PREVENTION OF STALING EFFECT OF WOOD APPLE PULP DURING STORAGE

By

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DECLARATION

The work described in this thesis was carried out by me at 'Vasmee' , Midigama fruit farm private Limited, Midigama under the supervision of . Mrs. I. Wickramasingheand Mr. S. B. Navarathna. A report on this has not been submitted by any other university for another degree.

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TO MY EVER LOVING PARENTS

AND TEACHERS

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ABSTRACT

Wood apple is a seasonal crop and considerable portion of wood apples are wasted in the wood apple season. Since there is no adequate storage facilities and there is no method available to preserve wood apple pulp in medium and small scale fruit processing industry, the processors uncounted with great difficulties, in order to produce wood apple related food products to cope with the constant demand prevail in the dynamic market during off season. Therefore this study was carried out to find out a productive method of preservation of wood apple during storage.

Sixteen wood apple pulp sample were prepared by using various treatment combinations with respect to the stipulated experimental design. These treatments are heat treated, with added sugar, with antioxidants (Citric acid, ascorbic acid, and vitamin E) and microbial inhibitors (SMS and sodium benzoate). All treatments were replicated three times. Brix values and pH of all sample were measured during the period of three month and acidity was analyzed in the sample which got highest average rank from sensory evaluation. Eight samples were selected out of sixteen samples based on preservative action and visual sense. Sensory evaluation was carried out with fifteen judges to select the best sample/s. sensory evaluation was analyzed and there is a significant difference between wood apple pulp sample at 5% level. According to that sample which got highest average rank for texture is without heat treatment, with added sugar, with antioxidants and microbial inhibitors. But for other three organoleptic properties, sample which got highest average rank is a with heat treated, with added sugar, with antioxidants and with microbial inhibitors. Therefore this treatment combination can be used for further development.

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CHAPTER 1

1.1 INTRODUCTION

Wood apple is indigenous to Sri Lanka and it is naturally found in Puttalam, Anuradapura, Polonnaruwa, Monaragala, Hambantota and Ampara areas. Therefore a bountiful harvest occurs during Maha season every year.

Wood apple is a seasonal crop that can be harvested from June to November and substantial amount of fruits wastes during harvesting season due to lack of post harvesting practices and inherent characteristics of the fruit it self such as fungal diseases, enzymatic activities, and autoxidation of wood apple pulp. Sri Lanka is also situated in the tropical belt and normal ambient air temperature is relatively very high, that also badly contributes in deterioration of the fruits. Wood apples are utilized to make variety of fruit related food products. During off season availability of wood apple is inadequate for the demand. Hence price fluctuation mechanisms is accelerated and as a result of that a higher price is being fetched. In modern fruit processing factory a cold storage facility is to be considered, in order to maintain smooth supply of fruits to the main processing plant, particularly during off season. Fruit processing industry is a popular industry in Sri Lanka, large, medium and small or domestic scale manufactures are engaged in it. Even though the large scale fruit processors are equipped with adequate facilities to cope with the most of quality problem, the small and medium scale fruit processors do not posses adequate technical know how and other necessary infrastructure facilities in order to manufacture cost effect and high quality wood apple based food products. As the small and medium scale manufactures not equipped with adequate storage facilities and there is no method available to preserve wood apple in fruit processing industry, the processors encountered with many problems. If it is supplied these facilities it will be a great advantage for the survival of the consumer oriented market. Hence, the aim of my research project was to find a productive method of preservation of wood apple to cope with the demand extent of the wood apple based fruit products during off season.

1.2 Objectives

- Finding a method for prevention of staling of wood apple pulp during storage.

- Continuous supply of wood apple during off season without interruption.

1.2.1 Specific Objectives

- Providing a preservation and storage method of wood apple pulp without utilizing costly cold storage facilities.

- To protect and maintain characteristics of wood apple pulp with least damage to original quality.

CHAPTER 2
LITERATURE REVIEW

2.1 Wood apple

Wood apple belongs to the family of Rutaceae. The botanical name is *Feronia Limonia* (The welth of India raw material,1976).

2.1.1 Origin and distribution

The wood apple plant is native and common in the wild in dry plants of India and Sri Lanka(Macmillan,1993) and cultivated along roads and edges of field and occasionally in orchard. They are also common is Burma, Malaysia, Pakistan, and Bangladesh. The wood apple is known to be growing well in tropical Asian regions near the equator. Records indicate that it is used as indigenous medical item from prehistorically time (kirtikar and Basu,1994).

2.1.2 Varieties

There are two forms, one with large, sweetish fruits, one with small, acid fruits.

2.1.3 Botany

The wood apple is a terrestrial perennial plant. It belongs to the family Rutaceae. The tree is of moderate size growing to 30-40 feet height, with straight sharp strong spines 1 to 7cm long(Macmillan,1993).The leaves alternate and imaripinnate. Peticle and rachis flat, often narrowly winged, leaflets 3 to 9, opposite 2,2.5 by 1.2-2.5cm, cuneate or obavate, tip often crenulate. Flowers are small, numerous dull red in colour and in lateral or terminal pubescent panicles. Male and female flowers are often found in the same panicle. Calyx is small and labed in to 5 or 6 in number, 5mm long spreading or deflened stamens 1012.Seriate, filament equal, subulate densely hairy at the base within, another large oblong ovary glabrous sessile. Fruit 5-6.3cm diameter, globose, hard pericarp woody, rough, grey coloured. Seed embedded in an edible pulp (Purseglore,1982,Kirtikar and Basu,1993).The fruit is sour, sweet with flavour and taste (Macmillan.1993).About 300 to 400 fruits can be obtained from a tree per season.

2.1.4 Cultivation

Favourable rainfall for cultivation of wood apple is 500-1000ml annually and altitude below 500m.This plant is capable of with standing to serve water stress condition. The suitable temperature range is between 25-32^{0}C well drained soil with alkaline pH is suitable for growing wood apple (Department agriculture,1993). Low country dry zone of Sri Lanka, which has 500-1000ml annual rainfall and temperature varies between 28-33^{0}C is a very favourable area for the cultivation of wood apple. Hence two third of Sri Lanka is suitable for wood apple farming.

2.1.5 Harvesting and Storage

There is no established maturity index to determine the harvesting period in wood apple. Generally, in wood apple trees the matured fruits fall out and therefore harvesting is not adopted. This fallen fruits get crack and damage which intern lead to easy infection by pathogens. Apart from this, it is a traditional practice to determine the maturity of wood apples by dropping and observing the jumps.

Table 2.1 Nutritional Composition of Wood apple Pulp

Moisture(g)	64.2
Energy(Kcal)	13.2
Protein(g)	7.1
Fat(g)	3.7
Carbohydrate(g)	18.1
Calcium(mg)	130
Phosphorous(mg)	116
Iron(mg)	0.6
β-Carotene(mg)	61
Thiamine(mg)	40
Riboflavin(mg)	170
Niacin(mg)	0.8
Vitamin C(mg)	3

Source: Table of Food Composition for using Sri Lanka (1979).

2.1.6 Food Product from Wood apple

Mature and ripe fruit is eaten fresh and a sweet drink is made from the inner portion of ripe fruits mixing with sugar and water. Occasionally, coconut milk which enriches the taste and the nutrition is also added (Rajapaksha,1998).The ripen wood apple fruit has many uses in food processing industry like RTS drink, jam, and nectar. When we consider wood apple it contains more pectin, therefore it is highly compatible for jam industry (Kirtikar and Basu, 1993).A bottle nectar is made by diluting the pulp with water, passing through a pulper to remove seeds and fiber, further diluting, straining, and pasteurizing. A clear juice for blending with other fruit juices has been obtained by clarifying the nectar with pectinal R-10 pulp sweetened with syrup of cane or palm sugar, has been canned. It is also used in chutney, and for making jelly and jam.

2.1.7 Medicinal value of the fruit

The half ripe wood apple fruit is very astringent and is prescribed in cases of dysentery to be taken with bees honey. The pulp of the fruit is edible and is useful in salivation, sore throat and infections of the gum, throat and mouth. The pulp of the unripe is a very tender fruit, can be ground and squeezed in to the eye when it is injured with a thorn. Wood apple juice helps to remove any foreign body in the eye. The ripe fruit is refreshing, aromatic, astringent, carminative, a tonic and an anti date. It is used as a stimulant in diseases of children (Seela,1993). The pulp is poultice on to bites and stings of venomous insect, as in the powdered rind.

2.2 Fruit Pulp and fruit juice

Fruit pulp and fruit juice should be obtained from fresh, firm, fully developed, evenly matured and sound fruits. Only fruits of uniform maturity and colour should be used to ensure the quality of the end product. Fruits should be free from physical injuries and microbial infections, as this helps to lower the initial microbial contamination level.

2.2.1 Preservation of fruit pulp and fruit juice

Food preservation can be defined as the science which deals with the methods of prevention of decay or spoilage of food, thus allowing it to be stored in a fit condition for future-use. Freshly extracted pulp is highly attractive in appearance, and possesses good taste and aroma, and deteriorate rapidly, if kept for some time. The spoilage occurs due to the following reasons.

1 Fermentation may be caused by mold, yeast and bacteria.
2 Enzyme present in the pulp may cause many undesirable changes the colour and flavour
3 Chemical present in the pulp may react with one another spill the taste and aroma of the pulp
4 Air coming in content with the pulp and render the pu5 Metal from the equipment may be get in to the pulp and spoil the taste.

2.2.2 Needs and benefits of industrial food preservation

A major problem facing us is that most people live in nation with low level of industrialization, and preserve foods are found as a significant component of diets of population in the highly industrialized nations. At the present time, most countries are in the process of forcing industrialization and with it is coming further urbanization. As a result in to the regions where industrial opportunities and the possibilities for a better life exist. On the otherhand, it is also a fact that there are now more people in the world with adequate standards of living than ever before in human history, and these people are demanding better quality foods. The kind of foods they are demanding results from the successful integration of the most advanced methods of the storage and distribution technology of the present day.

The high quality foods in greatest demand are also the highly perishable foods. Fortunately most perishable foods can be made stable and acceptable by the judicious application of present technology with the successful application of commercial food preservation technologies the availabilities of perishable foods can be extended, thereby contributing usefully to human welfare. Commercial food preservation improves food supplies in other ways as well. It encourages and/or initiates intensive food production practices and at the same time reduces losses due to spoilage and decay in harvested foods. Together these increase food supplies and eventually lower the unit food costs (Norman,1987).

2.2.3 Preservation methods of fruit pulp and fruit juice

Following method are generally used for the preservation of fruit pulp;

2.2.3.1 Preservation by Chemicals

It is essential that the use of chemicals is properly controlled, as their indiscriminate use is likely to lead to harmful results.

2.2.3.1.1 Sodium Benzoate

This is a salt of benzoic acid and is used in the preservation of fruit juices and squashes. Benzoic acid is the effective agent. As it is sparingly soluble in water its sodium salt, which is water soluble is generally used. The preservation action of benzoic acid increases in the presence of CO_2. Benzoic acid is more effective against yeast than against mold(Siddappa,1986). The quantity of sodium benzoate required would depend on the extent and type of microbial infection be over come and also and the nature of the juice, particularly its acidity. In juices having a pH of 3.5 to 4 which is the range for the maturity of fruit juices addition of 0.06 to 0.10 % of sodium benzoate has found to be sufficient.

2.2.3.1.2 Sulfur dioxide

Sodium Metabisulfite is commonly used as a stable source of sulfur dioxide being a dry chemical it is easier to use than liquid or gaseous, SO_2 the pH value s that of great imporiance in the preservation food products. By regulating the ph of the food product, one or more kind of microorganism in the beverage can be eliminated, and the preservation quality of the beverage is increased. It has been found that the preservation action of sulfur dioxide increase with the decrease in the naturally ph of the fruit juice. One great advantages of preserving fruit juice with sulfur dioxide is that its storage effect in retarding, prevent discolouration and loss of flavour in the product.

2.2.3.1.3 Antioxidant

Antioxidant are substances which are capable of retarding oxidation processes, and they also ensure consistent quality from batch to batch, thereby providing a minimum of variation in the taste, odour, colour and texture of finished products. There is a growing demand for vitamin based antioxidant such as tocopherols as adcorbyl palmitate, and also for spice extract(Jens,1993).

Ascorbic acid

Ascorbic acid minimizes fruits oxidation primarily by action as an antioxidant and itself becoming oxidizing in preferenceto the catechltannin compounds (Norman,1998).

Tocopherol (vitamin E)

The antioxidant action of tocopherol was first demonstrated by Olcott and Emerson and later tocopherol were identified as the action substances in the "inhibitols" previously isolated from a variety of vegetables oils.

Citric Acid

Citric acid is the most widely used chelater in the food industry. It is used alone and in combination with the phenolic type antioxidants. Chelators, including in most antioxidants formulation, must be approved from a toxico logical stand, pain, cause no odour, flavour or colour problems, and be affective at the concentration used.

2.2.3.2 Preservation by addition of sugar

Fruit juices containing 66 per cent or more of sugar do not ordinarily ferment. Sugar absorbed most of the available water with the result that the later is not available for the growth of micro organisms. Solutions with high total solids have a very slow water activity coefficient in regard to growth of micro organisms. Dry sugar does not ferment, and it is very difficult to induce fermentation in highly concentrated sugar solutions. Sugar syrup containing 66 per cent sugar have so little moisture available for micro organisms that their propagation is inhibited, and also those already present die out gradually. Thus sugar acts as a preservative by osmosis(Williiams,1984).

2.2.3.3 Preservation by heat treating

Sterilization by heat means the complete destruction by heat of all form of live in the fruit product sterilized. In order that sterilized products shall not spoil, they must be select in such a manner that all live microorganism are excluded. The temperature necessary to sterilize different product varies. The product that are difficult to sterilize are low in acid and often high in protein and contain certain spores bearing bacteria. Fruit juice are naturally processed commercially at temperature ranging from 65 to 850C. Higher temperature injure the flavour (Cruess,1997).

2.2.4 Problem associated with the of wood apple pulp preservation.

The main problem faced by the fruit processing industry are high fungal infection to the wood apples and the bitter and undesirable flavour caused by damaged wood apple seeds upon processing. Development of suitable both preharvest and post harvest technologies and removing seeds from wood apple pulp can be extended shelf life of the wood apple pulp.

The raw fruits is highly astringent and even after ripening, the astringency persist and for this reason, a good amount of the fruits are going to waste in spite of their food values. Any attempts to reduce the astringency will facilitate better utilization of these fruits. Astringency is known to be associated with tannins and a knowledge of the polyphenol make up of wood apple tannin will help in understanding the structure and its contribution to astringency (Leather Scince, 1969).

Table 2.2.1 Changing in tannin content of wood apple during maturation

Stage of ripening	% Tannin
Raw	1.1
Medium ripe	0.5
Fully ripe	0.22

Source: Leather Sciences, vol.16,(1969).

2.2 Sensory Evaluation of food products

Sensory evaluation is a scientific method used to evoke, measure, analyze and interpret those responses to products perceived though the sense of sight, smell, tough, taste, and hearing (Stone and Sidel, 1993). Here people are used as measuring instrument, and then it is necessary to rigidly control all testing methods and conditions to overcome error caused by psychological factors. The physical and mental condition of the panelist environment affect the sensory tests (Larmond and Elisabate,1977). The test area must be as free from odours as possible. A slight positive pressure in the evaluation areas will reduce the migration of odors from the food preparation and other areas. Air from the sample preparation area should be vented through to the outside of the building. Air entering the evaluation room should preferably pass through activated charcoal filters. All materials and equipment in the room should be odour free or have a low odour level. Adequate illumination is important in the testing areas. Special light effects such as coloured bulbs or sodium lamps may be desired, in some instances to hide difference in colour. Controlled temperature and humidity will result in comfortable surroundings that encourage concentration of panelists during a test.

2.2.1 Classification of sensory evaluation tests

The most commonly used tests can be divided in to three groups

a) Difference tests

b) Scale and category test

c)Analytical or descriptive test

2.2.1.1 Scale and category test

The following tests are used to estimate the order or size of differences, or the categories or classes to which samples should be allocated.

a)ranking

b)Classification

c)Rating

d)Scoring

e)Grating

Rating test

Definition

Method of classification involving categories. Each category is composed of an ordered scale. The points on each scale are of an ordinal nature. Scale rating reflect consumer panelist perceived intensity of a attribute under a given set of test conditions various rating scale have been developed and used in hedonic tests and food action rating.

Hedonic test

The 9-point hedonic scale is a rating scale that has been used for many years in sensory evaluation in the food industry to determine the acceptance of a food and to provide a benchmark on which to compare results.

Application

Rating test is recommended for use as a means of evaluating

a)The intensity of one or more attributes

b)The degree of preference

(S.L.S.931:1991)

2.3 Self life studying of food products

The purpose of a shelf life study is to find out how long a food product may be stored before there is an unacceptable deterioration in its sensory quality. Most food products will change to some extent even under the most carefully control storage conditions, so it is important to define the shell-life limit when considering shelf-life studies. Is it the point at which a detectable change in the sensory characteristics occurs, or the point at which a detectable change becomes unacceptable to the consumer? In fact, a precise working definition will vary from product to product, and from company to company, but the choice of definition will determine the sensory approach and the type of sensory test to be used to establish shelf- life (Roland etal,1999).

CHAPTER 3
MATERIALS AND METODOLOGY

3.1Materials for

3.1.1 Preparation of pulp

Ripe wood apple

Sugar

Citric acid

Ascorbic acid

Sodium Metabisulfite

Sodium benzoate

Vitamin E

Water

Glass bottles and lids

Electronic balance

Stainless steal saucepan

Gas cooker

Petridishes

Pulper

Hand Refractometer

Thermometer

3.1.2 Chemical analysis

3.1.2.1 Determination of pH

pH meter

Beaker

Buffer solution of exactly known pH

3.1.2.2 Analysis of Brix

Refractometer

Water

Cleaning tissue

Plastic rod

Beaker

3.1.2.3 Determination of acidity

Phenolphthalein

50% ethanol

Sodium hydroxide

Glass wares required for titration

3.1.3 Sensory evaluation

Ballot papers

Yogurt spoons

Cream cracker biscuits

White porcelain plates

Water glasses

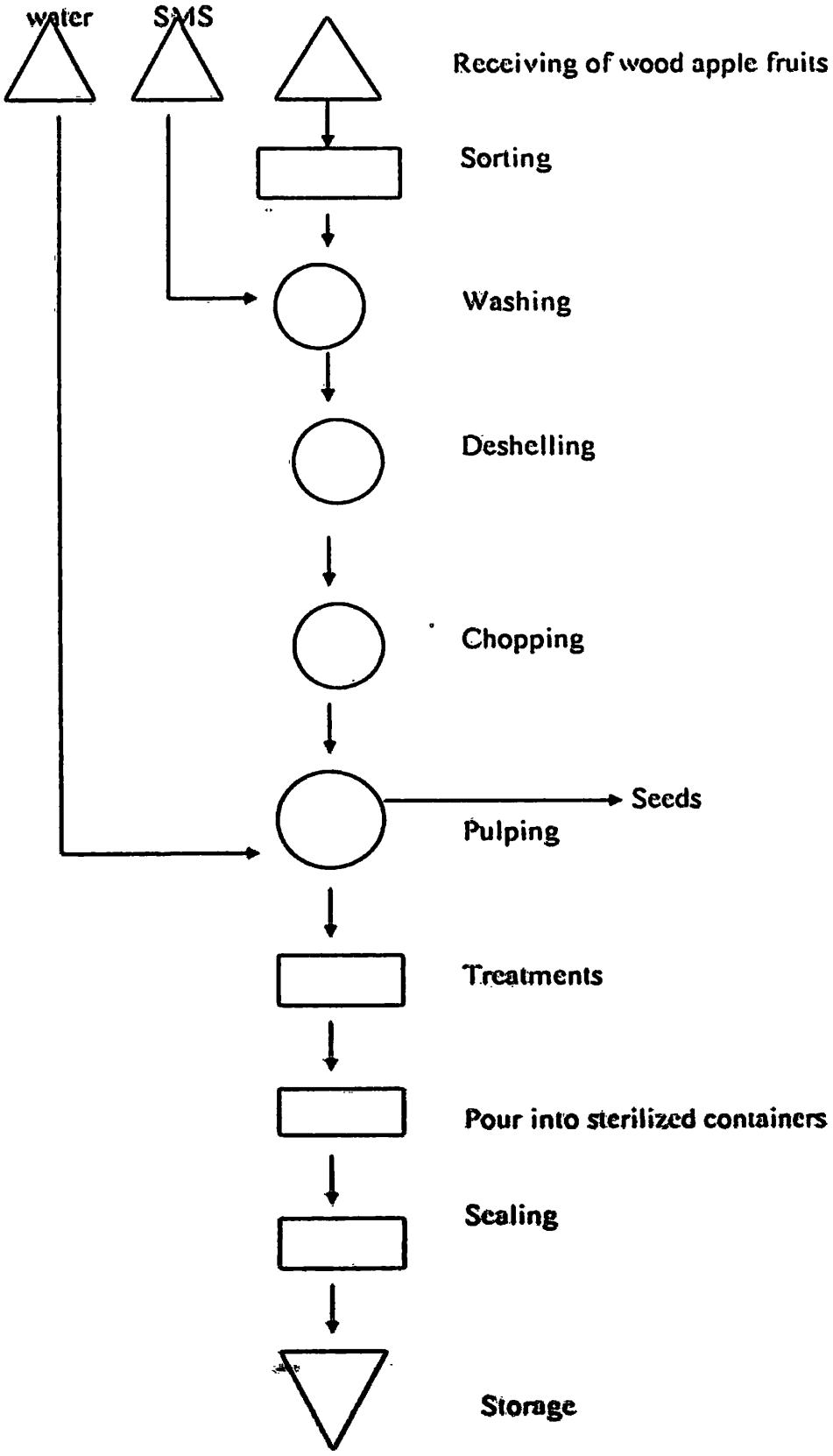
Panelists

3.2 Methodology

3.2.1 Preparation method of wood apple pulp

fresh and fully ripen wood apple fruits which free from physical injuries and microbial infections were selected and subjected for washing treatment with 500ppm sodium Metabisulphite solution in order to inhibit microbial activities of the fruit itself. Cleaned fruits were deshelled and was diluted with clean water 1:1 ratio by weight. Pulp was extracted by using the fruit pulper available in the factory.

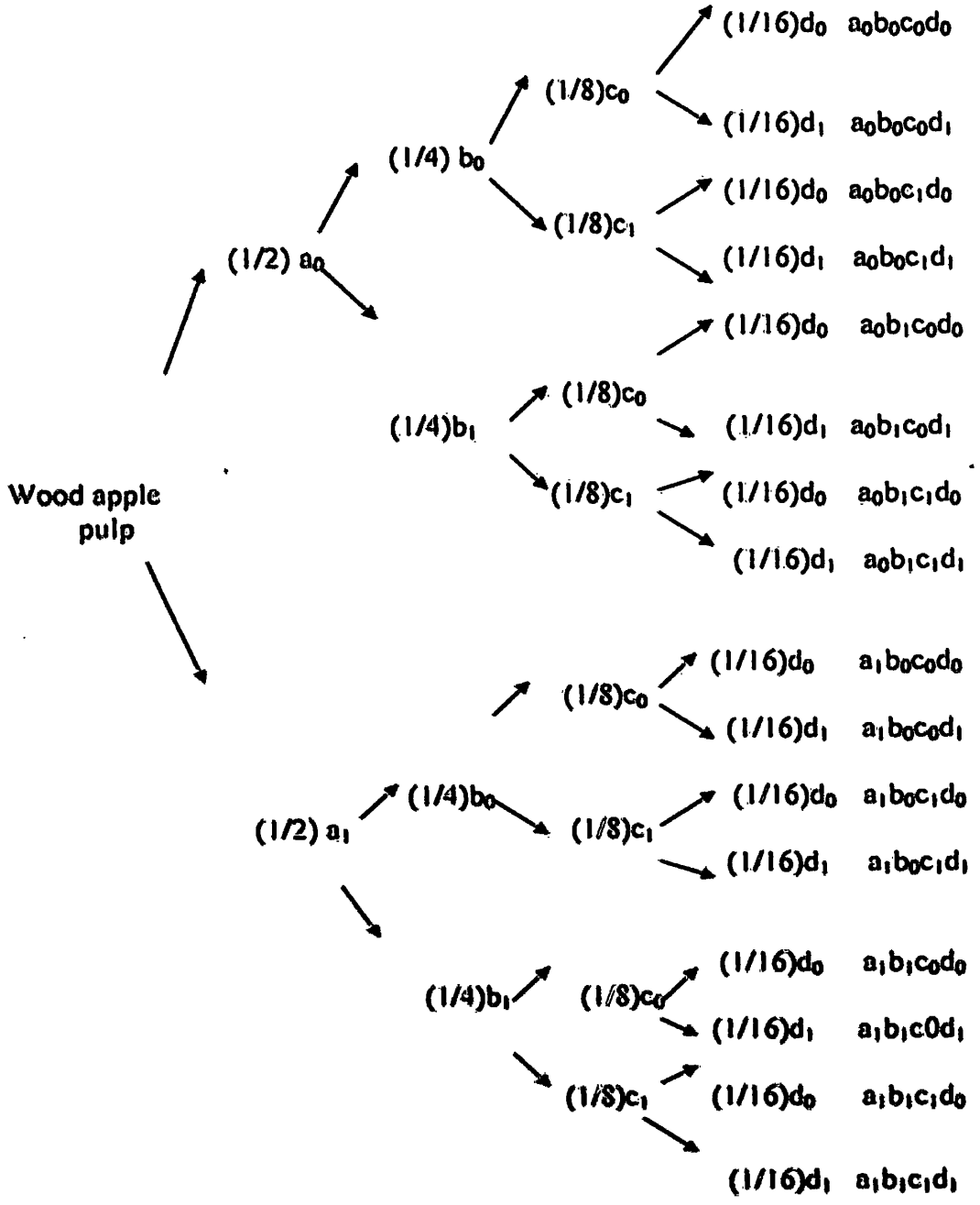
Figure 3.1 Wood apple pulp preparation procedure.



3.2.2 Treatment combination method

Sample were prepared by using following treatment combinations with respect to stipulated experiment design according to factorial experimental design. All treatments were replicate three times.

Figure 3.2 Treatment combination procedure for wood apple



a_0 -Without heat treatment

a_1 -With heat treatment(at 65- 70^{0}C for 5min.)

b_0–Without added sugar

b_1 – With added sugar(at 25%)

c_0 –Without antioxidants

c_1 –With antioxidants (Citric a:, Ascorbic a:, Vitamin E)

d_0 –Without microbial inhibitors

d_1 –With microbial inhibitors (Sodium metabisulfite, Sodium benzoate)

3.2.2.1 Sample preparation method

(a)$a_1b_0c_0d_0$

300g of wood apple pulp was weighed and heated in 65-70^{0}C for five minutes. Heated pulp was poured into a sterilized bottle and stored.

(ab)$a_1b_1c_0d_0$

300g of pulp was weighed and heated 65-70^{0}C for five minutes. 25% of sugar was added to it. Then it was poured into a sterilized bottle and stored.

(ac)$a_1b_0c_1d_0$

300g of pulp was weighed and heated in 65-70^{0}C for five minutes. 300ppm of citric acid 500ppm of ascorbic acid and 100ppm Vitamin E were added it. Then it was poured into a sterilized bottle and stored.

(abc)$a_1b_1c_1d_0$

300g of pulp was weighed and heated in 65-70^{0}C for five minutes.25% of sugar, 3000ppm of citric acid, 500ppm of ascorbic acid, and 100ppm of vitamin E were added to it. Then it was poured into a sterilized bottle and stored.

(ad)$a_1b_0c_0d_1$

300g of pulp was weighed and was heated in 65-70^{0}C for five minutes. 1000ppm of sodium metabisulfite and 500ppm of sodium benzoate were added to it. Then it was poured into a sterilized bottle and stored.

(abd) $a_1b_1c_0d_1$

300g of pulp was weighed and was heated in 65-70^{0}C for five minutes. 755 of sugar 1000ppm of SMS and 500ppm of sodium benzoate were added to it. Then it was poured into a sterilized bottle and stored.

(acd) $a_1b_0c_1d_1$

300g of pulp was weighed and was heated in 65-70^{0}C for five minutes. 300ppm of citric acid , 500ppm of ascorbic acid, 100ppm of vitamin E, 1000ppm of SMS and 500ppm of sodium benzoate were added to it. Then it was poured into a sterilized bottle and stored.

(abcd) $a_1b_1c_1d_1$

300g of pulp was weighed and was heated in 65-70^{0}C for five minutes. 25% of sugar , 3000ppm of citric acid, 500ppm of ascorbic acid, 100ppm of vitamin E, 1000ppm of SMS, and 500ppm of sodium benzoate were added it. Then it was poured into a sterilized bottle and stored.

(1)$a_0b_0c_0d_0$, (b)$a_0b_1c_0d_0$, (c)$a_0b_0c_1d_0$, (bc)$a_0b_1c_1d_0$, (d)$a_0b_0c_0d_1$, (bd)$a_0b_1c_0d_1$, (cd)$a_0b_0c_1d_1$, and (bcd)$a_0b_1c_1d_1$ samples were prepared as above without giving heat treatment.

3.2.3 Method of chemical analysis

3.2.3.1 Method of analysis Brix

The prism of refractometer was cleaned by using water and dried using cleaning tissue. Pulp Sample was prepared by stirring with the plastic stirring rod. Few drops of the sample were placed on to prism by using plastic stirring rod. The refractometer was closed and was read the Brix directly.

3.2.3.2 Method of pH determination

The pH meter was calibrated by using a buffer solution of exactly known pH. Sufficient sample was prepared for immersion of the electrode of the pH meter. Sample was mixed carefully until it was homogeneous. The electrode was introduced into the test sample. The pH of the pulp was read directly from the scale on the instrument to the nearest 0.05 pH unit till a constant value has been reached (SLS 328:1974).

Sample which got higher rank sum (Refer table) was selected from the sensory evaluation and titable acidity was analyzed in it.

3.2.3.3 Method of acidity determination

Standard sodium hydroxide solution(0.1N) and phenolphthalein indicator (0.5g of phenolphthalein was dissolved in 200ml of 50% ethyl alcohol by volume) were prepared.

Procedure

Five grams of the pulp was weighted and transferred to a beaker with 100ml of recently boiled and cooled distilled water and from it 25ml of content was taken to conical flask. One milliliter of phenolphthalein indicator solution was added and was titrated with standard sodium hydroxide solution(SLS 347,1975)

Calculation

Acidity (as ascorbic acid) per cent by mass =1.75nv/m

Where;

V= Volume in ml of standard sodium hydroxide required for titration.

N= Normality of standard sodium hydroxide solution.

M = Mass in gram of the pulp taken for the test.

3.2.4 Sensory evaluation

3.2.4.1 Sensory panel selection method

Uniform concentration of sucrose solution was provided for twenty panelists and asked them to record their choice on the hedonic scale. Fifteen panelists who accurately selected taste of sugar solution in same scale were taken as sensory panel

3.2.4.2 Sensory evaluation method

Each panelist was kept apart invisible to each other. A cardboard piece was used as curtain in order to facilitate minimizing of monitoring the influence of sensory properties. The sensory evaluation was carried out the panelist in the morning in order to avoid intensity of influence of external sensory force. Eight woo apple samples representing each treatment combination were placed before the panelist along with a ballot paper (appendix 1). Samples were placed in a porcelain plates and provided yogurt spoons and cream cracker biscuits. Aim of the sensory evaluation was explained to each panelist (appendix 2) and ask them to try out the samples.

Sensory evaluation was carried out three times once in three weeks during the period of three month and third sensory evaluation was analyzed according to nonparametric method.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results of wood apple pulp preparation

Table 4.1 preservation action of wood apple pulp

S. No.	Sample Type	Treatment combination	Observ-ation
1	A0b0c0d0	Raw pulp/No sugar/No antioxidants/No Microbial inhibitors	-
2	A1b0c0d0	Heated pulp/No sugar/No antioxidants/No microbial inhibitors	-
3	A0b1c0d0	Raw pulp/With sugar/No antioxidants/No microbial inhibitors	-
4	A1b1c0d0	Heated pulp/With sugar/No antioxidants/No microbial inhibitors	-
5	A0b0c1d0	Raw pulp/No sugar/With antioxidants/No microbial inhibitors	-
6	A1b0c1d0	Heated pulp/No sugar/With antioxidants/No microbial inhibitors	-
7	Aob1c1d0	Raw pulp/With sugar/With antioxidants/No microbial inhibitors	-
8	A1b1c1d0	Heated pulp/With sugar/With antioxidants/No microbial inhibitors	-
9	A0b0c0d1	Raw pulp/No sugar/No antioxidants/With microbial inhibitors	+
10	A1b0c0d1	Heated pulp/No sugar/No antioxidants/With microbial inhibitors	+
11	A0b1c0d1	Raw pulp/With sugar/No antioxidants/With microbial inhibitors	+
12	A1b1c0d1	Heated pulp/With sugar/No antioxidants/With microbial inhibitors	+
13	A0b0c1d1	Raw pulp/ No sugar/With antioxidants/With microbial inhibitors	+
14	A1b0c1d1	Heated pulp/No sugar/with antioxidants/With microbial inhibitors	+
15	A0b1c1d1	Raw pulp/With sugar/With antioxidants/With microbial inhibitors	+
16	A1b1c1d1	Heated pulp/With sugar/With antioxidants/With microbial inhibitors	+

\- - Presence of mould patches during the period of three month

\+ - Absence of mould patches during the period of three month

Antioxidants – Citric acid, Ascorbic acid, Vitamin E

Microbial inhibitors – Sodium metabi sulfite and sodium benzoate

4.1.1Changes of chemical properties of prepared sample during storage.

4.1.1.1 Brix value

All samples were prepared with pure wood apple pulp which natural Brix value was about 7^0 . Brix value of samples had been changed into different degrees, after subjected for different treatments.

Table 4.2 brix values of prepared sample and respectively after three weeks, six weeks, and nine weeks.

	Brix values			
S. No	Prepared pulp	After 3 weeks	After 6 weeks	After 9 weeks
1	7	6	6	5
2	8	8	7	7
3	27	27	26	26
4	28	28	27	26
5	7	7	6	6
6	8	8	7	6
7	27	27	27	26
8	28	28	28	27
9	7	7	7	7
10	8	8	8	8
11	27	27	27	27
12	28	28	28	28
13	7	7	7	7
14	8	8	8	8
15	27	27	27	27
16	28	28	28	28

(numbers donate to the sample as in table 4.1).

sample type depicted by numerical numbers 1, 2, 3, 4, 5, 6, 7, and 8 were prepared without incorporation of microbial inhibitors (SMS and sodium benzoate). The rest samples were prepared with addition of SMS and sodium benzoate. Since all sample did not contain microbial inhibitors were observed substantial amount of mold patches and gradually decrease of Brix values. Because wood apple is a favourable breeding ground for microbes as it contains considerable amount of simple sugars which enable to provide metabolism energy for microbes on their rapid growth. Mould is a living biological agent. Their mycelium can spread over the host. Biological system of mould secreted enzymes such as α and β amylases to its growing media and these enzymes can digest the available sugar in the media in order to compensate the requirements of its biological system and these digested sugar can be utilized for their day to day biological activities. Hence incorporation of antimicrobial substances such as SMS and sodium benzoate are an important aspect for fruit pulp preservation. Therefore no mould growth and no decrease of Brix values were occurred in sample number 9 to 16.

4.1.1.2 pH

Table 4.3 pH values of prepared samples respectively after three weeks, six weeks and nine weeks.

	pH value			
Sample No	Prepared pulp	After 3 weeks	After 6 weeks	After 9 weeks
1	3.42	3.41	3.4	2.1
2	3.54	3.54	3.51	3.1
3	3.47	3.47	3.43	3.4
4	3.47	3.47	3.42	3.41
5	3.34	3.34	3.32	3.3
6	3.34	3.34	3.33	3.31
7	3.35	3.35	3.35	3.32
8	3.36	3.36	3.36	3.32
9	3.53	3.53	3.53	3.53
10	3.53	3.53	3.53	3.53
11	3.53	3.53	3.53	3.53
12	3.26	3.26	3.26	3.26
13	3.54	3.54	3.54	3.54
14	3.57	3.57	3.57	3.57
15	3.42	3.42	3.42	3.42
16	3.41	3.41	3.41	3.41

(Numbers donate to the sample as in table 4.1)

sample numbers 9 to 16, did not decrease its pH value during the period of three month, and in sample numbers 1to 8, pH values were gradually decreased. Reasons for these changes can be described based on the Brix vale changes. Sugar is broken down to simple substances by yeast or mould. Terminal of this process is refer as fermentation. During fermentation yeast and mould have an ability to convert sugar into acetic acid. Hence usually the media that contain microbes which can slowly and gradually media towards the acidic side. Sample prepared with microbial inhibitors did not show this phenomenon.

4.1.1.3 Titrable acidity

Titable acidity was analyzed, sample which got higher average rank was selected from the sensory evaluation and value of titable acidity was 1.25.
(For the calculation refer appendix 3)

4.1.2 Changes of organoleptic properties of sample during storage.

Samples prepared with different treatments were subjected to sensory evaluation in order to asses the changes of sensory properties during the period of three month. Sensory panel was formulated and was provided the pulp only from sample 9 to 16 as the other samples were deteriorated as a result of mould attack (Collection data of sensory evaluation refer appendix 4).

4.1.2.1 Taste

Table 4.4 Analysis results of sensory evaluation for taste

Kruskal – wallis test

Treatment	N	Median	Ave. Rank	Z
$a_0b_0c_0d_1$	15	1	17.0	-5.18
$a_0b_0c_1d_1$	15	1	20.4	-4.73
$a_1b_0c_0d_1$	15	3	55.4	-0.16
$a_1b_0c_1d_1$	15	4	61.1	0.07
$a_0b_1c_0d_1$	15	4	62.0	0.17
$a_0b_1c_1d_1$	15	6	62.0	1.96
$a_1b_1c_0d_1$	15	7	87.2	3.18
$a_1b_1c_1d_1$	15	8	103.6	5.13
overall	120		60.5	

(treatments donate to the sample as in table as 4.1)

H = 78.66 DF = 7 P = 0.000

H = 80.07 DF = 7 P = 0.000

H_0 : There is no significant difference between wood apple sample at 5% level.

H_1 : There is a significant difference between wood apple sample.

According to above results P value is less than 0.05 significant level. So H_0 is reject. H_1 is accept and there is a significant different between wood apple sample at 5% level. Sample which got the highest average rank, $a_1b_1c_1d_1$ is the best sample and sample which got the next average rank, $a_1b_1c_0d_1$ is also good.

4.1.2.2 Colour

Table 4.5 Analysis results of sensory evaluation for colour

Kruskal-walis test

Treatment	N	Median	Ave. Rank	Z
$a_0b_0c_0d_1$	15	1.0	16.1	-5.28
$a_0b_0c_1d_1$	15	1.0	17.3	-5.14
$a_0b_1c_0d_1$	15	5.0	61.1	0.07
$a_1b_0c_0d_1$	15	5.0	63.2	0.33
$a_0b_1c_1d_1$	15	6.0	72.1	1.38
$a_1b_0c_1d_1$	15	6.0	76.0	1.49
$a_1b_1c_0d_1$	15	8.0	86.5	3.09
$a_1b_1c_1d_1$	15	8.0	94.7	4.02
overall	120		60.5	

(treatments donated to the sample as in table 4.1)

H = 74.12 DF = 7 P = 0.000

H = 75.88 DF = 7 P = 0.000

H_0 : There is no significant difference between wood apple sample at 5% level.

H_1 : There is a significant difference between wood apple sample at 5% level.

According to above results, P value is less than 0.05 significant level. So H0 is rejected. H1 is accepted and there is a significant different between wood apple sample at 5% level. Sample which got the highest rank, $a_1b_1c_1d_1$ is a best sample and sample which got the next average rank, $a_1b_1c_0d_1$ is also good.

4.1.2.3 Texture

Kruskal-wallis test

Table 4.6 Analysis results of sensory evaluation for texture

Treatment	N	Median	Ave. rank	Z
$A_0b_0c_1d_1$	15	1.0	15.4	-5.36
$A_0b_0c_0d_1$	15	1.0	16.4	-5.25
$A_0b_1c_0d_1$	15	5.0	59.9	-0.08
$A_1b_1c_0d_1$	15	6.0	64.6	0.49
$A_1b_0c_1d_1$	15	6.0	64.9	0.52
$A_1b_0c_0d_1$	15	6.0	67.9	0.88
$A_1b_1c_1d_1$	15	7.0	88.6	3.54
$A_0b_1c_1d_1$	15	8.0	106.3	5.45
Overall			60.5	

(treatments donated as table 4.1)

H = 86.25 DF = 7 P = 0.000

H = 88.35 DF = 7 P = 0.000 (adjusted for ties)

H_0 : There is no significant difference between wood apple sample at 5% level.

H_1 : There is a significant difference between wood apple sample at 5% level.

According to above results P value is less than 0.05 significant level. So H_0 is reject. H_1 is accepted and there is a significant different between wood apple sample at 5% level. Sample which got the highest average rank, $a_0b_1c_1d_1$ is a best sample and the sample which got next average rank, $a_1b_1c_1d_1$ is also good.

4.6 Aroma

Table 4.7 Analysis results of sensory evaluation for aroma.

Kruskal-wallis test

Treatment	N	Median	Ave. rank	Z
$a_0b_0c_0d_1$	15	1.0	15.5	-5.36
$a_0b_0c_1d_1$	15	1.0	16.8	-5.20
$a_1b_0c_0d_1$	15	4.0	60.6	0.01
$a_0b_1c^0d_1$	15	6.0	66.7	0.73
$a_1b_0c_1d_1$	15	6.0	69.7	1.10
$a_0b_1c_1d_1$	15	6.0	70.6	1.20
$a_1b_1c_0d_1$	15	7.0	86.6	3.13
$a_1b_1c_1d_1$	15	8.0	97.3	4.38
overall	120		60.5	

(treatments donated as table 4.1)

H = 76.92 DF = 7 P = 0.000

H = 79.05 DF = 7 P = 0.000

H0 : There is no significant difference between wood apple sample at5% level.

H1 : There is a significant difference between wood apple sample at 5% level.

According to above results P value is less than 0.05 significant level. So H_0 is rejected. H_1 is accepted and there is a significant difference between wood apple sample at5% level. Sample which got the highest average rank, $a_1b_1c_1d_1$ is a best sample and sample which got the next higher average rank, $a_1b_1c_0d_1$ is also good.

Treatment combinations of sample which got highest average rank according to texture are without heat treated, with added sugar, with antioxidants(citric acid, ascorbic acid, and vitamin E) and microbial inhibitors (SMS and sodium benzoate). But Treatment combinations of sample which got highest average rank according to taste colour, and aroma are heat treated, with added sugar, with antioxidants (citric ascorbic acid and vitamin E) and microbial inhibitors (SMS and sodium benzoate).According to that $a_1b_1c_1d_1$ sample can be taken as the best sample.

CHAPTER 5
CONCLUSION

Staling effect of wood apple pulp can be avoided by heat treating at 65-70^{0}C for five minutes and incorporation of sugar,antioxidants(citric acid, ascorbic acid, and vitamin E) and microbial inhibitors(SMS and sodium benzoate) at 25%, 3000ppm, 500ppm, 100ppm, 1000ppm and 500ppm respectively.

Wood apple pulp can be supplied during off season for three month without interruption, if the pulp is subjected to above similar treatments.

Wood apple pulp can be stored without utilizing costly cold storage facilities.

Brix value, pH value, and acidity of wood apple pulp are to be maintain at 28^0, 3.14 and 1.25 respectively in order to maintain least damage to original quality of wood apple pulp during storage.

Further studies and recommendation.

Eventhough the best sample was selected out of this experiment is $a_1b_1c_1d_1$ the experiment itself is lasted for three month. It is incompatible with the total duration of the off season which usually lasted for six month. Hence the trial should be extended at least for six month period in order to asses the effectively of the treatment combinations in terms of colour, taste, aroma, and texture.

In this project, best sample was got highest average rank according to taste, colour, and aroma in sensory evaluation. Therefore it will be studied to improve the texture of best wood apple sample.

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APPENDIX

APPENDIX I

SENSORY EVALUATION SHEET

DATE: PRODUCT: Wood apple pulp

- Indicate how much you like or dislike each sample after testing
- Assess the sample individually
- Give numerical values ringing from like extremely (9) to dislike extremely (1) as given below
- Rinse your mouth with water after testing each sample.

POINT SCALE	POINT
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither likes or dislike	5
Dislike slightly	4
Dislike Moderately	3
Dislike very much	2
Dislike extremely	1

Sensory aspects	235	852	123	431	362	675	593	249
Taste								
Colour								
Texture								
Aroma								

Specific comment

Signature:

APPENDIX 2

Instruction for sensory evaluation

Following instruction were given to the judge

1) Ask from judge do not eating for at least 20 minutes before start testing. Because above factors can affect feelings of judges.

2) Before start tasting and between tasting two sample eat piece of cream cracker biscuits can neutralize mouth from other taste.

3) Tell to judges if it is difficult to get idea about texture, colour like characteristics from given amount of sample, ask the sample bottle.

4) When panelists participating to the sensory evaluation ask to do not speak with Other ballot papers.

APPENDIX 3

Calculation for analysis tritable acidity

Weight of wood apple pulp = 5g

Required NaOH = 9 ml

Acidity (as ascorbic acid) = $\frac{1.75 \times 0.1 \times 9 \times 100}{25 \times 5}$

= 1.25%

APPENDIX 4

Collection data of sensory evaluation

1 Taste

Sensory Aspect	235	852	123	431	362	675	593	249
1	4	7	1	1	9	8	6	5
2	6	7	1	1	7	5	8	9
3	1	2	1	1	6	8	2	1
4	1	2	1	1	8	9	7	4
5	7	4	1	1	9	8	6	5
6	6	6	1	1	7	7	2	6
7	3	7	1	4	4	9	4	3
8	3	8	1	1	9	8	3	2
9	2	7	1	1	5	8	2	5
10	4	6	1	1	7	8	4	4
11	3	3	1	1	2	7	2	6
12	4	9	1	5	5	8	4	6
13	2	7	1	1	6	8	1	3
14	3	6	1	1	9	8	3	4
15	4	3	1	1	2	8	6	2

2 Colour

Sensory aspect	235	852	123	431	362	675	593	249
1	9	5	1	1	9	8	6	5
2	9	6	1	1	7	5	8	9
3	2	2	1	1	8	7	6	4
4	2	2	1	1	8	9	7	4
5	5	9	1	1	8	7	4	6
6	6	7	3	3	8	9	6	4
7	4	8	1	1	2	7	7	4
8	5	6	1	1	7	6	9	6
9	3	6	1	1	7	8	5	4
10	6	7	1	1	7	8	6	6
11	7	8	1	1	8	8	8	7
12	6	3	1	2	9	8	6	4
13	3	7	1	1	2	8	5	4
14	7	6	1	1	8	8	7	6
15	3	6	1	1	3	7	1	5

3 Texture

Sensory Aspect	235	852	123	431	362	675	593	249
1	5	8	1	1	4	7	6	4
2	5	9	1	1	6	7	6	3
3	4	8	2	1	7	6	7	5
4	7	7	2	1	6	9	7	3
5	6	8	1	1	5	7	7	8
6	7	7	2	1	6	6	4	3
7	5	8	1	1	6	5	5	4
8	6	9	2	1	7	8	5	6
9	6	8	1	1	5	7	4	7
10	3	7	1	3	5	6	6	4
11	5	9	1	3	3	6	6	3
12	7	7	1	1	6	7	4	5
13	6	8	1	1	7	8	3	8
14	6	7	1	1	4	7	5	6
15	6	7	1	1	3	6	7	6

4 Aroma

Sensory aspect	235	852	123	431	362	675	593	249
1	7	7	1	1	9	8	7	7
2	2	3	1	1	9	8	6	6
3	4	7	1	1	5	9	6	8
4	3	6	1	1	3	7	7	5
5	7	6	1	1	8	8	7	6
6	3	7	1	1	2	8	5	4
7	6	3	1	2	9	8	6	4
8	7	8	1	1	8	8	8	7
9	6	7	1	1	7	8	6	6
10	3	6	1	1	7	8	5	4
11	5	6	1	1	7	6	9	6
12	4	8	1	1	2	7	7	4
13	2	2	1	1	9	8	2	2
14	2	2	1	1	8	7	6	4
15	9	6	1	1	7	6	5	8

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