0.66	0.61
9	diethyl phthalate	222	32.891	-	0.89	0.12
10	(+)-methyl (E) α-santalenoate	248	37.440	-	0.09	0.11
	total			2.49	2.10	1.89
	n			6	5	7
Ketones						
1	ethyl vinyl ketone	84	2.739	0.02	-	-
2	2-nonanone	142	15.877	0.07	-	0.02
3	2-cyclohexen-1-one	138	20.128	0.15	-	-
4	piperitone isomer	154	20.542	0.08	-	0.05
5	2H-benzimidazol-2-one	148	26.895	-	5.21	-
6	methanone	182	33.521	-	0.20	-
	total			0.32	5.41	0.07
	n			4	2	2
Sulfur-containing compounds						
1	disulfide	146	15.175	0.11	-	0.03
	total			0.11	0.00	0.03
	n			1	0	1

(continued)

Table 6 (continued)

No.	Compounds	MW	t_R (Min)	% Relative peak area DVB/CAR/PDMS	PA	PDMS
Carboxylic acids						
1	ethylic acid	60	2.153	0.06	0.08	0.02
2	acetic acid	196	24.134	0.72	0.17	0.39
3	2,6-octadienoic acid	182	25.442	0.92	0.21	0.42
4	dodecanoic acid	200	32.054	-	-	0.07
5	tetradecanoic acid	228	36.647	-	-	0.13
6	pentadecanoic acid	242	38.734	-	0.13	-
7	2-propenoic acid	290	39.431	0.08	-	-
8	n-hexadecanoic acid	256	40.706	-	0.50	0.18
	total			1.78	1.08	1.20
	n			4	5	6
Hydrocarbons						
1	styrene	104	7.317	0.02	-	-
2	9-ethoxyphenanthrene	222	36.945	-	-	0.16
3	A-phellandrene epoxide	152	22.297	0.08	-	-
4	caryophyllene oxide	220	32.694	-	-	0.18
	total			0.10	0.00	0.34
	n			2	0	2
88	Total identified			94.95	78.36	97.37
	Total identified compounds per fiber			61	44	64

A total of 61 compounds were identified with DVB/CAR/PDMS fiber, amounting to 95% of the total volatile. The sample was dominated by the monoterpene hydrocarbons fraction (41%), with sabinene (33%) and α-phellandrene (4%) the main compounds. The sesquiterpene hydrocarbons fraction was fewre (39%) with α-farnesene (15%), isosativene (8%), and trans-β-farnesene (7%) as the main components.

It could identify 44 compounds with PA fiber, amounting to 78% of the total volatile. The sample was dominated by monoterpene and sesquiterpene hydrocarbons at approximately the same percentage relative area of 26–27%. Sabinene (22%), and α-farnesene (12%) were the main components. The alcohols fraction represented 16% of the total volatile with phenol (7%) as the major compound.

Sixty-four compounds could be identified with PDMS fiber, amounting to 97% of the total volatile. The sample was dominated by the monoterpene hydrocarbons fraction (46%) with sabinene (37%) and α-phellandrene (4%) the main compounds similar to DVB/CAR/PDMS fiber.

The distribution of chemical classes (monoterpene hydrocarbons, sesquiterpene hydrocarbons, alcohols, aldehydes, esters, ketones, sulfur–containing compounds, carboxylic acids, and hydrocarbons) of aroma compounds in mafai jeen fruit obtained through the usage of three fiber coatings are shown in Figure 4. PDMS

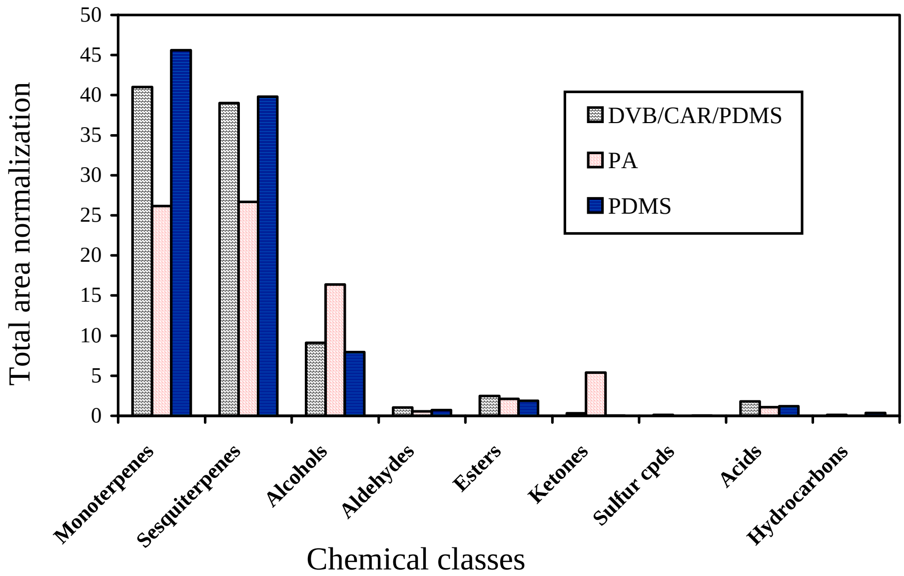


Figure 4 Distribution of chemical classes of aroma compounds in Mafai Jeen fruit by DVB/CAR /PDMS, PA, and PDMS fibers.

and DVB/CAR/PDMS showed a slightly different pattern among aroma compounds detected (Table 6 and Figure 4). The percentage of alcohols and ketones distributed in PA was higher than in PDMS and DVB/CAR/PDMS.

HS-SPME is an appropriate tool for qualitative and quantitative analysis of aroma compounds that varied according to the fiber coating used. Therefore, it is necessary to carefully select the fiber coating depending on the objective of the study.

2. To Study Effect of Drying Methods on the Mafai Jeen Qualities

2.1 Effect of Drying Conditions on Qualities of Dried Mafai Jeen

In this study, the effect of drying method on drying rate of Mafai Jeen was evaluated. It was found that visual appearance (attractive color) of vacuum dried Mafai Jeen sample was better than sun dried and hot air dried samples (see appendix Figure C1). When the experimental data of moisture content vs drying time were plotted, concave downward curves were obtained. These are typical of the drying curves obtained during drying. The results were generally in agreement with some literature studies on drying of various food products (Madamba *et al*., 1996; Senadeera *et al*., 2003; Yaldiz and Ertekin, 2001). Figure 5 shows the various drying

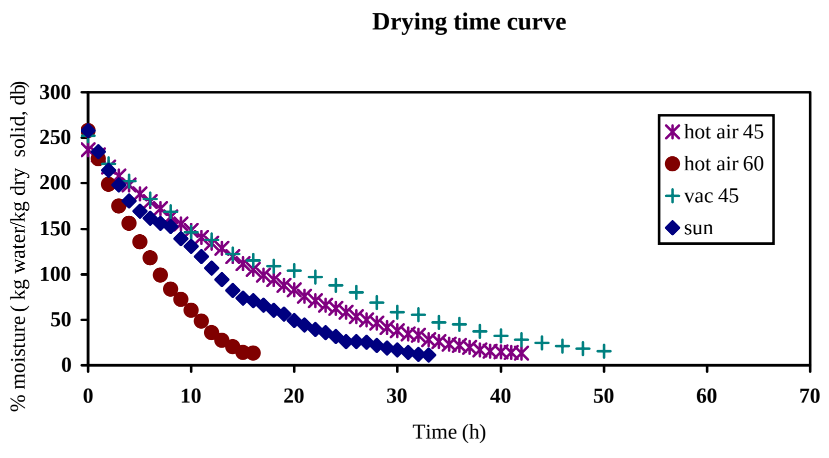


Figure 5 Drying time curve at different drying methods (sun drying, vacuum drying at 45 °C, hot air drying at 45 °C, and hot air drying at 60 °C).

methods. It can be seen that the increase in temperature from 45 °C to 60 °C hot air drying, reduced the time needed to reach equilibrium moisture content. This is according to kinetic theory, due to the increased energy of water molecules as temperature was increased. Hence, escaping of molecules became easier and faster from the medium.

Drying time in order to reach moisture content of about 14% wet basis (0.16 kg water/kg dry solid) was 17, 32, 42, and 50 h by hot air drying at 60 °C, sun drying, hot air drying at 45 °C, and vacuum drying at 45 °C, respectively. This moisture content was selected since it is the final moisture content of commercial dried Mafai Jeen product. It has also been speculated (Karel *et al.,* 1994) that moisture contents at or below 15% (wet basis) for most fruit is a rather safe indication that there is no microbial or mould growth and the reaction rate of a number of other deteriorative reactions (sugar crystallization, non-enzymatic browning, flavor deterioration, lipid oxidation, etc) is significantly reduced.

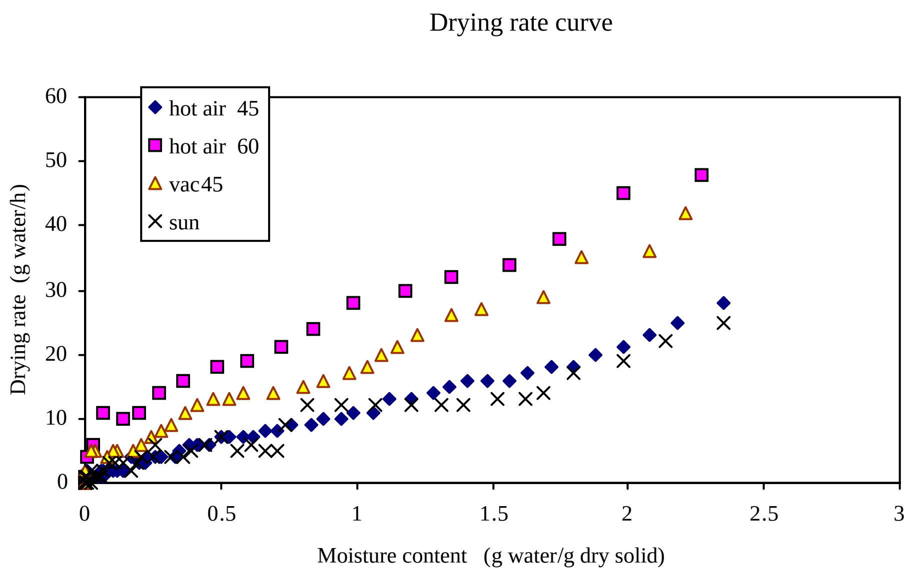


Figure 6 Drying rate curves for Mafai Jeen at different drying methods (sun drying, vacuum drying at 45 °C, hot air drying at 45 °C, and hot air drying at 60 °C).

The drying rate was determined from the slopes of the moisture content vs drying time curves, at each measurement point. The variation of the drying rates against moisture content are shown in Figure 6 for sun dry, vacuum dry at 45 °C, hot air dry at 45 °C, and hot air dry at 60 °C. It was found that the drying rate decreases continuously with decreasing temperature. A constant rate period was observed in sun drying of the Mafai Jeen samples. A comparison of the drying rates for the drying method obtained in experiment were hot air drying at 60 °C higher than vacuum drying at 45 °C, hot air drying at 45 °C and sun drying respectively.

2.1.1 Changes in Product Color

Non-enzymatic reaction or the Maillard reaction, is often the limiting factor of dehydrated foods, particularly those with intermediate moisture content (Marty-Audouin *et al.,* 1999). The Maillard reaction occurs when foods are heat-treated. Parameters affected in the Maillard reaction are primarily temperature and the duration of heat treatment. The retention of color can be a quality indicator to evaluate the extent of deterioration due to thermal processing (Avila and Silva, 1999). Change of color and total change value are shown in Table 7.

Table 7 Changes of color L^* a^* b^* values and total change (ΔE) for Mafai Jeen at different drying methods (sun drying, vacuum drying at 45 °C, hot air drying at 45 °C, and hot air drying at 60 °C).

Samples	Color change			
	ΔL^*	Δa^*	Δb^*	ΔE
Sun drying	-10.43	4.06	-6.10	12.75
Vacuum drying, 45 °C	-4.96	3.83	-2.10	6.61
Hot air drying, 45 °C	-12.07	2.10	-6.16	13.72
Hot air drying, 60 °C	-18.02	0.25	-11.71	21.49

Compared to the initial values L^* a^* b^* (38.95, 5.6, 17.94) of Mafai Jeen fresh fruit before drying, the ΔL^* values of hot air drying at 60 °C, hot air drying at 45 °C, sun drying, and vacuum drying at 45 °C decreased considerably to -18.02, -

12.07, -10.43, and -4.96, respectively. The respective net changes in product color, ΔE, were observed to be 21.49, 13.72, 12.75, and 6.61 for the same condition as ΔL^* values. Vacuum drying at 45 °C had 6.61 ΔE giving the best color dried Mafai Jeen but took the longest time to be dried. Sun drying had 12.75 ΔE which was a reasonable good color and also had a reasonable time of drying (32 h).

2.1.2 Proximate Analysis

The results of the chemical analysis performed on fresh and sun-dried fruit of Mafai Jeen are summarized in Table 8 The measure pH value of the fruit juice was 3.3, which corresponds with the high concentration of fruit acids and total soluble solid was 17.5 ^{o}Bx.

Table 8 Proximate composition of fresh and dried Mafai Jeen fruits.

Components (% by wt)	Fresh fruits	Sun-dried fruits
Water	71.97	16.34
Carbohydrate (by difference)	18.64	58.38
Fat	0.33	0.39
Fiber	4.58	8.42
Protein	1.88	7.56
Ash	2.6	8.91

2.1.3 Sensory Analysis

Sensory analysis scores of dried Mafai Jeen fruits are shown in Table 9. Mafai Jeen sample from sun drying was rated significantly higher than hot air drying and vacuum drying for aroma, flavor, texture and overall acceptance, except for color from vacuum drying which scored 7.6 or close to ‘Like very much’ and was higher than sun drying. The difference was particularly high with the special aroma of sun-dried fruit.

Table 9 Mean values for sensory evaluation of dried Mafai Jeen from different drying methods (sun dried, hot air dried at 45 °C, hot air dried at 60 °C, and vacuum dried at 45 °C).

Attributes	Sun-dried	Hot air dried 45 °C	Hot air dried 60 °C	Vacuum dried 45 °C
Color	6.8 ^{b}	6.9 ^{b}	5.4 ^{c}	7.6 ^{a}
Aroma	6.7 ^{a}	5.9 ^{b}	6.3 ^{ab}	5.9 ^{b}
Flavor	7.7 ^{a}	7.0 ^{b}	6.2 ^{c}	5.5 ^{d}
Texture	7.2 ^{a}	6.8 ^{a}	5.6 ^{b}	5.6 ^{b}
Overall acceptance	7.1 ^{a}	6.4 ^{b}	5.8 ^{c}	5.9 ^{c}

Mean in the same horizontal row with different superscripts are significantly different ($p< 0.05$).

2.2 Aroma Components of Mafai Jeen Fruit Treated by Different Drying Condition

The volatile fractions from Mafai Jeen fruit samples were isolated by hydro-distillation to obtain aroma compounds. They were transparent yellowish oils in the appearance, lighter than water and having a floral-fresh-lemon odor. the essential oil yield during extraction from vacuum dried sample compared to the oil obtained from

Table 10 Yields of oil in fresh fruit and dried Mafai Jeen by sun dried, vacuum dried at 45 °C, hot air dried at 45 °C, and hot air dried at 60 °C.

Sample No.	Fruit/sample	Moisture(%)	Essential oil (ml/100 g)	
			Dried fruit basis	Fresh fruit basis
1.	Fresh	72.05	0.11	0.11
2.	Sun-dried	15.75	0.50	0.16
3.	Vacuum dried at 45 °C	15.50	0.62	0.20
4.	Hot air dried at 45 °C	14.85	0.35	0.11
5.	Hot air dried at 60 °C	15.40	0.35	0.12

fresh fruit was about 82% higher. The yield of oil from Mafai Jeen fruit was 0.11 and 0.62 ml for 100 g fresh and vacuum dried fruits, respectively (Table 10). In order to study the effect of drying method on volatile compounds of Mafai Jeen fruit, the volatile compound in the essential oils of the fresh fruit was compared with these found in different drying method. Using the mass spectral matching against library standard. The results are shown in Table11.

Fifty-three compounds could be identified in all 5 essential oils of Mafai Jeen fruit, using GC-MS with a HP-5MS column which represent about 97.40-99.07% of the total relative area. The Mafai Jeen fruit essential oil consists a mixture of monoterpene hydrocarbons, sesquiterpene hydrocarbons, alcohols, aldehydes, ketones, carboxylic acids, and terpene oxides. No ester was detected in the examined fruit samples. All of Mafai Jeen oils were nearly similar in their main compositions. They consist mainly of monoterpene hydrocarbons (fresh fruit; 94.48%, hot air dried at 45 °C; 92.59%, hot air dried at 60 °C; 92.88%, vacuum dried at 45 °C; 94.13%, and sun-dried; 94.05%). The monoterpene hydrocarbons in fresh fruit, hot air dried at 45 °C, hot air dried at 60 °C, vacuum dried at 45 °C, and sun-dried oil were distinctly dominated by sabinene constituting about 66.73, 33.68, 41.13, 64.48 and 63.18% of the oils' composition, respectively. It is accompanied by significant amounts of α-pinene (11.74, 12.33, 12.02, 13.35, and 9.57%), α-phellandrene (7.25, 5.77, 6.15, 7.79, and 10.76%), and myrcene (4.27, 4.07, 4.50, 3.65, and 3.20%). Except of 2 samples; hot air dried at 45 °C and hot air dried at 60 °C were contained large amount of β-phellandrene 33.34 and 25.06% respectively. The aroma of fruits can change on heating due to the liberation of aroma substances from glycosidic precursors, oxidation, water addition, and cyclization of individual

Table 11 Volatile compounds identified in the Mafai Jeen essential oils; fresh fruit, hot air dried at 45 °C, hot air dried at 60 °C, vacuum dried at 45 °C, and sun-dried in order their retention time (t_R) using HP-5MS non-polar column.

Compounds	t_R (Min)	% Relative peak area				
		Fresh fruit	Hot air 45 °C	Hot air 60 °C	Vacuum 45 °C	Sun-dried
Monoterpene hydrocarbons						
1. d-limonene	9.029	-	-	-	-	0.03
2. tricyclene	9.144	-	-	-	0.04	-
3. α-thujene	9.433	-	-	0.04	0.05	-
4. α-pinene	9.750	11.74	12.33	12.02	13.35	9.57
5. camphene	10.274	0.54	0.73	0.65	1.09	0.76
6. β-pinene	11.520	-	-	-	-	0.10
7. myrcene	12.390	4.27	4.07	4.50	3.65	3.20
8. α-phellandrene	12.939	7.25	5.77	6.15	7.79	10.76
9. δ-3-carene	13.145	-	-	0.22	-	-
10. 3-carene	13.150	0.22	0.20	-	-	-
11. 4- carene	13.511	1.92	1.21	1.66	1.65	3.58
12. sabinene	14.400	66.73	33.68	41.13	64.48	63.18
13. β-phellandrene	14.526	-	33.34	25.06	-	-
14. β-fenchene	16.112	0.04	-	0.02	-	0.03
15. γ-terpinene	19.373	1.60	1.26	1.24	1.88	2.49
16. α-fenchene	19.676	0.17	-	0.19	0.15	0.18
17. trans-ocimene	27.380	-	-	-	-	0.17
total		94.48	92.59	92.88	94.13	94.05
Sesquiterpene hydrocarbons						
1. 1H-3a, 7-methanoazulene	29.606	-	-	-	0.04	0.19
2. isosativene	29.851	0.13	0.10	0.07	0.30	0.19
3. bergamotene	30.303	-	-	-	0.03	-

(continued)

Table 11 (continued)

Compounds	t_R (Min)	% Relative peak area Fresh fruit	Hot air 45 °C	Hot air 60 °C	Vacuum 45 °C	Sun-dried
4. tran-β-farnesene	30.924	-	-	-	-	0.05
5. naphthalene	31.443	-	0.10	0.05	-	-
6. α-muurolene	31.534	-	0.03	-	-	-
7. curcumene	31.650	0.03	-	-	-	-
8. β-biabolene	32.304	-	-	0.04	-	-
9. β-farnesene	32.314	-	-	-	0.04	-
10. cis-calamenene	32.679	-	0.04	-	-	-
11. δ-cadinene	32.679	-	-	0.02	-	-
12. valencene 2	34.208	-	-	-	0.03	-
13. aromadendrene	35.076	-	-	-	0.04	-
14. γ-curcumene	36.329	-	-	-	-	0.04
total		0.16	0.27	0.18	0.48	0.47
Alcohols						
1. 1-pentanol	7.576	-	0.05	-	-	-
2. 1-octanol	7.610	-	-	0.03	-	-
3. linalool	17.584	0.38	-	0.31	0.16	0.24
4. Fenchol	18.084	0.18	0.23	0.21	0.12	0.13
5. Isoborneol	20.590	0.05	-	0.06	-	0.08
6. 3-cyclohexen-1-ol	21.128	0.80	0.85	0.99	0.94	1.04
7. p-menth-2-en-1-ol	21.407	0.07	-	-	-	0.04
8. α-terpineol	21.835	1.18	1.23	1.17	1.00	1.79
9. Santalol	27.077	-	-	-	0.21	-
10. limonyl alcohol	27.076	0.07	-	0.07	-	-
total		2.73	2.36	2.84	2.43	3.32

(contnued)

Table 11 (continued)

Compounds	t_R (Min)	% Relative peak area Fresh fruit	Hot air 45 °C	Hot air 60 °C	Vacuum 45 °C	Sun-dried
Aldehydes						
1. α-campholene aldehyde	17.295	0.06	-	-	-	-
2. Benzaldehyde	24.023	-	-	0.05	-	-
3. Phellandral	25.278	-	0.07	-	0.08	0.19
total		0.06	0.07	0.05	0.08	0.19
Ketones						
1. Pulegone	20.984	0.13	-	-	0.15	-
2. 2-cyclohexen-1-one	21.566	1.02	1.34	1.07	0.90	0.43
3. Carvota acetone	24.244	-	-	-	-	0.05
4. Piperitone	24.518	0.08	-	0.13	-	-
total		1.23	1.34	1.20	1.05	0.48
Carboxylic acids						
1. acetic acid	25.591	0.13	0.11	0.07	0.14	0.17
total		0.13	0.11	0.07	0.14	0.17
Terpene oxides						
1. cis-linalool oxide	16.208	-	0.07	-	0.08	-
2. α-pinene oxide	17.295	0.06	-	-	-	-
3. cis-limonene oxide	19.041	0.10	0.13	0.09	0.10	-
4. phellandrene epoxide	22.378	0.12	-	0.09	0.09	0.12
total		0.28	0.20	0.18	0.27	0.12
Total identified		99.07	96.94	97.40	98.58	98.80

compounds (Belitz and Grosch, 1999) Monoterpene hydrocarbons are common components of traditional foods occurring in essentially all fruits and vegetables. *d*-limonene, β-myrcene, and terpinolene are currently recognized by the U.S. Food and Drug Administration (FDA) as GRAS ("generally regarded as safe") for their intended use as flavoring substances (Hall and Oser, 1965]. β-myrcene occur naturally in a wide variety of foods including lemon peel oil, orange peel oil, orange juice, and lime juice.

The major alcohols were α-terpineol (1.00-1.79%), 3-cyclohexen-1-ol (0.80-1.04%) and fenchol (0.13-0.23%). Only one compound of the sesquiterpene hydrocarbon; isosativene was presented in all of samples in small amounts (0.07-0.30%)

In the fresh fruit, it could identify 27 components in this oil, amounting to 99.07% of the relative area. Ten monoterpene hydrocarbons, 2 sesquiterpene hydrocarbons, 7 alcohols, 1 aldehyde, 3 ketones, 1 carboxylic acid, and 3 terpene oxides were found. The monoterpene hydrocarbons fractions (94.48%) dominated the essential oil sample. Sabinene (66.7%), α-pinene (11.7%), α-phellandrene (7.2%), and myrcene (4.3%) were the major components. The oxygenated components represented 4.3% of the total oil with α-terpineol (1.18%) and 2-cyclohexen-1-one (1.02%) as the main components. The sesquiterpene hydrocarbons were smaller with isosativene (0.13%) and curcumene (0.03%).

Three components; curcumene (0.03%), α-campholene aldehyde (0.06%), and α-pinene oxide (0.06%) were lossed or changed to other compounds after drying.

Thirteen components remaining after different drying method were; α-pinene, camphene, myrcene, α-phellandrene, 4- careen, sabinene, γ-terpinene, isosativene, fenchol, 3-cyclohexen-1-ol, α-terpineol, 2-cyclohexen-1-one, and acetic acid.

Probably, some of the identified compounds were formed or produced during drying and extraction of the samples, specially alcohols, and aldehydes. No relationship was found between the retention of volatile compounds by fresh fruit and different drying process. After vacuum drying, 7 new compounds; tricyclene (0.04%), 1H-3a,7-methanoazulene (0.04%), bergamotene (0.03%), β-farnesene (0.04%), valencene2 (0.03%), aromadendrene (0.04%), and santalol (0.21%) were produced.

After sun drying, 6 new compounds; d-limonene (0.03%), β-pinene (0.1%), trans-ocimene (0.17%), tran-β-farnesene (0.05%), γ-curcumene (0.04%), and carvota acetone (0.05%) were produced. After hot air drying at 60 °C, 5 new compounds; δ-3-carene(0.22%), β-biabolene (0.04%), δ-cadinene (0.02%), 1-octanol (0.03%), and benzaldehyde (0.05%) were produced.

After hot air drying at 45 °C, 3 new compounds; α-muurolene (0.03%), cis-calamenene (0.04%), and 1-pentanol (0.05%) were produced.

Earlier compositional studies of wild *C. lansium* essential oils in Hainan Island, China were found phellandrene (54.8%), limonene (23.6%), and *p*-menth-1-en-4-ol (7.5%) in the seed, β-santalol, 9-octadecenamide and sinensal in the flowers (Zhao *et al.*, 2004). Therefore, many of the volatile compounds identified using GC-MS are being reported for the first time.

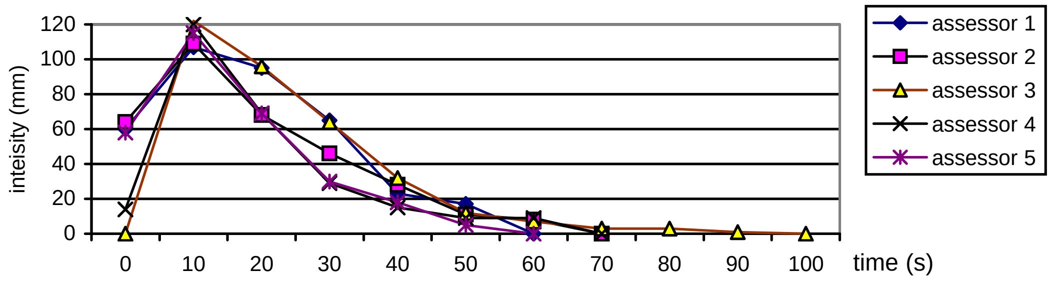
3. <u>To Study the Intensity of Astringent Taste of Mafai Jeen</u>

Initially, the individual TI curves for each of the 9 assessors for each of 6 samples were examined; a total of 54 curves. In Figure 7 a selected set of curves corresponding to tannic acid sol. 1 g/l, 25 °C. are presented for each assessor. The shapes of the curves are basically of 3 types:

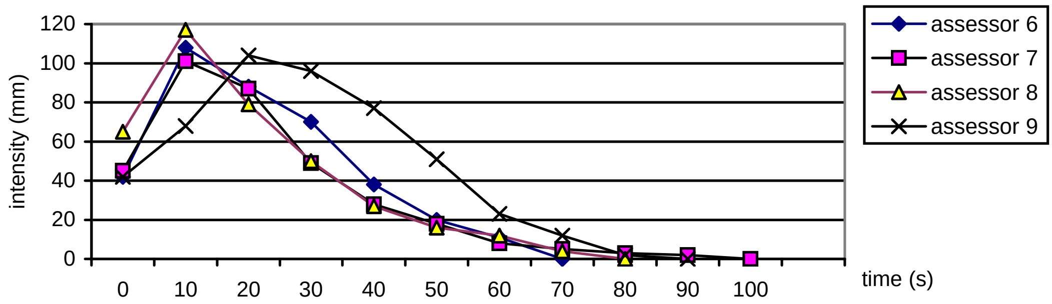
a. sharply curve, fast increasing from zero to maximum intensity, I max = 121 mm of astringency in 10s followed by decreasing as a normal curve (example, assessor 3, 4)

b. slow increasing to maximum intensity of astringency, 20s followed by slow decreasing at a rate of 24/s (example, assessor 9)

c. increasing to maximum intensity of astringency in 10s followed by fast decreasing at a rate of 42/s (example, assessor 1,2,5,6,7,8)



(a)



(b)

Figure 7 Time-intensity curves for a single assessment of tannic acid solution 1 g/l for each of 9 assessors. Increasing time-intensity scores are indicative of increasing astringency.

Time-intensity characteristic of tannic acid solution was determined at concentration of 1 g/l., average results of 9 assessors are shown in Table 12 and Figure 8. The astringency was perceived as nearly the same both at 7 and 25 °C. The maximum intensity of tannic acid solution were more than 106 mm. The maximum intensity was observed at within 10s after swallowing, some residual astringency was detected even after 100s after swallowing.

Table 12 Time-intensity course in astringent solutions ,the results of tannic acid solution (1 g/l) obtained with use of paper ballot 150 mm line scale.

Time interval recorded	Tannic acid 1g/l		Tannic acid 1g/l +sucrose 300g/l	
	at 7 °C (mm)	at 25 °C (mm)	at 7 °C (mm)	at 25 °C (mm)
0 s (In the mouth)	42	44	27	26
After 10 s	106	109	85	87
After 20 s	88	80	81	71
After 30 s	56	55	44	48
After 40 s	36	31	29	30
After 50 s	18	20	13	17
After 60 s	14	8	9	10
After 70 s	6	4	7	5
After 80 s	2	2	2	3
After 90 s	1	0	0	0
After 100 s	0	0		
I max(mm of scale)	106 [a]	109 [a]	85 [b]	87 [b]
T max (s)	10 [ns]	10 [ns]	10 [ns]	10 [ns]
T total (s)	100 [a]	90 [b]	90 [b]	90 [b]

Note: means with different superscripts within in the same row were significantly different ($p \leq 0.05$).

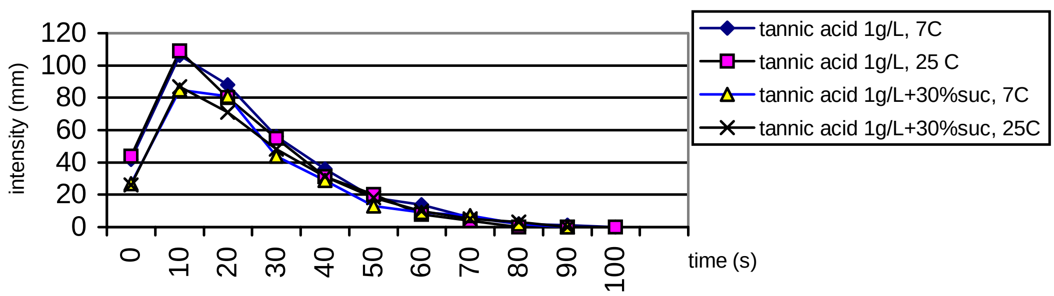


Figure 8 Time-intensity characteristics of tannic acid solution at 7 and 25 °C.

Resulted obtained using a solution of tannic acid 1 g/l added 30% of sucrose are average of 27 responses by the same person as in assessing the tannic acid solution. The maximum intensity was lower than in case of only one tannic acid solution in significantly. The maximum value was reached at 10s after swallowing, some residual astringency remaining even after 90s after swallowing. Sucrose was found to suppress the astringency feeling in human mouth may be due to the masking effect on the receptor of tongue.

Sweetness

As the level of sucrose was raised, all astringency TI parameters decreased significantly as illustrated in Figure 9 and Table 13 [I max : $F(3,320) = 10.674$, $P<0.0001$; T max : $F(3,320) = 4.153$, $P<0.0001$; T total : $F(3,320) = 7.809$,

Table 13 Time-intensity characteristics of dry Mafai Jeen with 0, 10, 20, and 30% sucrose.

Treatment	Maximum Intensity (mm)	Reduction rate of astringent (mm)	Time to maximum (s)	Time of disappearance of astringency (s)
0% sucrose	109 [a]	-	21 [a]	71 [a]
10% sucrose	97 [b]	-12	19 [ab]	64 [b]
20% sucrose	95 [bc]	-2	17 [b]	63 [b]
30% sucrose	89 [c]	-6	17 [b]	60 [b]

Note: means with different superscripts within in the same row were significantly different ($p \leq 0.05$)

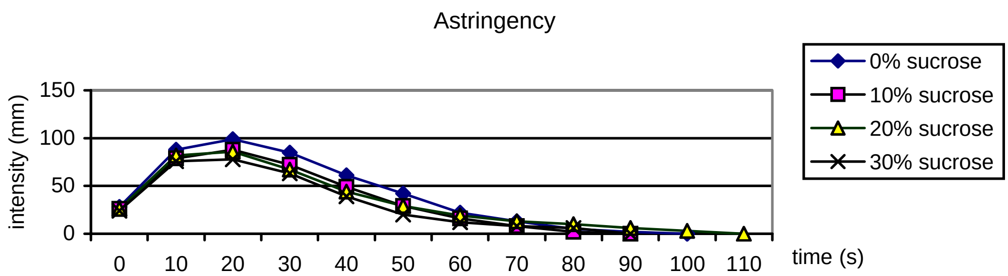


Figure 9 Time-intensity characteristics of dry Mafai Jeen with 0, 10, 20, and 30% sucrose.

P<0.0001]. Both astringency time to maximum and time of disappearance decreased significantly with increasing sucrose concentration. Significant negative correlations were found between astringency and sweetness.

Sourness

As illustrated in Figure 10 and Table 14, Time-intensity characteristics of dry Mafai Jeen with 0, 1, and 2% of ascorbic acid. As the ascorbic acid concentration was raised, all astringency TI parameters increased significantly.

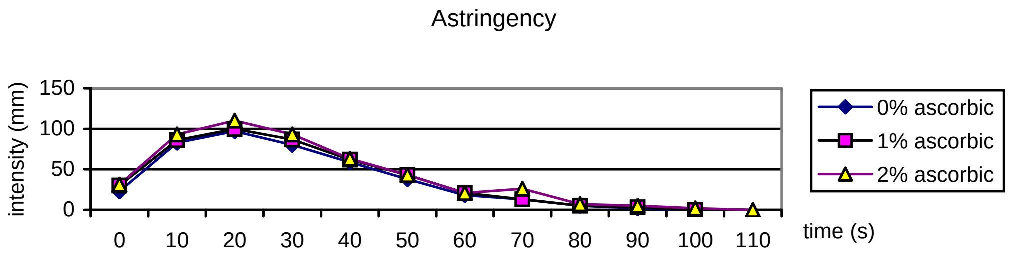


Figure 10 Time-intensity characteristics of dry Mafai Jeen with 0, 1, and 2% of ascorbic acid.

Table 14 Time-intensity characteristics of dry Mafai Jeen with 0, 1, and 2% of ascorbic acid.

Treatment	Maximum intensity (mm)	Increased rate of astringent (mm)	Time to maximum (s)	Time of disappearance of astringency (s)
0% Ascorbic acid	97 [b]	-	20 [a]	66 [b]
1% Ascorbic acid	102 [b]	+5	18 [b]	68 [b]
2% Ascorbic acid	111 [a]	+9	18 [b]	73 [a]

Note: means with different superscripts within in the same row were significantly different ($p \leq 0.05$).

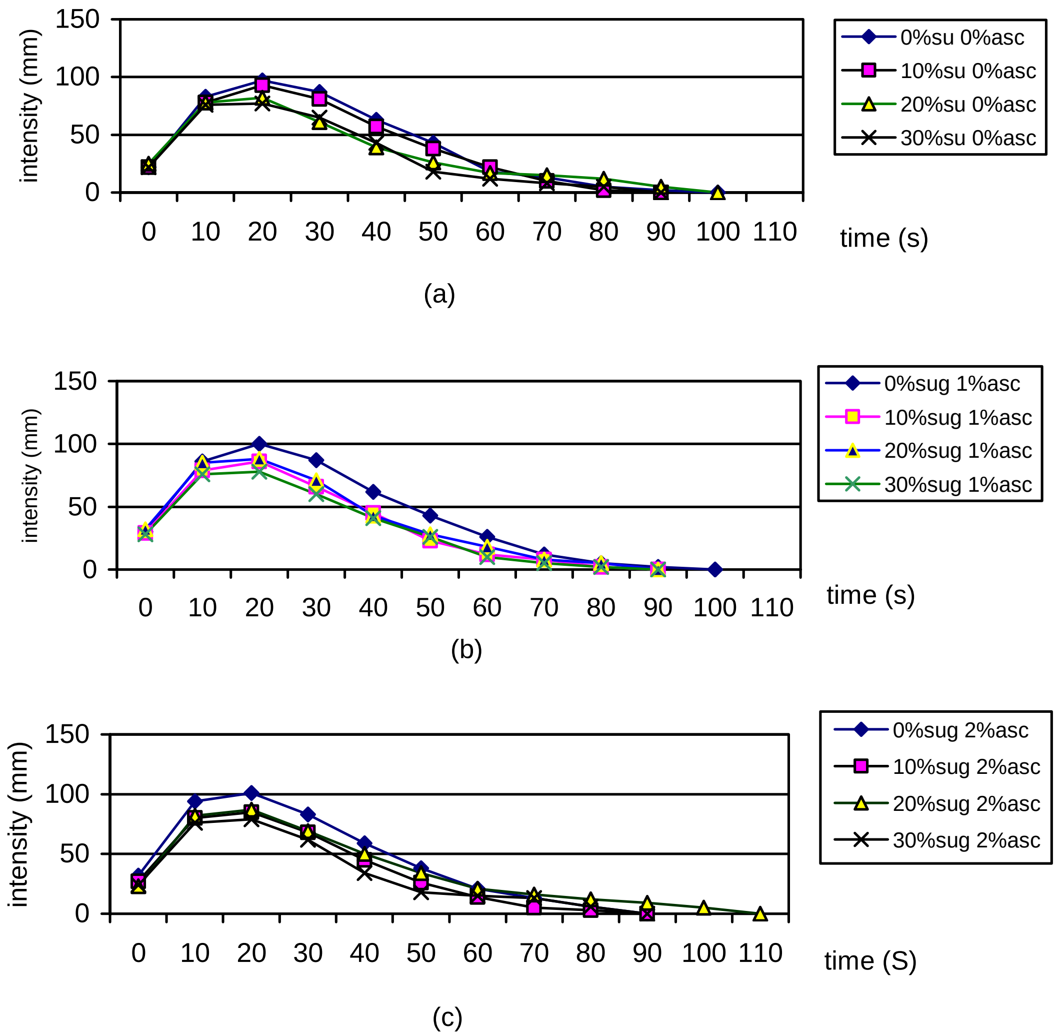


Figure 11 Time-intensity characteristics of dried Mafai Jeen at 0, 1, 2% ascorbic acid and 0, 10, 20, 30, 40% sucrose.

Dried Mafai Jeen contains significant amount of the sucrose (%) and ascorbic acid (%). Therefore, we studied the effect of this addition of sucrose and ascorbic acid on the intensity of astringent taste. The effect of the ingredients and their combinations on the maximum astringency (I max), the time to reach the maximum (T max), and the rate of disappearance of astringency are shown in Figure 11 and Table 15. It showed significant differences between the samples of difference composition of dried Mafai Jeen, when increasing sucrose, the astringency decreased significantly.

Table 15 Time-intensity of dried Mafai Jeen modified by additions of taste active substances.

Treatment	Maximum intensity (mm)	Intensity change (mm)	Time to maximum (s)	Time of disappearance of astringency (s)
0% sucrose, 0% ascorbic	106 [abc]	0	22 [a]	69 [abc]
10% sucrose, 0% ascorbic	99 [bcd]	-7	22 [a]	69 [abc]
20% sucrose, 0% ascorbic	94 [bcd]	-5	18 [ab]	62 [bcd]
30% sucrose, 0% ascorbic	90 [d]	-4	18 [ab]	64 [bcd]
0% sucrose, 1% ascorbic	107 [ab]	0	22 [a]	73 [a]
10% sucrose, 1% ascorbic	96 [bcd]	-11	17 [b]	60 [cd]
20% sucrose, 1% ascorbic	97 [bcd]	+1	17 [b]	61 [cd]
30% sucrose, 1% ascorbic	92 [cd]	-5	17 [b]	58 [d]
0% sucrose, 2% ascorbic	115 [a]	0	19 [ab]	70 [ab]
10% sucrose, 2% ascorbic	97 [bcd]	-18	18 [ab]	62 [bcd]
20% sucrose, 2% ascorbic	96 [bcd]	-1	18 [ab]	65 [abcd]
30% sucrose, 2% ascorbic	84 [d]	-12	16 [b]	58 [d]
Fresh fruit	109 [a]		19 [ab]	77 [a]

Note: means with different superscripts within in the same row were significantly different ($p \leq 0.05$).

Figure 12; illustrated the average curves for each assessor from dried Mafai Jeen. The data were averaged over approximately 36 individual curves. The shapes of the curves were 3 types:-

1) Assessor 2 and 5 evaluated astringency as high score and take long time to disappearance.
2) Assessor 7 found the time to maximum reaching fastest.
3) The curves of assessor 1, 3, 4, 6, 8, 9 were in the middle.

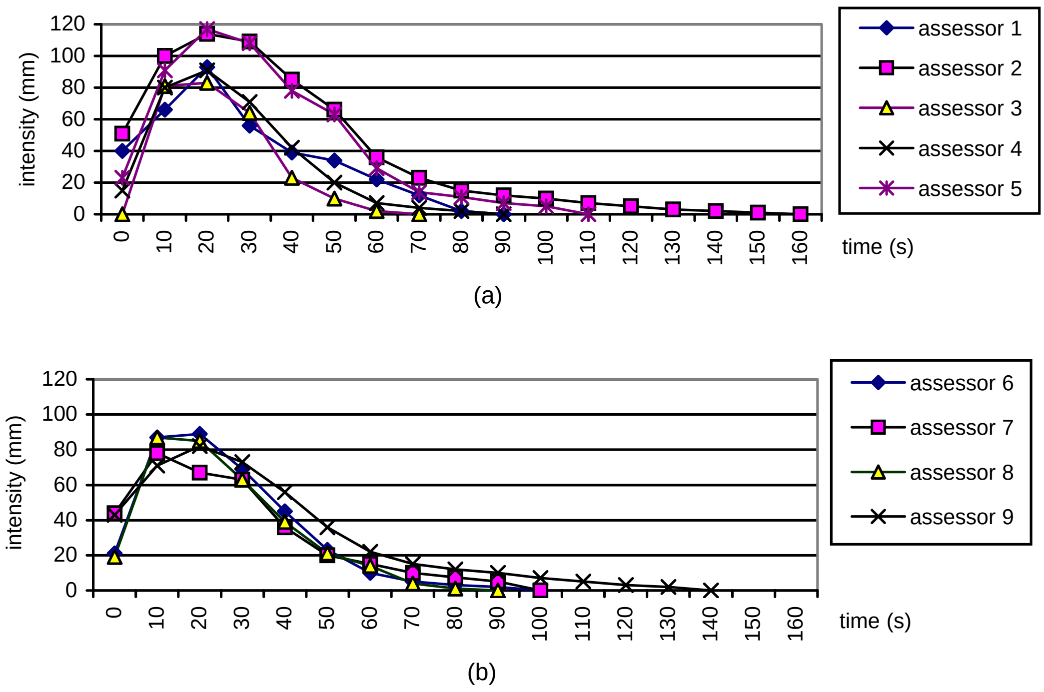


Figure 12 Average curves for each assessor from dried Mafai Jeen. Each curve is averaged over approximately 36 individual curves. Increasing time-intensity scores are indicative of increasing astringency.

4. To Develop Mafai Jeen Candy with Shelf Life Study

4.1 Plant Material Qualities

The chemical analysis on fresh fruit of Mafai Jeen showed that the measured pH value was 3.3 (Table 16). Therefore Mafai Jeen is considered to be a high acid food. It has acidity of 0.77%. The total soluble solid was also high at 14.5 ^{o}Bx, with 6.12% total sugar and 4.06% reducing sugar. The Mafai Jeen fruit is juicy and contained 71.91% moisture. It has light green and light yellow shade, color read as *L** *a** *b** were 38.95, 2.61, and 17.94, respectively.

Table 16 The qualities of fresh Mafai Jeen fruits for this experiments.

Qualities attribute		Mean values
pH		3.30 ±0.07
Total soluble solid (^{o}Bx)		14.50 ±1.40
Reducing sugar (%)		4.06 ±0.06
Total sugar (%)		6.12 ±0.08
Acidity (%)		0.77 ±0.01
Moisture (%)		71.91 ±1.83
Color	L^*	38.95 ±1.65
	a^*	2.61 ±0.17
	b^*	17.94 ±0.87

4.2 Development of Mafai Jeen Candy

4.2.1 Focus Group Discussion

The responses and conclusion for all question discussed in the focus group sessions were summarized as followed.

1) Consumers' perceptions of a healthy food.

The participant had different understanding about the perception of a healthy food. Some believed that a healthy food was a "varied and well balanced diet"; others believed that a healthy food was a "lot of fruits and vegetables". There was a strong agreement among respondents that a "healthy food" is foods as natural as possible without pesticides used in the production of a food.

2) If you were asked to make a suggestion to develop the Mafai Jeen fruit products, what would be your most suggested product?

During discussion, the products of the other fruit candy, tablets, and beverage were presented. Two-third of participants in all three groups mentioned fruit candy as the most suggested and all focus groups commented about the importance of improving accountability as the product should contain natural color or no artificial flavors, the least sucrose content, smooth mouth feel, and moderately sour taste. Convenience packed that are individually wrapped were preferred by most to minimize losses.

Some participants in all focus groups suggested to develop Mafai Jeen fruit tablet, Mafai Jeen fruit drink, Mafai Jeen tea,

One participant expressed an interest in exploring the possibility of allowing essential oils to be ingredient-based for hard candy.

3) Of all the new product we discussed, which one is most important attribute to you?

The product should be made from natural ingredient was most mentioned by participants in all focus groups.

The nutritional and healthy benefits of product were frequently mentioned.

4) Is there anything we should have talked about but didn't?

Some participants mentioned regulations. They would like the regulations to be clearer. They expressed a need for an explanation for the nutritional and healthy benefits to be provided on the product packaging.

A FGDs among of 3 sessions indicated that healthy natural Mafai Jeen candy product was required. The product should contain no synthetic color or artificial flavors, the least sucrose content, smooth mouth feel, and moderately sour taste.

4.2.2 The Sucrose and Glucose Syrup Concentration in the Recipe

The effect of glucose syrup and sucrose concentration on hardness, moisture, a_W, and color value were shown in Table 17. Glucose syrup concentration had no effect (p>0.05) on % moisture but reduced (p<0.05) hardness, a_W, color *L** value, and increased color *b** value. Sucrose concentration had no effect (p>0.05) on color *a** value, but reduced (p<0.05) hardness, moisture, color *L** value, and color *b** value. A significant (p<0.05) interaction between glucose syrup and sucrose concentration was also observed for hardness and color *L** value. Hardness values decreased while sucrose increased, the hardness value of Mafai Jeen fruit candy were 11.68-18.36. No significant interaction (p>0.05) was observed for moisture, a_W, color *a** value, and color *b** value.

The effect of glucose syrup and sucrose concentration on sensory attribute; color, taste, sweet, texture, and overall acceptance were shown in Table 18. Glucose syrup concentration had no effect (p>0.05) on color, but significant different (p<0.05) on taste, sweetness, texture, and overall acceptance. The mean scores of 5% glucose syrup showed the highest acceptance for all sensory attributes. Sucrose concentration had significant different (p<0.05) on color, taste, sweetness, texture, and overall acceptance. The mean scores of 35% sucrose shown the highest acceptance for all sensory attributes. No significant interaction (p>0.05) was observed for all sensory attributes.

In conclusion, the 35% of sucrose and 5% of glucose syrup were consider to used for furthered experiment in the next topic due to highest score in sensory acceptance test.

Table 17 Effect of glucose syrup and sucrose concentration on hardness, moisture, a_w, and color value of Mafai Jeen candy.

Treatment	Hardness	Moisture (%)	a_w	Color value *L**	*a**	*b**
A: Glucose syrup (%)						
0	17.39^{a}	6.44^{ns}	$.590^{a}$	52.42^{a}	1.77^{b}	22.80^{b}
5	13.84^{b}	6.47^{ns}	$.567^{b}$	51.25^{ab}	1.33^{b}	22.44^{b}
10	12.73^{c}	6.39^{ns}	$.578^{ab}$	49.88^{b}	3.37^{a}	27.41^{a}
Significant level	0.000	ns	0.031	0.033	0.003	0.000
B: Sucrose (%)						
20	18.36^{a}	7.22^{a}	$.603^{a}$	53.70^{a}	2.11^{ns}	27.19^{a}
25	16.36^{b}	6.95^{a}	$.593^{ab}$	52.15^{ab}	2.27^{ns}	25.72^{b}
30	13.83^{c}	6.51^{ab}	$.553^{c}$	51.72^{ab}	2.40^{ns}	24.35^{c}
35	13.03^{cd}	5.81^{b}	$.566^{bc}$	50.40^{b}	2.09^{ns}	22.70^{d}
40	11.68^{d}	5.69^{b}	$.572^{bc}$	47.91^{c}	1.92^{ns}	21.14^{e}
Significant level	0.000	0.014	0.013	0.004	ns	0.000
Interaction A x B						
Significant level	0.000	ns	ns	0.017	ns	ns
Glucose syrup / sucrose (%)						
0 / 20	21.01	7.71	0.628	55.28	2.49	24.94
0 / 25	19.77	6.39	0.608	53.57	2.21	24.79
0 / 30	17.35	6.82	0.583	52.85	1.82	22.82
0 / 35	14.98	5.77	0.561	51.34	1.41	21.26
0 / 40	13.85	5.53	0.573	49.06	0.94	20.23
5 / 20	17.92	7.49	0.591	52.04	1.62	26.73
5 / 25	14.83	7.11	0.584	51.30	1.53	23.72
5 / 30	12.46	6.13	0.541	52.67	1.45	22.29
5 / 35	13.08	5.68	0.566	51.92	1.22	20.91
5 / 40	10.94	5.94	0.553	48.35	0.87	18.58
10 / 20	16.15	6.46	0.605	53.90	2.22	29.92
10 / 25	14.49	7.35	0.589	51.59	3.09	28.65
10 / 30	11.70	6.58	0.535	49.65	3.94	27.95
10 / 35	11.05	5.99	0.571	47.95	3.65	25.94
10 / 40	10.27	5.61	0.592	46.34	3.97	24.62

abc, means followed by the different letter within a column are significantly different ($p \leq 0.05$).
ns, not different (no significant; p>0.05).

Table 18 Effect of glucose syrup and sucrose concentration on sensory attribute; color, taste, sweet, texture, and overall acceptance of Mafai Jeen candy.

Treatment	Color	Taste	Sweetness	Texture	Overall acceptance
A: Glucose syrup (%)					
0	6.19[ns]	5.14[b]	4.95[c]	4.81[c]	4.86[b]
5	6.34[ns]	6.38[a]	6.51[a]	6.69[a]	6.59[a]
10	6.13[ns]	5.67[ab]	5.45[b]	5.35[b]	5.17[b]
Significant level	ns	0.016	0.000	0.000	0.000
B: Sucrose (%)					
20	6.09[b]	4.92[b]	4.72[b]	4.71[d]	4.80[c]
25	5.87[ab]	5.18[b]	5.18[b]	5.23[cd]	5.01[c]
30	6.32[ab]	5.68[ab]	5.38[b]	5.63[bc]	5.62[b]
35	6.48[a]	6.48[a]	6.57[a]	6.51[a]	6.25[a]
40	6.33[ab]	6.38[a]	6.32[a]	6.02[ab]	6.04[ab]
Significant level	0.041	0.021	0.001	0.002	0.001
Interaction A x B					
	ns	ns	ns	ns	ns
Glucose syrup / sucrose (%)					
0 / 20	5.93	4.11	4.36	4.02	4.09
0 / 25	6.14	4.36	4.56	4.13	4.31
0 / 30	6.30	5.06	4.69	4.95	5.13
0 / 35	6.15	6.19	5.38	5.76	5.45
0 / 40	6.43	5.98	5.75	5.21	5.36
5 / 20	6.31	5.19	5.44	5.29	5.54
5 / 25	5.82	5.77	6.21	6.54	6.07
5 / 30	6..91	6.02	6.03	6.48	6.40
5 / 35	6.82	7.54	7.49	7.66	7.61
5 / 40	6.44	7.41	7.38	7.52	7.34
10 / 20	6.03	5.47	4.36	4.84	4.77
10 / 25	5.65	5.42	4.79	5.03	4.63
10 / 30	6.35	5.98	5.42	5.46	5.33
10 / 35	6.49	5.71	6.85	6.10	5.70
10 / 40	6.13	5.77	5.83	5.34	5.42

abc, means followed by the different letter within a column are significantly different ($p \leq 0.05$).
ns, not different (no significant; p>0.05).

4.2.3 The Thickening Agent for Mafai Jeen Fruit Candy

The texture of Mafai Jeen fruit candy product was an important factor for the consumer acceptance of Mafai Jeen fruit candy, so the thickening agent has been used for improved the texture acceptance. Three type of thickening agent; maltodextrin DE 10, pectin (150grade), and CMC (PM 7) were used in this study. The rank sum of preference test of Mafai Jeen fruit candy for 15 samples, various concentration of 0.5%, 1.0%, 1.5%, 2.0%, and 2.5% (w/w Mafai Jeen puree) were shown in Table 19.

Table 19 The rank sum of preference for three thickening agent added in Mafai Jeen fruit candy.

Thickening agent	Concentration (%)				
	0.5	1.0	1.5	2.0	2.5
Maltodextrin DE 10	121^{c}	132^{c}	87^{bc}	42^{a}	67^{b}
Pectin(150grade)	129^{c}	116^{c}	47^{a}	79^{b}	80^{b}
CMC(PM 7)	70^{b}	45^{a}	91^{bc}	118^{c}	126^{c}

Rank sums that do not have a common superscript are significantly different($p<0.05$)

A Friedman's test and Fisher's analog of LSD_{rank} test indicated and existence of difference in five samples of Mafai Jeen fruit candy. The rank sum of preference for maltodextrin DE10 from the most preference to least preference were 2.0, 2.5, 1.5, 0.5, and 1.0%, respectively. The rank sum of preference for pectin (150 grade) from the most preference to least preference were 1.5, 2.0, 2.5, 1.0, and 0.5%, respectively. And the rank sum of preference for CMC (PM7) from the most preference to least preference were1.0, 0.5, 1.5, 2.0, and 2.5%, respectively. So, the first rank in this study; 2.0% maltodextrin, 1.5% pectin, and 1.0% CMC were used to study the sensory descriptive analysis in further experiment.

4.2.4 Descriptive Sensory Analysis of Mafai Jeen Fruit Candy

The model used for the analysis of the descriptive sensory evaluation was a randomized block design, in which panelists were considered as blocks. ANOVA was executed using the SPSS version 10.01. Table 20 shows the means, standard deviations and Pr>F values for the intensities of each of the attributes evaluated in each of the three Mafai Jeen fruit candy.

The glossy, pickled lemon aroma, dried preserved mandarin peel aroma, pungent aroma, sweet, sour, bitter, astringent, hardness, cohesiveness, crumble, sandy, chewiness, roughness, bitter in residual, astringent in residual and toothpack showed significant difference in their intensities among the three Mafai Jeen fruit candy. Caramel aroma (p=0.236), pickled lemon flavor (0.122), and dried preserved mandarin peel flavor (0.102) were not significant different among the three samples.

The Duncan's post-hoc test indicated that glossy, sweet taste, astringent taste, crumble, chewiness, bitter in residual, and toothpack were different among the 2% maltodextrin, 1.5% pectin, and 1% CMC added in Mafai Jeen fruit candy. Pickled lemon aroma, dried preserved mandarin peel aroma, pungent aroma, sour taste, bitter taste, sandy, roughness, and astringent in residual had different intensities in 1% CMC added in Mafai Jeen fruit candy lower scores compared with the 2% maltodextrin and 1.5% pectin. Hardness and cohesiveness had different intensities in 1% CMC added in Mafai Jeen fruit candy higher scores compared with the 2% maltodextrin and 1.5% pectin. Caramel aroma, pickled lemon flavor, and dried preserved mandarin peel were not different among the three Mafai Jeen fruit candy.

Mafai Jeen fruit candy mixed with 2% maltodextrin had highest intensities scores in dried preserved mandarin peel aroma, sour taste, bitter taste, astringent taste, crumble, sandy, roughness, bitter in residual, and astringent in residual. 1.5% pectin had highest intensities scores in glossy, pickled lemon aroma, pungent aroma, caramel aroma, sweet taste, pickled lemon flavor, and dried preserved mandarin peel flavor. 1% CMC had highest intensities scores in hardness cohesiveness, chewiness and toothpack (Table 20, Figure 13 and Figure 14).

Table 20 Means, standard deviations and analysis of variance for three Mafai Jeen fruit candy[a].

Attribute	Mafai Jeen fruit candy			Pr>F
	2% Maltodextrin	1.5% Pectin	1% CMC	
Appearance				
Glossy	7.32^{b} ± 1.45	10.09^{a} ± 2.94	3.38^{c} ±1.21	0.000
Odor/aroma				
Pickled lemon	3.38^{ab} ±1.22	4.05^{a} ±1.76	2.92^{b} ±0.77	0.019
Dried preserved mandarin peel	2.00^{a} ±0.81	1.72^{a} ±1.21	0.76^{b} ±0.41	0.000
Pungent	4.72^{a} ±1.83	5.00^{a} ±1.67	3.28^{b} ±1.49	0.002
Caramel	0.60^{a} ±0.68	0.90^{a} ±0.78	0.40^{a} ±0.43	0.236
Taste				
Sweet	10.50^{b} ±1.54	11.87^{a} ±1.34	6.92^{c} ±0.52	0.000
Sour	9.14^{a} ±2.09	8.77^{a} ±1.24	5.76^{b} ±1.52	0.000
Bitter	4.32^{a} ±2.01	3.51^{a} ±1.47	1.46^{b} ±0.85	0.000
Astringent	4.22^{a} ±1.45	3.37^{b} ±0.94	0.80^{c} ±0.67	0.000
Flavor				
Pickled lemon	3.64^{a} ±1.43	4.42^{a} ±1.95	2.92^{a} ±1.65	0.122
Dried preserved mandarin peel	1.52^{a} ±0.85	1.68^{a} ±1.30	0.80^{a} ±0.31	0.102
Texture				
Hardness	4.24^{b} ±0.98	3.48^{b} ±1.79	5.50^{a} ±1.13	0.000
Cohesiveness	4.62^{b} ±1.11	4.54^{b} ±1.25	9.34^{a} ±1.13	0.000
Crumble	3.30^{a} ±1.71	2.04^{b} ±1.71	0.46^{c} ±0.54	0.000
Sandy	5.34^{a} ±0.94	4.51^{a} ±2.14	0.42^{b} ±0.37	0.000
Chewiness	5.78^{b} ±1.39	3.21^{c} ±1.97	11.22^{a} ±1.32	0.000
Roughness	5.78^{a} ±1.08	5.35^{a} ±1.52	2.80^{b} ±1.57	0.000
Residual				
Bitter	4.70^{a} ±1.08	3.40^{b} ±1.74	1.68^{c} ±0.59	0.000
Astringent	2.48^{a} ±1.05	2.37^{a} ±1.07	1.64^{b} ±0.89	0.000
Toothpack	1.64^{c} ±0.70	2.94^{b} ±1.68	5.54^{a} ±2.19	0.000

[a] Means in each row having different superscripts are significantly different ($P \leq 0.05$)

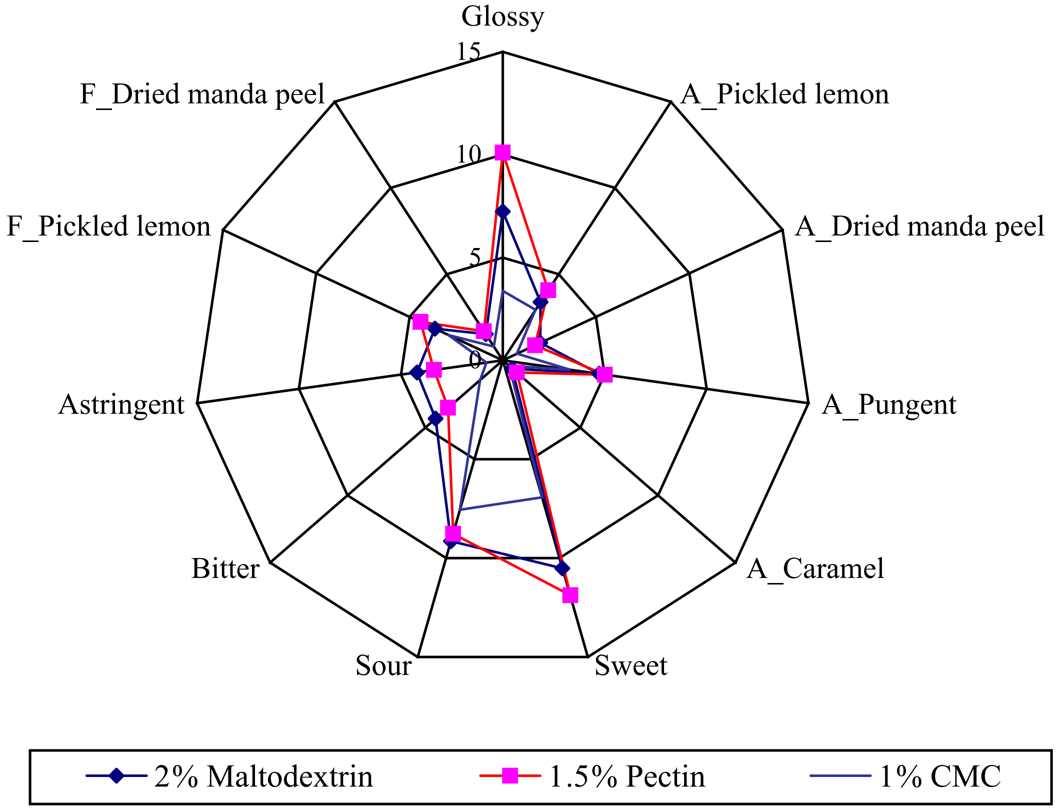


Figure 13 Spider web diagram of average scores obtained by descriptive analysis of Mafai Jeen fruit candy, in appearance, aroma (A), taste, and flavor (F).

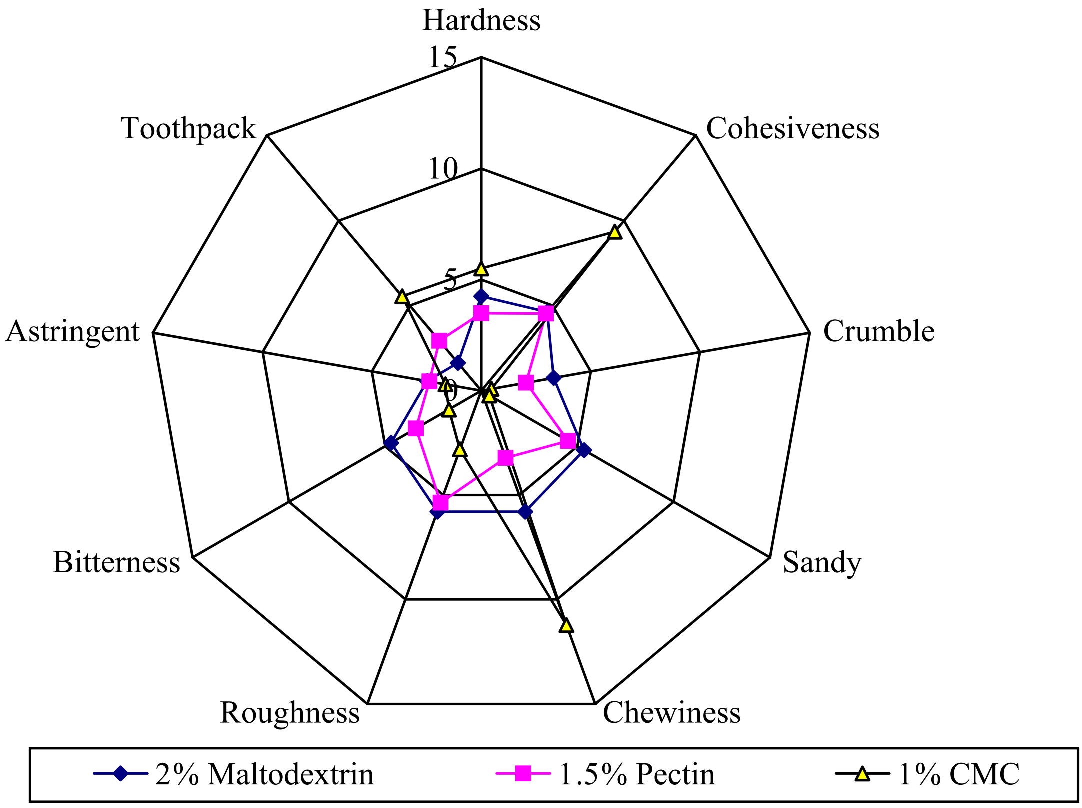


Figure 14 Spider web diagram of average scores obtained by descriptive analysis of Mafai Jeen fruit candy, in texture.

4.2.5 Consumer Test

a. Consumer Demographics and Product Information

Demographic information of 135 consumers was shown in Table 21. The majority of the participating consumers was in the age range of 25-44 years old (58.5%); followed by consumers in the range of 45-54 years old (17.8%). The lowest percentage of participants (7.4%) was 55 years old or older. Of the total, 50.4% of subjects were female and 49.6% were male. Their education level was divided into bachelor (50.4%), graduate level (23.0%), Diploma (14.8%), less than high school (7.4%), and high school (4.4%). A greater proportion of them were employed full-time (76.3%), followed by student (14.8%), unemployed (5.9%), and employ part-time (3.0%).

Table 21 Demographic and socioeconomic information.

	Male, %	Female, %	Total, %
Age			
18-24 years	10.4	5.9	16.3
25-34 years	8.9	23.7	32.6
35-44 years	17.0	8.9	25.9
45-54 years	11.9	5.9	17.8
55-64 years	1.5	3.0	4.4
Over 64 years	0.0	3.0	3.0
Gender	49.6	50.4	100.0
Education			
Less than high school	-	7.4	7.4
High school	-	4.4	4.4
Diploma	4.4	10.4	14.8
Bachelor	29.6	20.7	50.4
Graduate (M.S., M.A., Ph. D.)	15.6	7.4	23.0
Work status			
Employed full-time	40.7	35.6	76.3
Employ part-time	-	3.0	3.0
Unemployed	-	5.9	5.9
Student	8.9	5.9	14.8
Income/month			
< 10,000 ฿	8.9	17.8	26.7
10,000-19,999 ฿	10.4	13.3	23.7
20,000-29,999 ฿	5.9	7.4	13.3
30,000-39,999 ฿	3.0	4.4	7.4
40,000-49,999 ฿	4.4	3.0	7.4
Over 50,000 ฿	17.0	4.4	21.5

About 63.7% of the consumers had incomes less than ฿30,000/ month, and 36.5% had income of ฿30,000/month or higher.

Table 22 gives product information about Mafai Jeen fruit candy collected from consumers. About 57.0% of consumers ate fruit candy more than twice a month, again, female consumers responded in a higher percentage (40.7%) when compared to males (16.3%), and 43% were ate once a month or less than once a month. Taste, texture, and color were important quality attribute that consumers want in fruit candy products. The most of consumer (48.9%) prefer the sweet/sour equally taste. One hundred percent of them said they were aware of fruit herb/ health benefits. In addition, 100% of the consumers declared that they also to purchase candy containing fruit herb. A large number of consumers (57%) have known a Mafai Jeen fruit products in the market.

b. Consumer Acceptability

Table 23 reports the mean scores and ANOVA results for the acceptability of appearance, overall taste, aroma, sweetness, sourness, texture, and overall liking of three Mafai Jeen fruit candy; 2% maltodextrin, 1.5% pectin, and 1.0% CMC added. The analysis of variance and a post-hoc test indicated an existence of differences in acceptability of all attributes. Acceptability of appearance for 1.5% pectin is highest with a score of 6.35, while the lowest score was observed for 2.0% maltodextrin (5.01). 1.5% pectin got 6.65 score in overall taste which was higher than that of the 2% maltodextrin. 1.5% pectin and 1.0% CMC in Mafai Jeen fruit candy were not different in acceptability of their sourness (6.29 and 6.10), while 2% maltodextrin (with a mean score of 4.80) was different when compared to the two. 1.5% pectin in Mafai Jeen fruit candy was most accepted when consumers evaluated aroma, sweetness, sourness and attributes with hedonic scores of 6.25, 6.50, 6.29 and 7.20, respectively. Gel structured of pectin tab more aroma compound than the other thickening agent. 2.0% maltodextrin in Mafai Jeen fruit candy was least accepted with the scores for taste, aroma, specific flavor, and sweetness attributes of 4.5, 4.5, 4.6

Table 22 Consumer product information about Mafai Jeen fruit candy.

Question	Gender		
	Male, %	Female, %	Total, %
How often do you eat fruits candy?			
More than once a week	3.7	8.9	12.6
Once a week	4.4	20.7	25.1
Twice a month	8.2	11.1	19.3
Once a month	23.0	8.9	31.9
Very rarely	10.4	0.7	11.1
What is the most important quality attribute that you want in fruit candy products?			
Color/appearance	20.7	8.9	29.6
Texture/mouthfeel	5.9	11.8	17.7
Taste	21.6	17.8	39.4
Nutrition	-	5.9	5.9
Aroma/odor	1.5	5.9	7.4
Which taste do you prefer most for fruit candy product? (check one)			
Sweeter and less sour	15.6	8.9	24.4
More sour and less sweet	7.4	19.3	26.7
Sweet/sour equally	26.7	22.2	48.9
Are you aware of fruit herb/ health benefits?			
YES	49.6	50.4	100
NO			
Would you consider buying fruit herb candy?			
YES	49.6	50.4	100
NO			
Have you heard of or seen Mafai Jeen fruit products in the market?			
YES	33.3	23.7	57.0
NO	16.3	26.7	43.0

and 5.2, respectively. In conclusion, the addition 1.5% pectin to the Mafai Jeen fruit candy gave the most accepted when participants estimated overall liking, with a score of 6.32, followed by the 1.0% CMC with a score of 5.90. The 2.0% maltodextrin in Mafai Jeen fruit candy had again the lowest score, with 4.63 (5= neither like nor dislike), indicating significant lower in acceptability when compared with the other two samples (1.5% pectin and 1.0% CMC).

Table 23 Means, standard deviations and analysis of acceptability attributes of the three Mafai Jeen fruit candy.

	Mafai Jeen fruit candy			
Attributes	2% maltodextrin	1.5% pectin	1.0% CMC	Pr > F
Appearance	5.01 [c] ±0.71	6.35 [a] ±0.96	5.42 [b] ±1.01	<0.0001
Overall taste	5.20 [b] ±0.84	6.65 [a] ±1.67	6.20 [ab] ±1.11	<0.0001
Aroma	4.48 [c] ±1.24	6.25 [a] ±1.53	5.66 [b] ±1.41	<0.0001
Sweetness	4.60 [c] ±1.14	6.50 [a] ±1.74	6.10 [b] ±1.17	<0.0001
Sourness	4.80 [b] ±1.10	6.29 [a] ±1.49	6.10 [a] ±1.07	<0.0001
Texture	4.00 [c] ±1.01	7.20 [a] ±1.74	5.69 [b] ±1.58	<0.0001
Overall Liking	4.63 [b] ±0.89	6.32 [a] ±1.20	5.90 [a] ±0.92	<0.0001

Means in each row having different superscripts are significantly different (Pr ≤ 0.05).

c. Purchase Intent- McNemar Test

The McNemar test was performed using descriptive statistics/crosstabs (SPSS version 10.0.1). It was used to establish any potential association between purchase intent of the Mafai Jeen candy before and after the consumers being informed that the product may offer health benefits. Table 24-26 described counts number and frequencies of purchase intent responses before and after knowing that the product contained health benefits.

Table 24 Purchase intent responses for 2.0% maltodextrin DE 10 added in Mafai Jeen candy before and after knowing that the product was enriched with health-promoting.

Purchase intent (Question 1)	Purchase intent after knowing health benefits (Question 2)		
	YES	NO	TOTAL
YES	30 (22.2%)	2 (1.5%)	32 (23.7%)
NO	24 (17.8%)	79 (58.5%)	103 (76.3%)
TOTAL	54 (40.0%)	81 (60.0%)	135 (100.0%)

Table 25 Purchase intent responses for 1.5% pectin (150grade) added in Mafai Jeen candy before and after knowing that the product was enriched with health-promoting.

Purchase intent (Question 1)	Purchase intent after knowing health benefits (Question 2)		
	YES	NO	TOTAL
YES	66 (48.9%)	7 (5.2%)	73 (54.1%)
NO	35 (25.9%)	27 (20.0%)	62 (45.9%)
TOTAL	101 (74.8%)	34 (25.2%)	135 (100.0%)

Table 26 Purchase intent responses for 1.0% CMC(PM 7) added in Mafai Jeen candy before and after knowing that the product was enriched with health-promoting.

Purchase intent (Question 1)	Purchase intent after knowing health benefits (Question 2)		
	YES	NO	TOTAL
YES	58 (43.0%)	6 (4.4%)	64 (47.4%
NO	32 (23.7%)	39 (28.8%)	71 (52.6%)
TOTAL	90 (66.7%)	45 (33.3%)	135 (100.0%)

Table 27 showed details about McNemar test results. It can be seen that a significant difference existed between the two responses, with a chi square (χ^2) values of 50.488 (for the evaluation of the 2.0% maltodextrin added), 20.519 (for the evaluation of the 1.5% pectin added), and 31.43 (for the evaluation of the 1.0% CMC added), which are greater than the critical χ^2 df 1 of 3.84, with Pr > χ^2 <0.0001 for the three cases (with an alpha = 0.05). The decision of buying the Mafai Jeen fruit candy was influenced by the fact that consumers had been informed about the health benefits of the product. The difference of proportions (p_{+1} - p_{1+}) between purchase intent after (p_{+1}) and before (p_{1+}) knowing that the product was enriched with health benefits was calculated for each of the evaluation of the three Mafai Jeen fruit candy. For example, the proportion of consumers that answered yes to purchase intent of the Mafai Jeen candy added 2.0% maltodextrin before knowing the health benefits of the product is 0.24 (i.e., applying equation (7), p_{1+}=32/135) see Table 28.

Table 27 McNemar test results of three Mafai Jeen fruit candy with different thickening agent.

Mafai Jeen fruit candy	95% Confidence intervals for difference of proportions	Statistic χ^2	Pr > χ^2
2.0% maltodextrin	(0.11, 0.21)	50.488	<0.0001
1.5% pectin	(0.17, 0.25)	20.519	<0.0001
1.0% CMC	(0.16, 0.24)	31.430	<0.0001

The proportion of consumers that answered yes to purchase intent of the Mafai Jeen candy added 2.0% maltodextrin after they had been informed about the health benefits of the product is 0.40 (i.e., applying equation (7), p_{+1}=54/135). Then the difference of proportions (p_{+1}- p_{1+}) between consumers that said yes to purchase intent of the Mafai Jeen candy added 2.0% maltodextrin after had been informed that the product was enriched with health benefits (p_{+1}), and consumers who said yes to purchase intent of the Mafai Jeen candy added 2.0% maltodextrin before knowing the health benefits of the product (p_{1+}) is 0.16 (i.e., 0.40-0.24).

Table 28 The proportion of consumer answered yes to purchase before and after informed about the health benefits of the products.

	p_{1+} (before)	p_{+1} (after)	$p_{+1} - p_{1+}$
2.0% maltodextrin	32/135 = 0.24	54/135 = 0.40	0.16
1.5% pectin	73/135 = 0.54	101/135 = 0.75	0.21
1.0% CMC	64/135 = 0.47	90/135 = 0.67	0.20

The 95% confidence intervals for the difference of proportions were calculated in order to obtain a better understanding of the association between the two questions' responses (i.e., applying equation 8).The 95% confidence interval for the difference of proportion of purchase intent of the Mafai Jeen candy added 2.0% maltodextrin was 0.11, 0.21 (i.e., 0.16 ±0.05). The confidence interval explained that, for the Mafai Jeen candy added 2.0% maltodextrin, the probability that consumers would buy it after they had been informed about the health benefits of the product was 0.11 to 0.21 times higher than the probability that consumers would buy it before they had been informed about the health benefits.

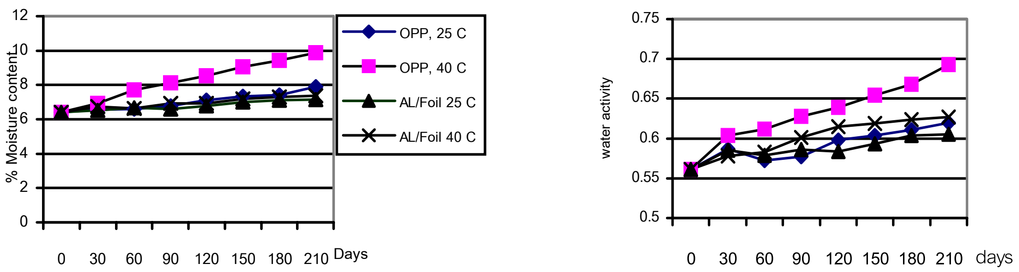
The 95% confidence interval for the difference of proportion of purchase intent of the Mafai Jeen candy added 1.5% pectin was 0.17, 0.25 (i.e., 0.21 ±0.04). The probability of buying the Mafai Jeen candy added 1.5% pectin after participants had been informed that the product was enriched with health benefits was from 0.17 to 0.25 higher than the probability of buying the product before consumer had known that it contained health benefits.

The 95% confidence interval for the difference of proportion of purchase intent of the Mafai Jeen candy added 1.0%, CMC was 0.16, 0.24 (i.e., 0.20±0.04). The probability of buying the Mafai Jeen candy added 1.0%, CMC after participants had been informed that the candy was enriched with health benefits was 0.16 to 0.24 higher than the probability of buying the product before consumers had been informed about the health benefits of the product. There was a positive increase in the probability of buying the Mafai Jeen fruit candy after consumers had been informed that the product was enriched with health promoting ingredients. Therefore, there was a positive increase in the purchase intent after consumers had been informed the Mafai Jeen fruit candy was enriched with health benefits. Walker (2002) studied the difference in the purchase intent of low-fat sugar-free orange sherbets before and after consumers had been informed that the product contained health promoting soy protein. Pavon (2003) studied the difference in the buying intention of flavored milk candy before and after consumers had been informed about the health benefits of the products. In both studies, the fact that the product could promote health benefits positively increased the purchase intent of them.

4.3 To Study on Shelf Life of Developed Product

4.3.1 Moisture Content and Water Activity

The graphical representation in Figure 15 (a) shown no significant difference in effect of both packaging on the % moisture content values for the first 60 days of storage for 25 °C. The differences that were observed after 90 days due to OPP pouch having higher % moisture content value than AL/Foil. In the case of samples treated on 40 °C had significant difference % moisture content value on

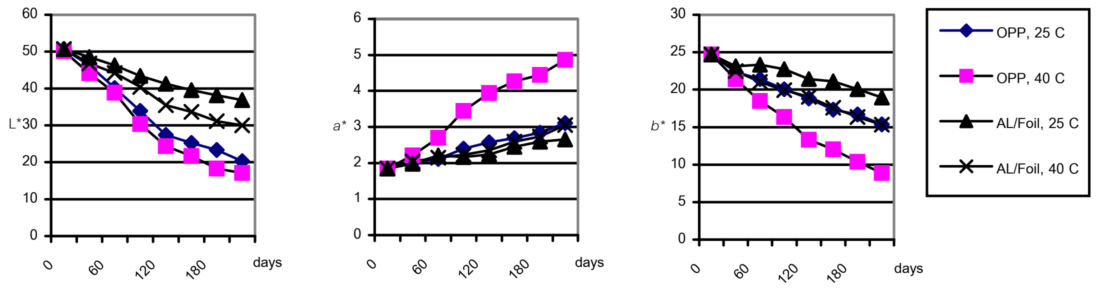


(a) Moisture (b) Water activity

Figure 15 Moisture contents (a) and water activity (b) of Mafai Jeen fruit candy stored at various time condition in oriented polypropylene (OPP) and aluminum laminated foil (AL/Foil) pouches both packaging. The result shown OPP pouch having higher % moisture content value than AL/Foil. Change in water activity was shown in Figure 15 (b). The water activity of Mafai Jeen fruit candy packed in AL/Foil, 25 °C was less increased compared to the other treatment. After 30 days storage, the water activity of the OPP pouch with 40 °C sample distinctly increased.

4.3.2 Color Assessment

The graphical representation (Figure 16 (a)) of the difference in lightness values of Mafai Jeen fruit candy showed that OPP pouch samples were darker than the AL/Foil pouch during storage at both 25 °C and 40 °C. The graphical representation in Figure 16 (b) shown that the color a^* value for the treatments of OPP and AL/Foil pouches increased constantly with increase in storage time. The AL/Foil, 25 °C treated samples had less increase in redness compared to the other treated samples. There was a decrease in color b^* values for all the treatments; the graphical representation in Figure 16 (c) shown that the AL/Foil pouch at 25 °C retained more degree of yellowness in the Mafai Jeen fruit candy than the other treated samples. Therefore, AL/Foil pouch stored at 25 °C gave a better result in color L^* a^* b^* values after storage until 210 days.

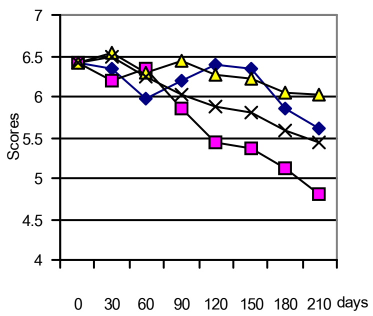


(a) Color L^* value (b) Color a^* value (c) Color b^* value

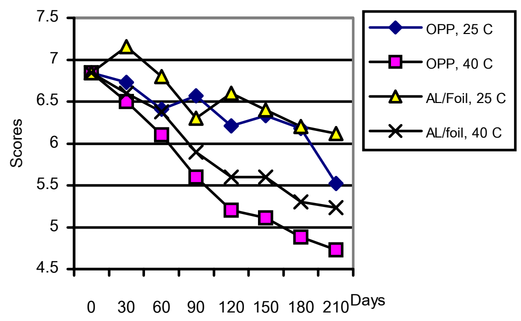
Figure 16 Color L^* value (a), color a^* value (b), and color b^* value (c) of Mafai Jeen fruit candy stored at various time condition in oriented polypropylene (OPP) and aluminum laminated foil (AL/Foil) pouches.

43.3. Sensory analysis

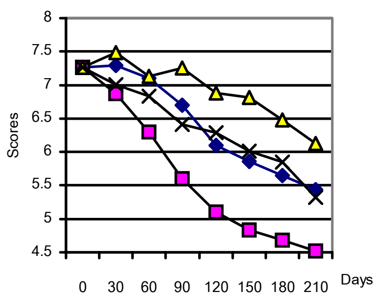
The effect of storage on color acceptance were rated similarly by the consumer (Figure 17 (a)) for 25 °C, slightly decreased for AL/Foil 40 °C and score lower 5 at 210 days for OPP 40 °C. The effect on taste acceptance were rated decreasing in taste acceptance with increasing storage time and temperature (Figure 17 (b)). Sample at zero days were rated 6.84 (like moderately) on taste acceptance and decreased with increasing storage time and temperature, sample storage in OPP 40 °C was rate lower 5 after 180 days. Texture acceptance is one important criteria in consumer acceptance of fruit candy. The changes of texture acceptance of Mafai Jeen



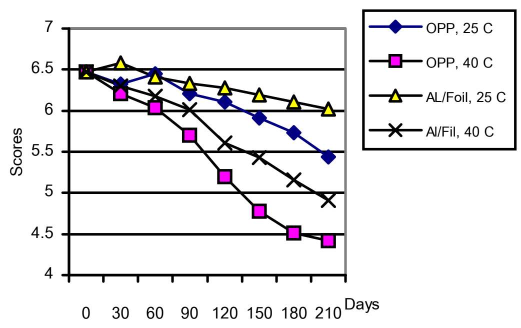
(a) Color score



(b) Taste score



(c) Texture score



(d) Overall acceptance score

Figure 17 Mean hedonic rating (9-point scale, 1=dislike extremely, 9=like extremely) on color score (a), taste score (b), texture score (c), and overall acceptance score (d) of Mafai Jeen fruit candy stored at various time condition in oriented polypropylene (OPP) and aluminum laminated foil (AL/Foil) pouches.

fruit candy for various storage condition was shown in Figure 17 (c)) the sample stored at OPP, 40 °C for 150 days significantly decreased with storage time and the score lower 5, while sample stores at AL/Foil, 25 °C for 210 days showed only a small decrease and acceptance score more than 6.

The changes of hedonic ratings for overall acceptance of Mafai Jeen fruit candy at varied storage conditions were shown in Figure 17 (d). The sample stored at 40 °C with OPP and AL/Foil pouches after 120 days significantly decreased with storage time and score lower 5 at 180 and 210 days for OPP 40 °C and AL/Foil pouches 40 °C, respectively. The Mafai Jeen fruit candy sample stores in AL/Foil, 25 °C for 210 days fell slowly during storage, at day zero, sample was rated at 6.47 (like slightly to like moderately) on the 9-point hedonic scale and the rate was 6.02 (like slightly) at 210 days storage time.

Increasing the storage time and temperature resulted in decreasing acceptance of color, taste, texture, and overall acceptance. Mafai Jeen fruit candy were rated more than 6 (like slightly) for AL/Foil pouches 25 °C still acceptance after they had been stored at 210 days, but the OPP pouch at 40 °C became unacceptable for the texture and overall acceptance attributes score lower than 5 (neither like nor dislike) after 150 days storage. AL/Foil pouch delayed the drop in sensory quality, and extended shelf life.

CONCLUSION

The volatile components of fruits, seeds, and leaves from Mafai Jeen obtained through headspace sampler, were analyzed by GC-MS. The sesquiterpene fraction (27.7%) was most common in the leaf. The monoterpene fraction (76 – 98%) was dominate in flesh, skin, and seed; with sabinene the main component in leaf (14.9%), flesh (50.6%), skin (69.1%), and seed (83.6%). Other major components in the leaf were β-bisabolene (9.9%), β-caryophyllene (7.7%), and α-zingiberene (6.5%); in the flesh, 3-cyclohexen-1-ol (15%), cyclohexene (6.5%), 1,4-cyclohexadiene (6.2%), and 1-phellandrene (5%); in the skin, α-phellandrene (10.6%), α-pinene (9.4%), and isosativene (1.4%); and in the seed, α-pinene (4.3%), α-phellandrene (3.0%), and myrcene (2.9%). The volatile aroma compounds in Mafai Jeen fruit were also examined using three SPME fibers coated with polydimethylsiloxane (PDMS), polyacrylate (PA), and divinylbenzene/carboxen/polydimethylsiloxane (DVB/CAR/PDMS) equipped with GC-MS. Eighty-eight compounds were detected in the Mafai Jeen aroma. The main compounds were sabinene, α-farnesene, and isosativene.

The study effect of drying methods on the Mafai Jeen qualities revealed the following conclusions. The drying time to reach 14% (wb) moisture content was 17, 32, 42, and 50 h by hot air drying at 60 °C, sun drying, hot air drying at 45 °C, and vacuum drying at 45 °C, respectively. The total changes in product color, ΔE, were observed to be 21.49, 13.72, 12.75, and 6.61 by hot air drying at 60 °C, hot air drying at 45 °C, sun drying, and vacuum drying at 45 °C, respectively. Analysis by GC-MS of the volatile oils obtained from fresh fruit and dried fruits, it can report that the Mafai Jeen fruit consist a mixture of monoterpene hydrocarbons, sesquiterpene hydrocarbons, alcohols, aldehydes, ketones, carboxylic acids, and terpene oxides. No ester was detected in the examined fruit samples. All of Mafai Jeen oils were nearly similary in their main compositions. They consist mainly of monoterpene hydrocarbon (sabinene, α-pinene, α-phellandrene, and myrcene).

Time-intensity (TI) is a descriptive sensory technique in which the intensity of one or more sensory characteristics is rated in real time. In this study, the intensity of astringent taste was experimented in Mafai Jeen fruits using TI method. Twelve samples of dried Mafai Jeen, varying in the rate of sucrose from 0, 10, 20 to 30 g/100g of fruits and varying in the rate of ascorbic acid from 0, 1 to 2 g/100g of fruits were prepared. Solution of tannic acid 1 g/l both in water 7 and 25 °C tasted same astringent. The interaction between astringency and sweetness was investigated. Maximum intensity, time to maximum and total duration for astringency decreased significantly with increasing sucrose concentration. Raising ascorbic acid increased astringent intensity and duration significantly.

Results obtained from development Mafai Jeen fruit candy product through focus group discussion, study on sugar concentration in the recipe, study on thickening agent for Mafai Jeen fruit candy, descriptive sensory analysis of Mafai Jeen fruit candy, and consumer affective test. A focus group discussion among of 3 groups indicated that healthy natural Mafai Jeen candy product was required. The product should contain natural color or no artificial flavors, the least sucrose content and moderately sour taste. 35% of sucrose and 5% of glucose syrup added in Mafai Jeen fruit candy was the most accepted score of preference test. The 1st rank of preference of 3 thickening agents added in Mafai Jeen fruit candy were 2% of maltodextrin, 1.5% of pectin, and 1% of CMC.

Determination of the product sensory characteristics presented in each of the three Mafai Jeen fruit candy increased an understanding of the product quality. Descriptive sensory evaluations of the three Mafai Jeen fruit candy revealed that they were different among one another, based on descriptive sensory attributes. A lexicon developed to describe the Mafai Jeen fruit candy product included appearance note: glossy; aroma notes: pickled lemon, dried preserved mandarin peel, pungent, and caramel; taste notes: sweet, sour, bitter, and astringent; flavor notes: pickled lemon, and dried preserved mandarin peel; texture notes: hardness, cohesiveness, crumble, sandy, chewiness, and roughness; and residual note: bitter, astringent, and toothpack.

Consumer test was done with 135 consumers using a 9-point hedonic scale. Different thickening agents added to the Mafai Jeen fruit candy caused a significant difference in the consumer responses toward evaluated sensory attributes. 1.5% pectin and 1.0% CMC added in Mafai Jeen fruit candy were well accepted which overall liking scores 6.3 and 5.9 (like slightly), and 2.0% maltodextrin was least accepted which score 4.60 (Neither like nor dislike). Consumer purchase decision of Mafai Jeen fruit candy was positively influenced after the consumers known that promote health benefits. Consumers would be more willing to purchase Mafai Jeen fruit candy when they known the benefits of the product that for health promoting.

Processing steps to produce Mafai Jeen candy involved blending Mafai Jeen for 6 min, heating 58.5% of Mafai Jeen puree over gas stove at 95 °C for 20 min, 35% (w/w) of sucrose were added and continue heating for 20 min, added 5% of glucose syrup and 1.5% of pectin, continue heating until the total soluble solid reached 75 ^{o}Bx.

The effects of storage time and temperature resulted in decreasing sensory acceptance of color, taste, texture, and overall acceptance, Mafai Jeen fruit candy were rated more than 6 (like slightly) for AL/Foil pouches 25 °C still acceptance after they had been stored at 210 days, but the OPP pouch at 40 °C became unacceptable for the texture and overall acceptance attributes score lower than 5 (neither like nor dislike) after 150 days storage. AL/Foil pouch delayed the drop in sensory quality, and extended the shelf life.

RECOMMENDATION FOR FUTURE WORK

The future study of aroma compounds in Mafai Jeen should be identified by varieties and by areas to provide more information on aroma compounds in Mafai Jeen fruit. The trend towards natural aroma compounds is creating opportunities for the development of new essential oils. Essential oils that are sources of natural aroma chemicals will be of particular interest to the flavor and fragrance industry. Mafai Jeen oil is a potential source of natural terpene and can be produced economically in North of Thailand. The oil has potential applications in flavors and fragrance compounds.

More research needs to be done before launching the product to the market. Some modification may be needed; this includes the addition of alternative thickening agent, such as carrageenan, gelatin, arabic gum or mixed together. In addition, the shape and size may be reformed for a new targeted to children. Nevertheless, new consumer sensory studies together with marketing research should be done to warrant the success of the new products.

This study represents the first step for the development of a process to insert or position the new Mafai Jeen candy in the market.

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APPENDIX

APPENDIX A

Pictures of Mafai Jeen

A

B

Appendix Figure A 1 The Mafai Jeen varieties in Thailand A: Sweet-sour flavor; round shape, B: Sweet flavor; conical-oblong shape.

APPENDIX B

Figure of Some Equipment Used in Experiments

Appendix Figure B1 The Clevenger-type apparatus hydrodistillation extraction.

Appendix Figure B2 Gas chromatography-mass spectrometry (GC-MS) instrument.

APPENDIX C

Pictures of Some Experiments

Appendix Figure C 1 Visual appearance of dried Mafai Jeen with various drying methods.

A B C

Appendix Figure C 2 Apparatus for headspace extraction.
A: sample in sealed vial, B: magnetic stirring heater, C: gas chromatography.

Appendix Figure C 3   Focus group discussion in Nan Province.

Appendix Figure C 4   Focus group discussion in Bangkok.

<u>Appendix Figure C 5</u> Training of panelists in sensory descriptive analysis of Mafai Jeen candy.

<u>Appendix Figure C 6</u> Mafai Jeen fruit candy.

Appendix Figure C 7 A trained panelist performing sensory evaluation of Mafai Jeen fruit candy in partitioned booth.

APPENDIX D

Ranking for Preference

PRODUCT Mafai Jeen fruit candies
DATE………………**TIME**……………..**ASSESSOR**…………..

Please taste the samples in the order presented, moving from left to right and rank them in order of preference. You may retaste the samples to check the ranking. Give the sample that you most prefer the rank of 1 and the sample you prefer next a rank of 2 etc.

You must give each sample a different rank. Equal ranks are not allowed.

Samples					
Rank					

Appendix Figure D1 Ballot used in the ranking of preference for Mafai Jeen fruit candy products.

BALLOT FOR MAFAI JEEN FRUIT CANDY

Panelist Code #.............................. Date.............................. Sample No......................

Please bite a piece of saltine cracker and sip some water to rinse your palate. Taste the Mafai Jeen candy samples with the sample number indicated on appearance, odor and texture. After you have tasted the product, please mark response for the attribute below.

Appearance

Glossy

warm-up=5 Ka la mar =15

weak strong

Odor/Aroma

Pickled lemon

warm-up=3 pickled lemon=15

weak strong

Dried preserved mandarin peel

warm-up=2 Dried preserved mandarin peel =15

weak strong

Pungent

warm-up=5 Dried Mafai Jeen =10 vinegar=15

weak strong

Caramel

warm-up=0 Werther's Original chewy toffees =3

weak strong

Tastes

Sweet

10% sucrose =10 warm-up=12 15% sucrose =15

weak strong

Sour

0.08% citric acid=5 warm-up=10

weak strong

Appendix Figure D2 Ballot used in the descriptive analysis for Mafai Jeen fruit candy products.

Bitter

warm-up=4 0.05% caffeine=12

weak strong

Astringent

warm-up=3 0.1% alum=5 dried preserved mandarin peel=6 0.15% alum=15

weak strong

<u>Flavor</u>

Pickled lemon

warm-up=5 pickled lemon=15

weak strong

Dried preserved mandarin peel

warm-up=2 Dried preserved mandarin peel =12

weak

<u>Texture</u>

<u>First bite</u>

Hardness

Marmalade=2 warm-up=3 boiled egg white=5 MYMINT candy=13

weak strong

<u>Masticatory</u>

Cohesiveness

pipo jelly=2 warm-up=4 MYMINT candy=13 sugus=15

weak strong

Crumble

warm-up=1 ka nom phing kaset =7 coconut sugar cube=12 peanut candy=15

weak strong

Sandy

warm-up=3 coconut sugar cube=7 ka nom phing kaset=10

weak strong

(Continued)

<u>Appendix Figure D2</u> (Continued)

Chewiness

warm-up=6 banana candy=13

weak strong

Roughness

pipo jelly=0 warm-up=4 hawthorn piece=6

weak strong

<u>Residual</u>

Bitter

warm-up=4 0.05% caffeine=12

weak strong

Astringent

warm-up=2 0.1% alum=5 Dried preserved mandarin peel =6 0.15% alum=15

weak strong

Toothpack

warm-up=6 banana candy=10

weak strong

<u>Appendix Figure D2</u> (Continued)

APPENDIX E1

CONSUMER STUDY QUESTIONNAIRE

I am a Ph.D. student studying in Product Development at Kasetsart University. I would like to evaluate Mafai Jeen fruit candy product. The reason for this research is to gather information on consumer attitude and their acceptance of the product.

DEMOGRAPHIC SURVEY: All information collected will not be identified with your name.

1. What is your age group? (Please check one)
   _______ 18 – 24 years ______ 25 – 34 years ______ 35 – 44 years
   _______ 45 – 54 years ______ 55 – 64 years ______ over 64 years

2. What is your gender?____ Male _______ Female

3. Level of education? (Please check one)
   ________ Less than high school _______ High school
   ________ Some college _______ Bachelor's degree
   ________ Graduate (M.S., M.A., Ph.D.)

4. Which of the following best describes you?
   ________ Employed full-time ________ Unemployed
   ________ Employed part-time ________ Homemaker
   ________ Re tired ________ Student

5. Income (Please check one)
   _______Under ฿ 10,000 _______ ฿10,000–19,999 _______฿20,000–29,999
   _______ ฿30,000–39,999 _______ ฿ 40,000–49,999 _______ over ฿50,000

WAMPEE CANDY PRODUCT INFORMATION

1. Do you eat fruit candy?
   Yes [ ] No [ ]

2. How often do you eat fruit candy?
   ________ More than once a week
   ________ Once a week
   ________ Twice a month
   ________ Once a month
   ________ Very rarely

3. What is the most important quality attribute that you want in fruit candy products?
   (Please check one)
   _______ Color / appearance _______ Texture / mouthfeel
   _______ Taste _______ Nutrition
   _______ Aroma / odor _______ Other (please specify)____________

4. Which taste do you prefer most for fruit candy products?
   _______ Sweeter and less sour _______ More sour and less sweet
   _______ Sweet / sour equally _______ Other (please specify)_______________

5. Are you aware of health benefits of fruit herbs?
   Yes [ ] No [ ]

6. Would you consider buying fruit herbs candy?
   Yes [ ] No [ ]

7. Have you heard or seen Mafai Jeen products in the market?
   Yes [ ] No [ ]

Sample No._____________

Please evaluate this product and check the space that best reflects your feeling about the product.

1. How would you rate the OVERALL APPEARANCE/COLOR of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

2. How would you rate the OVERALL TASTE (flavor and odor) of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

3. How would you rate the SWEETNESS of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

4. Please rate the SWEETNESS of this product based on your preference.

[ ] Not sweet enoug [ ] Just about right [ ] Too sweet

5. How would you rate the SOURNESS of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

6. How would you rate the TEXTURE/MOUTHFEEL of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

7. Do you detect BITTERNESS AFTERTASTE in this product? [ ] Yes [ ] No

8. Please rate your OVERALL LIKING of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

9. Is this product ACCEPTABLE? [ ] Yes [ ] No

10. Would you BUY this product if it were commercially available? [ ] Yes [ ] No

11. Would you BUY this product after knowing it contains fruit herb used medicinally? [ ] Yes [ ] No

Thank you!!

CURRICULUM VITAE

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	2. Volatile components of the leaves, fruits and seeds of wampee [Clausena lansium (Lour.) Skeels] (J. of Food Composition and Analysis, Received: May 2, 2005, Revised: June 22, 2006, Accepted: July 14, 2006)
	3. Volatile components of wampee fruits [Clausena lansium (Lour.) Skeels] treated by different drying conditions. (Thammasart Int. J. Sc. Tech., 2006. 11(1); p 66-71)