

Senior Project
The Study of Pomegranate Wine Making

By
Ms. Tharinee Leethaweessup

A special project submitted to the Faculty of Biotechnology
Assumption University in part fulfillment of the requirements for the degree of
Bachelor of Science in Biotechnology

December, 2001

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Title **The Study of Pomegranate Wine Making**

By **Ms.Tharinee Leethaweesup**

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Level of study **Bachelor of Science**

Department **Agro-Industry**

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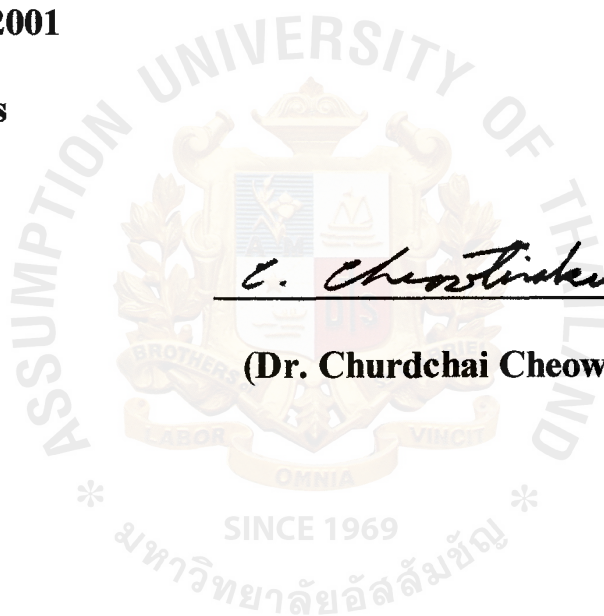
Advisory Committees



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(Dr. Churdchai Cheowtirakul)



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ABSTRACT

At present, Thai people prefer to consume Thai wine much to ever. This may due to the country was facing an economic crisis. Pomegranate or Tab-Tim is widely grown in Thailand and stand a good chance to be developed in to many values added products. But, somehow, because of their characteristic and price, pomegranate is not a very popular fruit. Pomegranate can be used as a very fine raw material for making wine. The pomegranate wine that mixed with a little vodka and sugar gives a good taste and can be expected to be a new product, which will be popular in the future.



CONTENT

	Page
List of tables	i
List of figures	ii
Introduction	1
Literature review	2
Objectives	10
Materials and Methods	11
Result and Discussion	14
Conclusion	17
References	18
Appendix	19
Appendix A: Statistical Analysis	20



LIST OF TABLE

	Page
1. Sensory Evaluation of the pomegranate wine mixed with vodka on flavor	21
2. Sensory Evaluation of the pomegranate wine mixed with sugar on flavor	23
3. Sensory Evaluation of the pomegranate wine mixed with sugar on clearness	25
4. Sensory Evaluation of the pomegranate wine, pomegranate wine mixed with vodka, pomegranate wine mixed with sugar and pomegranate wine mixed with vodka and sugar in the diff ratios on flavor	27
5. Sensory Evaluation of the pomegranate wine, pomegranate wine mixed with vodka, pomegranate wine mixed with sugar and pomegranate wine mixed with vodka and sugar in the diff ratios on color	29
6. Sensory Evaluation of the pomegranate wine, pomegranate wine mixed with vodka, pomegranate wine mixed with sugar and pomegranate wine mixed with vodka and sugar in the diff ratios on clearness	31
7. Sensory Evaluation of the pomegranate wine, pomegranate wine mixed with vodka, pomegranate wine mixed with sugar and pomegranate wine mixed with vodka and sugar in the diff ratios on overall acceptance	33

LIST OF FIGURE

A picture of the pomegranate Wine	20
A picture of the pomegranate tree	21
A picture of the pomegranate fruit(cultivar Tab-tim Siam)	21



INTRODUCTION

Pomegranate, a yellow-red round shape fruit with a branded of sweet sour taste is well known for Thai people named as Tab-tim. Most of the Tab-tim is cultivated in the upcountry area due to the availability of the land. Some people believed that the red color of the Tab-tim could bring them a good luck if planted in front of their house. Anyway, Tab-tim has some disadvantage too. It is very difficult to consume, because they compose of a vast number of tiny seeds. Therefore most of the fruit trees are left to die by their growers.

In some countries such as America and Iran, pomegranate can be developed into many products such as a concentrate pomegranate juice, a ready to drink pomegranate liquier, pomegranate jellies or pomegranate custard for examples.

In the past few years, the amount of wine produced in Thailand has been increasing. The amount of imported wine is decreasing because of the economic crisis. A lot of Thai people have turned to drink Thai fruit wine instead. This research provides a guideline for making pomegranate wine. My sincere hope is that, in the future, this wine will become a popular drink for the Thai wine consumer and will be used as a social drink in every occasion.

LITERATURE REVIEW

Pomegranate *Punica granatum* L.

Common name: Pomegranate, Granade (French), Granada (Spanish), Granaatappel (Dutch), Granatapfel (Germans), Melogranato (Italians), Gangsalan (Indonesia), Tab Tim (Thailand), Delima (Malaya), and Roma (Brazilians).

Relate Species: *Punica proto-punica*

Origin: The pomegranate is native from Iran to the Himalayas in northern India and was cultivated and naturalized over the whole Mediterranean region since ancient times. It is widely cultivated throughout India and the drier parts of Southeast Asia, Malaya, the East Indies and tropical Africa. Spanish settlers introduced the tree into California in 1769. It is grown for its fruits mainly in the drier parts of California and Arizona.

Adaptation: Pomegranates prefer a semi-arid mild-temperate to subtropical climate and are naturally adapted to region with cool winter and hot summers. A humid climate adversely affects the formation of fruit. The tree can be severely injured by temperature below 12°F. In U.S. pomegranates can be grown outside as far north as southern Utah and Washington, D.C. but seldom set fruit in these areas. The tree adapts well to container culture and will sometimes fruit in a greenhouse.

Description

Growth Habits: The pomegranate is a neat, rounded shrub or small tree that can grow to 20 or 30 ft, but more typically to 12 to 16 ft in height. Dwarf varieties are also known. It is usually deciduous, but in certain areas the leaves will persist on the tree. The trunk is covered by a red-brown bark, which later becomes gray. The branches are stiff, angular and often spiny. There is a strong tendency to sucker from the base. Pomegranates are also long lived. There are specimens in Europe that are known to be over 200 years of age. The vigor of a pomegranate decline after about 15 years, however.

Foliage: The pomegranate has glossy, leathery leaves that are narrow and lance-shaped.

Flowers: The attractive scarlet, white or variegated flowers are over an inch across and have 5 to 8 crumpled petals and a red, fleshy, tubular calyx, which persists on the fruit. The flowers may be solitary or grouped in twos and threes at the ends of the branches. The pomegranate is self-pollinated as well as cross-pollinated by insects. Cross-pollination increases the fruit set. Wind pollination is insignificant.

Fruit: The nearly round, 2-1/2 to 5 inch wide fruit is crowned at the base by the prominent calyx. The tough, leathery skin or rind is typically yellow overlaid with light or deep pink or rich red. Membranous walls separate the interior and white, spongy, bitter tissue into compartments packed with sacs filled with sweet acid, juicy, red, pink or whitish pulp or aril. In each sac there is one angular, soft or hard seed. The seeds represent about 52% of the weight of the whole fruit.

Culture

Location: Pomegranates should be placed in the sunniest, warmest part of the yard or orchard for the best fruit, although they will grow and flower in part shade. The attractive foliage, flowers and fruits of the pomegranate, as well as its smallish size make it an excellent landscaping plant.

Soil: The pomegranate does best in well-drained ordinary soil, but also thrives on calcareous or acidic loam as well as rock-strewn gravel.

Climate: The species is primarily mild-temperature to subtropical and naturally adapted to regions with cool winters and hot summer, but certain types are grown in home dooryards in tropical areas, such as various islands of the Bahamas and West Indies. In southern Florida, fruit development is enhanced after a cold winter. The plant favors a semi-arid climate and is extremely drought-tolerant.

Pollination: The pomegranate is both self-pollinated and cross-pollinated by insects. There is very little wind dispersal of pollen. Self-pollination of bagged flowers has resulted in 45% fruit set. Cross-pollination has increased yield to 68%. In hermaphrodite flowers, 6 to 20% of the pollen may be infertile; in male, 14 to 28%. The size and fertility of the pollen vary with the cultivar and season.

Fertilizing: In the West, the trees are given 2 to 4-ounce applications of ammonium sulfate or other nitrogen fertilizer the first two springs. After that very little fertilizer is needed, although the plants respond to an annual mulch of rotted manure or other compost.

Pruning: Plant should be cut back when they are about 2 ft. high. From this point allow 4 or 5 shoots to develop, which should be evenly distributed around the stem to keep the plant well balanced. These should start about 1 ft from the ground, giving a short but well-defined trunk. Any shoot, which appears above or below, should be removed, as should any suckers. Since the fruit are borne only at the tip at new growth, it is recommended that for the first 3 years the branches are judiciously shorten annually to encourage the maximum number of new shoots on all sides, prevent straggly development and achieve a strong well-framed plant. After the 3rd year, only suckers and dead branches are removed.

Propagation: The pomegranate can be raised from seed but may not come true. Cutting root easily and plant from them bear fruit after about 3 years. Twelve to 20 inches long cutting should be taken in winter from mature, one-year old wood. The leaves should be removed and the cutting treated with rooting hormone and inserts about two-thirds their length into the soil or into some other warm rooting medium. Plants can also be air-layered but grafting is seldom successful.

Pets and Disease

The pomegranate butterfly, *Virachola isocrates*, lays eggs on flower buds and calyx of developing fruit; in a few days the caterpillars enter the fruit by way of the calyx. These fruit borers may cause loss of an entire crop unless the flowers are sprayed 2 times 30 days apart. A stem borer sometimes makes holes right through the branches. Both *Pleuroplaconema* or *Ceuthospora Phyllosticta* discoloration of fruits may cause twig dieback and seeds result from infestation by *Aspergillus castaneus*. The fruits may be sometimes disfigured by unless these organisms are controlled by appropriate spraying measures. A high amount of rain during the raining season may induce soft rot. A post-harvest rots cause by *Alternaria solani*, which is particularly prevalent in cracked fruits. Minor problems are leaf and fruit spot caused by *Cercospora*, *Gloeosporium* and *Pestalotia*. Also foliar damages can cause by whitefly, thrip, mealy bugs and scale insects; and defoliation by *Euprotis spp.* and *Archyophora dentula*. Termites may infest the trunk.

Cultivars

Balegal: Originated in San Diego, Calif. Selected by Paul H. Thomson. Large, roundish fruit, 3 inches in diameter, and somewhat larger than Fleshman. Skin pale pink, lighter than fleshman. Flesh is slightly darker than Fleshman and very sweet.

Cloud: (From the Univ. of Calif., Davis pomegranate collection) Medium-sized fruit with a green-red color. Juice sweet and white.

Crab: (From the Univ. of Calif., Davis pomegranate collection) Large fruit have red juice that is tart but with a rich.

Early Wonderful: Large, deep-red, thin-skinned, delicious fruit. Ripen about 2 weeks ahead of wonderful. The bush is medium-sized with large orange-red fertile flowers. Blooms late and very productive.

Fleshman: Originated in Fallbrook, Calif. Selected by Paul H. Thomson. Large, roundish fruit, about 3 inches in diameter, pink outside and in. Very sweet flavor seeds relatively soft, quality very good.

Francis: Originated in Jamaica via Florida. Large, sweet, split-resistant fruit. Prolific producer.

Granada: Originated in Lindsay, Calif. introduced in 1966. Bud mutation of Wonderful. Fruit resembles Wonderful, but displays a red crown while in the green state, darker red in color and less tart. Ripens one month earlier than Wonderful. Flower also deeper red. Tree identical to Wonderful.

Green Globe: Originated in Camarillo, Calif. Selected by John Chater. Large, sweet, aromatic, green-skinned fruit. Excellent quality.

Home: (From the Univ. of Calif., Davis pomegranate collection) The fruit is variable yellow-red in color, with light pink juice that is sweet and of rich flavor. Some bitterness.

King: (From the Univ. of Calif., Davis pomegranate collection) Medium to large fruit, somewhat smaller than Balegal and fleshman. Skin darker pink to red. Flavor very sweet. Has a tendency to split. Bush somewhat of a shybearer.

Phoenicia (Fenecia): Originated in Camillo, Calif. Selected by John Charter. Large fruit, 4-5 inches in diameter, mottled red-green skin. Flavor sweet, seeds relative hard.

Sweet: Fruit is lighter in color than Wonderful, remains slightly greenish with a red blush when ripe. Pink juice; flavor much sweeter than other Cultivars. Excellent in fruit punches. A tree highly ornamental, bears at an early age, productive.

Utah Sweet: Very sweet, good quality fruit. Pink skin and pulp. Seeds notably softer than those of Wonderful and other standard cultivars. Attractive pinkish-orange flowers.

Wonderful: Originated in Florida. First propagated in California in 1896. It produced large, deep purple-red fruit and rind medium thick, tough. Flesh deep crimson in color, juicy and of delicious vinous flavor. Seeds not very hard. Better for juicing than for eating out of hand. Plant is vigorous and productive. Leading commercial variety in California.



Harvesting and Yield

The fruits ripen 6 to 7 months after flowering. In Israel, cultivar 'Wonderful' is deemed ready to harvest when the soluble solids (SSC) reach 15%. In California, maturity has been equated with 1.8% titratable acidity (TA) and SSC of 17% or more. The fruit cannot be ripened off the tree even with ethylene treatment. Growers generally consider the fruit ready to harvest if it makes a metallic sound when tapped. The fruit must be picked before over maturity when it tends to crack open if rained upon or under certain conditions of atmospheric humidity, dehydration by winds, or insufficient irrigation. Of course, one might assume that ultimate splitting is the natural means of seed release and dispersal. The fruits should not be pulled off but clipped close to the base so as to leave no stem to cause damage in handling and shipping. Appearance is important, especially in the United States where pomegranate may be purchased primarily to enhance table arrangements and other fall (harvest-time) decoration. Too much sun exposure causes sunscald brown, russet blemishes and roughening of the rind. The fruit ships well, cushioned with paper or straw, in wooden creats or, for nearby markets, in baskets. Commercial California growers grade the fruit into 8 sizes, pack in layers, unrapped but topped with shredded plastic, in covered wood boxes, precool rapidly, and ship in refrigerated trucks. A fruit is cut in the stem end which is placed on a glass to let the juice run out, squeezing the juice from time to time to get all the juice. The juice can be used in a variety of ways: as a fruit juice, to make jellies, sorbets or cold or hot sauces as well as to flavor cakes, baked apples, etc. Pomegranate syrup is sold commercially as grenadine. The juice can also be made into a wine.

Keeping Quality and Storage

The pomegranate is equal to the apple in having a long storage life. It is best maintained at temperature of 32 to 41°F (0–5°C). The fruits improve in storage, become juicier and more flavorful; may be kept for a period of 7 months within this temperature range and at 80 to 85% relative humidity, without shrinking or spoiling. At 95% relative humidity, the fruit can be kept only 2 months at 41°F (5°C); for longer periods at 50°F (10°C). After prolonged storage, internal breakdown is evidenced by faded, streaky pulp of flat flavor. "Wonderful" pomegranates, storage in Israel for Christmas shipment to Europe, are subject to superficial browning (husk scald). Control has been achieved by delaying harvest and storing in 2% O₂ at 35.6°F (2°C). Subsequent transfer to 68°F (20°C) dispels off-flavor from ethanol accumulation.

Food Uses

In some countries, such as Iran, the juice is very popular beverage. Most simply, the juice sacs are removed from the fruit and put through a basket press. Otherwise, the fruits are quartered and crushed, or the whole fruit may be pressed and the juice strained out. In Iran, the cut-open fruits may be stomped by a person wearing special shoes in a clay tub and the juice runs through outlets into clay troughs. Hydraulic extraction of juice should be at a pressure of less than 100psi to avoid undue of tannin. The juice from crushed whole fruits contains excess tannin from the rind (as much as .175%) and a gelatin process precipitates this out. After filtering, adding sodium benzoate may preserve the juice or it may be pasteurized for 30 minutes, allowed to settle for 2 days, then strained and bottled. For beverage purposes, it is usually sweetend. For people in South Carolina make pomegranate jelly by adding 7 ½ cups of sugar and one bottle of liquid pectin for every 4 cups of juice. In Saudi Arabia, the juice sacs may be frozen intact or the extracted juice may be concentrated and frozen, for future use. Pomegranate juice is widely made into grenadine for use in mixed drinks. In the Asiatic countries it may be made into a thick syrup for use as a sauce. It is also often converted into wine. For enjoying out-of-hand or at the table, the fruit is deeply scored several times vertically and then broken apart; then the clusters of juice sacs can be lift out of the rind and eaten. This could be considering as a family activity, prolonging the pleasure of dining. In the home kitchen, the juice can be easily extracted by reaming the halved fruits on an ordinary orange-juice squeezer.

OBJECTIVES

- 1.To explore the possibility of using pomegranate as a raw material of making wine
- 2.To explore the method of making pomegranate wine.
- 3.To formulate the pomegranate wine with optimum taste by sensory evaluation.



MATERIALS AND METHODS

Materials

1. Raw Materials

- 1.1 Pomegranate
- 1.2 Yeast
- 1.3 Sugar
- 1.4 vodka

2. Chemicals

- 2.1 NA(nutrients agar)
- 2.2 KMS (potassium metabisulfite)
- 2.3 Equal(compose of lactose 70% and aspatam 20%, 0.099 g./tablet)

3. Equipments

- 3.1 Flask1000ml.(for starter)
- 3.2 Beaker1000ml.(for media making)
- 3.3 Pot (for wine making)
- 3.4 Jar (for wine fermenting)
- 3.5 Plastic sheet (for cover the jar)
- 3.6 Refractometer (Brix measured)

Method

Starter culture preparation

Yeast: *Saccharomyces cerevisiae*

Preparing media(YM-Agar)

Agar	10.0	g.
Glucose	5.0	g.
Peptone	2.5	g.
Yeast Extract	1.5	g.
Malt Extract	1.5	g.
Distiled water	500	ml.

1. Add all ingredients together (except the agar) into a beaker and boil it on a hot plate.
2. Stir well until all the ingredients are dissolved, and then add in agar and stir well.
3. Pour a ready media into a tube and sterile under pressure (temp 121°C for 15 mins).
4. Pour into a tube and lay the tube on a tray to make a slant agar.
5. Steak one loop of yeast from yeast stock tube on a slant agar tube (2 tubes/jar) and keep in the incubator (37°C) for 24-36 hrs.

Starter

For the pomegranate wine, pomegranate was used for making starter culture instead of pineapple. Because pineapple has yellow color, this may cause problem to the color of wine.

1. Make a pomegranate solution (starter culture will be used at the rate of 3-5%/litre). The pomegranate to water ratio is 1:2.
2. Add sugar to obtain a solution of 12 brix.
3. Pour into flask and heat at 100 C for 15 minutes.
4. After cool down yeast was added.
5. Put on shaker at room temperature for 24 hours.

Preparing sterile bottle and jar

1. Pour boil water into jar and bottle and swirl.
2. Cover with plastic sheet.

Process of pomegranate wine making

1. Peel the fully ripened pomegranate.
2. separate the seed, put in a small tray and weigh the proper amount.
3. Soak with water and rinse out.
4. Prepare sugar syrup by mixing sugar in boiling water. Measure the brix, to obtain syrup with 18 brix.
5. Add pomegranate, stir well and measure the brix again. We might have to add some more sugar until the degree brix equal to 22-24.
6. Pour this must into a sterilized jar and cover with plastic sheet.
7. Outside the jar must be cleaned with alcohol before and after adding yeast.
8. Wait until it cools down (about 40°C), and then add the prepared yeast starter and cover with cotton wool plug.
9. After a day should measure degree brix, and shake the jar everyday for 7 days.
10. When a degree brix is down to 12-13, use a sterilized rubber tube to suck the solution out (leave the solid part) into another sterilized jar.
11. Add KMS (0.1g./2 lit wine) and keep for 3 days.
12. Filtration and pour into a sterilized bottle, cover well and keep in a refrigerated.

RESULTS AND DISCUSSION

1.The suitable ratio for pomegranate wine makingTable1: Sensory evaluation of pomegranate wine with the different ratio of water (for pomegranate wine making)

Attribute	Pomegranate (P)+water(W) 1:1	(P)+(W) 1:1.5	(P)+(W) 1:2
Flavor	5.85 ^a	5.40 ^a	5.30 ^a
Color	6.80	6.25 ^a	5.60 ^a
Clearness	8.20 ^a	8.30 ^a	8.60 ^a
Overall	6.30	5.70	5.10

Note *The result with the same letter designated no statistically significant difference, at 95% confident level.*
 The result with different letters designated a statistically significant difference, at 95% confident level.

From table 1, it was found that there was no significant difference at 95% confidence in flavor of three-difference ratio of water using. The ratio 1:1 of pomegranate and water received the highest scores. While the ratio 1:2 of pomegranate and water received the lowest scores. The color of pomegranate wine using the ratio of 1:1 received the highest scores and also significant difference from others. There was no significant difference among three samples on clearness. For overall acceptant, the ratio 1:1 of pomegranate and water received the highest scores.

2. The suitable ratio for flavoring pomegranate wine with vodka and sugar

Table2: Sensory evaluation of pomegranate wine with the different ratio of vodka adding

Attribute	Pomegranate (P)+vodka 100:10 Ml	(P)+vodka 200:10 Ml	(P)+vodka 300:10 Ml
Flavor	4.55 ^a	4.65 ^a	4.35 ^a

Note *The result with the same letter designated no statistically significant difference, at 95% confident level.*
 The result with different letters designated a statistically significant difference, at 95% confident level.

From table 2, it was found that there was no significant difference at 95% confidence in flavor of three-difference ratio of vodka adding. The amount of vodka added 10 ml in pomegranate wine 200 ml received the highest scores. While the amount of vodka added 10 ml in pomegranate wine 300 ml received the lowest scores. Accually, we can use the entire ratio because there were not much difference. Beside, the lesser amount is cheaper.

Table3: Sensory evaluation of pomegranate wine with different ratio of sugar adding

Attribute	Pomegranate(P)+sugar 200ML:0.09g.(S ₁)	(P) +sugar 300ML:0.09g.(S ₂)	(P) +sugar 400ML:0.09g.(S ₃)
Flavor	3.9 ^b	7.25 ^a	6.25 ^a
Clearness	4.4 ^b	5.95 ^a	6.25 ^a

Note *The result with the same letter designated no statistically significant difference, at 95% confidence level.*
The result with different letters designated a statistically significant difference, at 95% confidence level.

From table 1, it was found that there were no significant difference at 95% confidence in flavor and clearness between S₂ and S₃. There were also found that S₁ is significant difference from S₂ and S₃ on both flavor and clearness. The flavor of mixed pomegranate wine and sugar (300ml:0.09g) was most accepted. While the clearness of mixed pomegranate wine and sugar (400ml:0.09g) were the most accept but still not significant difference from mixed pomegranate wine and sugar (300ml:0.09g).

2.The study of optimum taste of flavored pomegranate wine

As we can see from the result above, the mixing between pomegranate wine, vodka and sugar is accepted by most of taster. So, the table bellow showed the optimum ratio of vodka and sugar in pomegranate wine.

Attribute	Pomegranate wine (P)	(P)+vodka 200:10ml	(P)+sugar 300ml:0.099g.	(P)+vodka+sugar 300ml:10ml:0.099g.
flavor	4.8 ^a	4.7 ^a	6.35 ^b	7.55 ^b
color	5.0 ^a	4.65 ^a	4.5 ^a	4.65 ^a
clearness	7.95 ^a	8.20 ^a	7.45 ^a	7.80 ^a
overall	4.95 ^b	4.95 ^b	6.40 ^a	7.65 ^a

Note *The result with the same letter designated no statistically significant difference, at 95% confidence level.*

The result with different letters designated a statistically significant difference, at 95% confidence level.

It was founded that there was no significantly difference on clearness and color attributes between all of the four treatments. There were also no significantly difference on flavor and overall between pomegranate wine and pomegranate wine mixed with vodka. There were a highly significantly difference on flavor and overall between pomegranate wine mixed with vodka and pomegranate wine mixed with vodka and lactose.

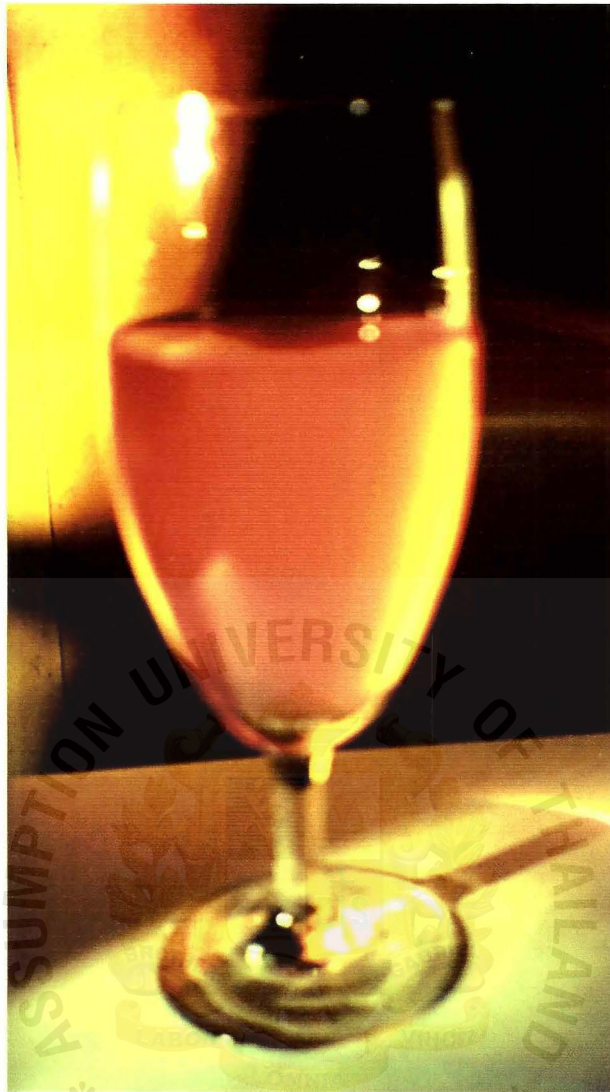
CONCLUSION

- 1) A Pomegranate wine is a good smooth taste wine with soft pink color.
- 2) We can use another kinds of alcohol such as vodka to mix with pomegranate wine and considered as a new product.
- 3) Vodka and sugar can be use to flavor a pomegranate wine and give a good taste which were accepted by most of people.
- 4) The suitable ratio for sugar and vodka adding is 0.099g. (1 tablet) and 10ml per 300ml of pomegranate wine.
- 5) Both of vodka and sugar added is not effect to the color and clearness of a pomegranate wine.
- 6) The pomegranate wine will give a nice color when using a full ripen “Tabtim Siam” cultivars and also use a pomegranate itself as a starter.



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A Pomegranate Wine
Degree Brix equal to 5.5
% Alcohol/volume equal to 12.0



A Pomegranate tree which is grown mostly every house in upcountry



A Pomegranate “Tab-tim Siam”, which gave a rose color to the wine but quite expensive



APPENDIX

Chilling Injury

Food Value Per 100g of Edible Portion

Calories	63-78
Moisture	72.6-86.4g
Protein	0.05-1.6g
Fat	Trace only to 0.9g
Carbohydrates	15.4-19.6g
Fiber	3.4-5.0g
Ash	0.36-0.73g
Calcium	3-12mg
Phosphorus	8-37mg
Iron	0.3-1.2mg
Sodium	3mg
Potassium	259mg
Carotene	None to Trace
Thiamine	0.003mg
Riboflavin	0.012-0.03mg
Niacin	0.0180-0.3mg
Ascorbic Acid	4-4.2mg
Citric Acid	0.46-3.6mg
Boric Acid	0.005mg

*Analyses of fresh juice sacs made by various investigators.

From: <http://www.hort.purdue.edu>

APPENDIX A

Statistical Analysis

Questionnaire for 9 points Hedonic Scale

Name:..... Sex:..... Date:.....

Please evaluate samples of Pomegranate wine, score is based on Hedonic Testing System.

Preference of panelist as follow:

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

	Sample1	Sample2	Sample3	Sample4
Color	_____	_____	_____	_____
Flavour	_____	_____	_____	_____
Taste	_____	_____	_____	_____
Overall acceptant	_____	_____	_____	_____

Appendix Table1: The analysis of variance on flavor of difference ratios of pomegranate wine making

S1: (Pomegranate: Water) = 1000g: 1000ml

S2: (Pomegranate: Water) = 1000g: 1500ml

S3: (Pomegranate: Water) = 1000g: 2000ml

Blocks	Samples			$X_{.j}$	$\bar{X}_{.j}$
	S_1	S_2	S_3		
1	5	5	4	14	4.6667
2	4	4	4	12	4.0000
3	6	7	5	18	6.0000
4	5	6	5	16	5.3333
5	4	4	5	13	4.3333
6	3	4	3	10	3.3333
7	5	5	4	14	4.6667
8	4	5	5	14	4.6667
9	4	6	7	17	5.6667
10	6	7	7	20	6.6667
11	6	5	5	16	5.3333
12	6	5	4	15	5.0000
13	4	3	3	10	3.3333
14	4	3	3	10	3.3333
15	5	5	5	15	5.0000
16	4	3	3	10	3.3333
17	4	3	3	10	3.3333
18	4	4	4	12	4.0000
19	4	4	4	12	4.0000
20	4	5	4	13	4.3333
$X_{.i}$	91.0	93.00	87.00	$X_{ii} = 271$	
$\bar{X}_{.i}$	4.55	4.65	4.35	$\bar{X}_{ii} = 4.5166$	

Note the pomegranate wine making(in difference ratios) is done on three difference samples.

$$CF = (271)^2 / (20)(3) = 1,224.0166$$

$$SS_{total} = (5^2 + 4^2 + \dots + 4^2 + 4^2) - CF \\ = 70.9834$$

$$SS_{trt} = \{(91)^2 + (93)^2 + (87)^2 / 20\} - CF \\ = 1,224.95 - 1,224.0166 = 0.9334$$

$$SS_{blk} = \{(14^2 + 12^2 + \dots + 13^2) / 3\} - CF \\ = 1,277.6666 - 1,224.0166 = 53.65$$

$$SS_e = SS_{total} - SS_{trt} - SS_{blk} \\ = 70.9834 - 0.9334 - 53.65 = 16.4$$

ANOVA

SOV	df	SS	MS	F
Total	tr-1=59	70.9834		
Trt	t-1 = 2	0.9334	0.4667	1.08
Blk	r-1 = 19	53.6500	2.8237	
Error	38	16.4000	0.4316	

Duncan's Multiple Range Test

$$1) S_y = \sqrt{MSE/n} = \sqrt{0.4316/3} = 0.379$$

$$2) \alpha = 0.05 \quad p = 2, 3 \\ Df_{err} = 38$$

	$\frac{p}{2}$	$\frac{p}{3}$
r_∞	2.661	3.016
$r_\infty * S_y$	1.008	1.143

Compare the trt means with range obtained from calculation. Arrange trt mean in ascending order from small to large.

$$4.35^a \quad 4.55^a \quad 4.65^a$$

Note: Treatment under the same letter is not significantly different

Appendix Table2: The analysis of variance on color of difference ratios of pomegranate wine making

S1: (Pomegranate: Water) = 1000g: 1000ml

S2: (Pomegranate: Water) = 1000g: 1500ml

S3: (Pomegranate: Water) = 1000g: 2000ml

Blocks	Samples			X_j	\bar{X}_j
	S_1	S_2	S_3		
1	5	5	4	14	4.6667
2	4	4	4	12	4.0000
3	6	7	5	18	6.0000
4	5	6	5	16	5.3333
5	4	4	5	13	4.3333
6	3	4	3	10	3.3333
7	5	5	4	14	4.6667
8	4	5	5	14	4.6667
9	4	6	7	17	5.6667
10	6	7	7	20	6.6667
11	6	5	5	16	5.3333
12	6	5	4	15	5.0000
13	4	3	3	10	3.3333
14	4	3	3	10	3.3333
15	5	5	5	15	5.0000
16	4	3	3	10	3.3333
17	4	3	3	10	3.3333
18	4	4	4	12	4.0000
19	4	4	4	12	4.0000
20	4	5	4	13	4.3333
X_i	91.0	93.00	87.00	$X_{ii} = 271$	
\bar{X}_i	4.55	4.65	4.35	$\bar{X}_{ii} = 4.5166$	

Note the pomegranate wine making(in difference ratios) is done on three difference samples.

$$CF = (271)^2 / (20)(3) = 1,224.0166$$

$$SS_{total} = (5^2 + 4^2 + \dots + 4^2 + 4^2) - CF \\ = 70.9834$$

$$SS_{trt} = \{(91)^2 + (93)^2 + (87)^2 / 20\} - CF \\ = 1,224.95 - 1,224.0166 = 0.9334$$

$$SS_{blk} = \{(14^2 + 12^2 + \dots + 13^2) / 3\} - CF \\ = 1,277.6666 - 1,224.0166 = 53.65$$

$$SS_e = SS_{total} - SS_{trt} - SS_{blk} \\ = 70.9834 - 0.9334 - 53.65 = 16.4$$

ANOVA

SOV	df	SS	MS	F
Total	tr-1=59	70.9834		
Trt	t-1 = 2	0.9334	0.4667	1.08
Blk	r-1 = 19	53.6500	2.8237	
Error	38	16.4000	0.4316	

Duncan's Multiple Range Test

$$2) S_y = \sqrt{MSE/n} = \sqrt{0.4316/3} = 0.379$$

$$2) \alpha = 0.05 \quad p = 2, 3 \\ Df_{err} = 38$$

	α	
	2	3
r_∞	2.661	3.016
$r_\infty * S_y$	1.008	1.143

Compare the trt means with range obtained from calculation. Arrange trt mean in ascending order from small to large.

$$4.35^a \quad 4.55^a \quad 4.65^a$$

Note: Treatment under the same letter is not significantly different

Appendix Table3: The analysis of variance on clearness of difference ratios of pomegranate wine making

S1: (Pomegranate: Water) = 1000g: 1000ml

S2: (Pomegranate: Water) = 1000g: 1500ml

S3: (Pomegranate: Water) = 1000g: 2000ml

Blocks	Samples			X_j	\bar{X}_j
	S_1	S_2	S_3		
1	5	5	4	14	4.6667
2	4	4	4	12	4.0000
3	6	7	5	18	6.0000
4	5	6	5	16	5.3333
5	4	4	5	13	4.3333
6	3	4	3	10	3.3333
7	5	5	4	14	4.6667
8	4	5	5	14	4.6667
9	4	6	7	17	5.6667
10	6	7	7	20	6.6667
11	6	5	5	16	5.3333
12	6	5	4	15	5.0000
13	4	3	3	10	3.3333
14	4	3	3	10	3.3333
15	5	5	5	15	5.0000
16	4	3	3	10	3.3333
17	4	3	3	10	3.3333
18	4	4	4	12	4.0000
19	4	4	4	12	4.0000
20	4	5	4	13	4.3333
X_i	91.0	93.00	87.00	$X_{ii} = 271$	
\bar{X}_i	4.55	4.65	4.35	$\bar{X}_{ii} = 4.5166$	

Note the pomegranate wine making(in difference ratios) is done on three difference samples.

$$CF = (271)^2 / (20)(3) = 1,224.0166$$

$$SS_{total} = (5^2 + 4^2 + \dots + 4^2 + 4^2) - CF \\ = 70.9834$$

$$SS_{trt} = \{(91)^2 + (93)^2 + (87)^2 / 20\} - CF \\ = 1,224.95 - 1,224.0166 = 0.9334$$

$$SS_{blk} = \{(14^2 + 12^2 + \dots + 13^2) / 3\} - CF \\ = 1,277.6666 - 1,224.0166 = 53.65$$

$$SS_e = SS_{total} - SS_{trt} - SS_{blk} \\ = 70.9834 - 0.9334 - 53.65 = 16.4$$

ANOVA

SOV	df	SS	MS	F
Total	tr-1=59	70.9834		
Trt	t-1 = 2	0.9334	0.4667	1.08
Blk	r-1 = 19	53.6500	2.8237	
Error	38	16.4000	0.4316	

Duncan's Multiple Range Test

$$3) S_y = \sqrt{MSE/n} = \sqrt{0.4316/3} = 0.379$$

$$2) \alpha = 0.05 \quad p = 2, 3 \\ Df_{err} = 38$$

$$\begin{array}{c} p \\ 2 \quad \underline{\quad 3 \quad} \\ r_{\infty} = 2.661 \quad 3.016 \\ r_{\infty} * S_y = 1.008 \quad 1.143 \end{array}$$

Compare the trt means with range obtained from calculation. Arrange trt mean in ascending order from small to large.

$$4.35^a \quad 4.55^a \quad 4.65^a$$

Note: Treatment under the same letter is not significantly different

Appendix Table4: The analysis of variance on overall of difference ratios of pomegranate wine making

S1: (Pomegranate: Water) = 1000g: 1000ml

S2: (Pomegranate: Water) = 1000g: 1500ml

S3: (Pomegranate: Water) = 1000g: 2000ml

Blocks	Samples			X_j	\bar{X}_j
	S_1	S_2	S_3		
1	5	5	4	14	4.6667
2	4	4	4	12	4.0000
3	6	7	5	18	6.0000
4	5	6	5	16	5.3333
5	4	4	5	13	4.3333
6	3	4	3	10	3.3333
7	5	5	4	14	4.6667
8	4	5	5	14	4.6667
9	4	6	7	17	5.6667
10	6	7	7	20	6.6667
11	6	5	5	16	5.3333
12	6	5	4	15	5.0000
13	4	3	3	10	3.3333
14	4	3	3	10	3.3333
15	5	5	5	15	5.0000
16	4	3	3	10	3.3333
17	4	3	3	10	3.3333
18	4	4	4	12	4.0000
19	4	4	4	12	4.0000
20	4	5	4	13	4.3333
X_i	91.0	93.00	87.00	$X_{ii} = 271$	
\bar{X}_i	4.55	4.65	4.35	$\bar{X}_{ii} = 4.5166$	

Note the pomegranate wine making(in difference ratios) is done on three difference samples.

$$CF = (271)^2 / (20)(3) = 1,224.0166$$

$$SS_{total} = (5^2 + 4^2 + \dots + 4^2 + 4^2) - CF \\ = 70.9834$$

$$SS_{trt} = \{(91)^2 + (93)^2 + (87)^2 / 20\} - CF \\ = 1,224.95 - 1,224.0166 = 0.9334$$

$$SS_{blk} = \{(14^2 + 12^2 + \dots + 13^2) / 3\} - CF \\ = 1,277.6666 - 1,224.0166 = 53.65$$

$$SS_e = SS_{total} - SS_{trt} - SS_{blk} \\ = 70.9834 - 0.9334 - 53.65 = 16.4$$

ANOVA

SOV	df	SS	MS	F
Total	tr-1=59	70.9834		
Trt	t-1 = 2	0.9334	0.4667	1.08
Blk	r-1 = 19	53.6500	2.8237	
Error	38	16.4000	0.4316	

Duncan's Multiple Range Test

$$4) S_y = \sqrt{MSE/n} = \sqrt{0.4316/3} = 0.379$$

$$2) \alpha = 0.05 \quad p = 2, 3 \\ Df_{err} = 38$$

$$\begin{array}{ccc} & p & \\ & 2 & 3 \\ r_{\alpha} = & 2.661 & 3.016 \\ r_{\alpha} * S_y = & 1.008 & 1.143 \end{array}$$

Compare the trt means with range obtained from calculation. Arrange trt mean in ascending order from small to large.

$$4.35^a \quad 4.55^a \quad 4.65^a$$

Note: Treatment under the same letter is not significantly different

Appendix Table5: The analysis of variance on flavor of pomegranate wine mixed with wodka in different ratios(P:W)

S1: (P:W) = 100ml: 10ml

S2: (P: W) = 150ml: 10ml

S3: (P: W) = 200ml: 10ml

Blocks	Samples			X_j	\bar{X}_j
	S_1	S_2	S_3		
1	5	5	4	14	4.6667
2	4	4	4	12	4.0000
3	6	7	5	18	6.0000
4	5	6	5	16	5.3333
5	4	4	5	13	4.3333
6	3	4	3	10	3.3333
7	5	5	4	14	4.6667
8	4	5	5	14	4.6667
9	4	6	7	17	5.6667
10	6	7	7	20	6.6667
11	6	5	5	16	5.3333
12	6	5	4	15	5.0000
13	4	3	3	10	3.3333
14	4	3	3	10	3.3333
15	5	5	5	15	5.0000
16	4	3	3	10	3.3333
17	4	3	3	10	3.3333
18	4	4	4	12	4.0000
19	4	4	4	12	4.0000
20	4	5	4	13	4.3333
X_i	91.0	93.00	87.00	$X_{ii} = 271$	
\bar{X}_i	4.55	4.65	4.35	$\bar{X}_{ii} = 4.5166$	

Note For pomegranate wine mixed with wodka(in diff ratio) is needed to do only flavor testing

$$CF = (271)^2 / (20)(3) = 1,224.0166$$

$$SS_{total} = (5^2 + 4^2 + \dots + 4^2 + 4^2) - CF \\ = 70.9834$$

$$SS_{trt} = \{(91)^2 + (93)^2 + (87)^2 / 20\} - CF \\ = 1,224.95 - 1,224.0166 = 0.9334$$

$$SS_{blk} = \{(14^2 + 12^2 + \dots + 13^2) / 3\} - CF \\ = 1,277.6666 - 1,224.0166 = 53.65$$

$$SS_e = SS_{total} - SS_{trt} - SS_{blk} \\ = 70.9834 - 0.9334 - 53.65 = 16.4$$

ANOVA

SOV	df	SS	MS	F
Total	tr-1=59	70.9834		
Trt	t-1 = 2	0.9334	0.4667	1.08
Blk	r-1 = 19	53.6500	2.8237	
Error	38	16.4000	0.4316	

Duncan's Multiple Range Test

$$5) S_y = \sqrt{MSE/n} = \sqrt{0.4316/3} = 0.379$$

$$2) \alpha = 0.05 \quad p = 2, 3 \\ Df_{err} = 38$$

$$\begin{array}{cc} & p \\ & \underline{2 \quad 3} \\ r_\infty = & 2.661 \quad 3.016 \\ r_\infty * S_y = & 1.008 \quad 1.143 \end{array}$$

Compare the trt means with range obtained from calculation. Arrange trt mean in ascending order from small to large.

$$4.35^a \quad 4.55^a \quad 4.65^a$$

Note: Treatment under the same letter is not significantly different

Appendix Table6: The analysis of variance on flavor of pomegranate wine mixed with sugar indifferent ratios (P: S).

S1: (P: S) = 200ml: 0.09g.

S2: (P: S) = 300ml: 0.09g.

S3: (P: S) = 400ml: 0.09g.

Blocks	Samples			X_j	\bar{X}_j
	S_1	S_2	S_3		
1	5	7	5	17	5.6667
2	5	7	6	18	6.0000
3	3	7	4	14	4.6667
4	4	6	6	16	5.3333
5	5	7	7	19	6.3333
6	3	8	7	18	6.0000
7	3	7	6	16	5.3333
8	4	7	7	18	6.0000
9	4	7	6	17	5.6667
10	5	7	6	18	6.0000
11	3	8	6	17	5.6667
12	3	6	6	15	5.0000
13	4	8	7	19	6.3333
14	4	8	7	19	6.3333
15	5	9	7	21	7.0000
16	4	8	7	19	6.3333
17	4	7	7	18	6.0000
18	3	7	7	17	5.6667
19	3	7	6	16	5.3333
20	4	7	5	16	5.3333
X_i	78.00	145.00	125.00	$X_{ii}=348$	
\bar{X}_i	3.90	7.15	6.25	$\bar{X}_{ii}= 5.8$	

$$CF = (348)^2 / (20)(3) = 2,018.40$$

$$SS_{total} = (5^2 + 5^2 + \dots + 7^2 + 7^2) - CF \\ = 153.60$$

$$SS_{trt} = \{(78)^2 + (125)^2 + (145)^2 / 20\} - CF \\ = 118.3$$

$$SS_{blk} = \{(17^2 + 18^2 + \dots + 16^2) / 3\} - CF \\ = 16.9333$$

$$SS_e = SS_{total} - SS_{trt} - SS_{blk} \\ = 153.6 - 118.3 - 16.9333 = 18.3667$$

ANOVA

SOV	df	SS	MS	F
Total	tr-1=59	153.6		
Trt	t-1 = 2	118.3	59.15	66.3711*
Blk	r-1=19	16.9333	0.8912	
Error	38	18.3667	0.4833	

Duncan's Multiple Range Test

$$1) S_y = \sqrt{MSE/n} = \sqrt{0.4833/3} = 0.401$$

$$2) \alpha = 0.05 \quad p = 2, 3 \\ Df_{err} = 38$$

$$\begin{array}{cc} & p \\ & \underline{2 \quad 3} \\ r_{\alpha} = & 2.661 \quad 3.016 \\ r_{\alpha} * S_y = & 1.067 \quad 1.209 \end{array}$$

Compare the trt means with range obtained from calc. Arrange trt mean in ascending order from small to large.

3.90 6.25^a 7.25^a

Note : Treatment under the same letter is not significantly different

Appendix Table7: The analysis of variance on clearness of pomegranate wine mixed with sugar in different ratios (P: S).

S1: (P: S) = 200ml: 0.09g.

S2: (P: S) = 300ml: 0.09g.

S3: (P: S) = 400ml: 0.09g.

Blocks	Samples			X_j	\bar{X}_j
	S_1	S_2	S_3		
1	4	6	6	16	5.3333
2	4	5	5	14	4.6667
3	5	6	6	17	5.6667
4	4	6	6	16	5.3333
5	4	6	7	17	5.6667
6	4	6	6	16	5.3333
7	5	6	6	17	5.6667
8	5	6	6	17	5.6667
9	5	7	7	19	6.3333
10	5	6	7	18	6.0000
11	4	6	6	16	5.3333
12	4	6	7	17	5.6667
13	5	6	7	18	6.0000
14	5	7	7	19	6.3333
15	4	5	5	14	4.6667
16	3	6	6	15	5.0000
17	5	6	6	17	5.6667
18	4	5	6	15	5.0000
19	5	6	6	16	5.3333
20	4	6	7	18	6.0000
X_i	88.00	119.00	125.00	$X_{ii}=332$	
\bar{X}_i	4.40	5.95	6.25	$\bar{X}_{ii}= 5.5333$	

$$CF = (332)^2 / (20)(3) = 1,837.0667$$

$$SS_{total} = (4^2 + 4^2 + \dots + 6^2 + 7^2) - CF \\ = 58.9333$$

$$SS_{trt} = \{(88)^2 + (119)^2 + (125)^2 / 20\} - CF \\ = 39.4333$$

$$SS_{blk} = \{(16^2 + 14^2 + \dots + 18^2) / 3\} - CF \\ = 12.9333$$

$$SS_e = SS_{total} - SS_{trt} - SS_{blk} \\ = 58.9333 - 39.4333 - 12.9333 = 6.5667$$

ANOVA

SOV	df	SS	MS	F
Total	tr-1=59	58.9333		
Trt	t-1 = 2	39.4333	59.15	28.9653*
Blk	r-1=19	12.9333	0.8912	
Error	38	6.5667	0.4833	

Duncan's Multiple Range Test

$$1) S_y = \sqrt{MSE/n} = \sqrt{0.1728/3} = 0.24$$

$$2) \alpha = 0.05 \quad p = 2, 3 \\ Df_{err} = 38$$

$$\begin{array}{c} p \\ \hline 2 \quad 3 \\ r_{\infty} = 2.661 \quad 3.016 \\ r_{\infty} * S_y = 0.6386 \quad 0.7238 \end{array}$$

Compare the trt means with range obtained from calc. Arrange trt mean in ascending order from small to large.

4.40 5.95^a 6.25^a

Note: Treatment under the same letter is not significantly different

Appendix Table8: The analysis of variance on flavor of pomegranate wine (S1), pomegranate wine mixed with vodka (S2), pomegranate wine mixed with sugar (S3), pomegranate wine mixed with sugar and vodka (S4) in different ratios.

S1 = pomegranate wine

S2 = pomegranate wine: vodka = 150:10 ml.

S3 = pomegranate wine: sugar =300ml: 0.099g.

S4 = pomegranate wine: vodka: sugar =300ml: 10ml: 0.099g

Blocks	Samples				X _j	\bar{X}_j
	S ₁	S ₂	S ₃	S ₄		
1	6	4	7	8	25	6.25
2	5	6	8	8	27	6.75
3	5	5	7	9	26	6.50
4	4	5	8	7	24	6.00
5	4	4	5	8	21	5.25
6	5	6	7	7	25	6.25
7	4	3	5	7	19	4.75
8	6	4	7	7	24	6.00
9	6	5	6	8	25	6.25
10	4	5	6	7	22	5.50
11	4	4	6	8	22	5.50
12	5	5	6	8	24	6.00
13	5	6	6	9	26	6.50
14	5	6	5	7	23	5.75
15	5	5	7	8	25	6.25
16	4	3	6	6	19	4.75
17	4	4	5	6	19	4.75
18	6	6	8	8	28	7.00
19	4	3	6	7	20	5.00
20	5	5	6	8	24	6.00
X _i	96	94	127	151	X _{ii} =468	
\bar{X}_i	4.8	4.7	6.35	7.55	$\bar{X}_{ii} = 5.85$	

$$CF = (468)^2 / (20)(4) = 2,737.8$$

$$SS_{total} = (6^2 + 5^2 + \dots + 7^2 + 8^2) - CF \\ = 174.2$$

$$SS_{trt} = \{(96)^2 + (94)^2 + (127)^2 + (151)^2 / 20\} - CF \\ = 111.3$$

$$SS_{blk} = \{(25^2 + 27^2 + \dots + 24^2) / 4\} - CF \\ = 34.7$$

$$SS_e = SS_{total} - SS_{trt} - SS_{blk} \\ = 174.2 - 111.3 - 34.7 = 28.2$$

ANOVA

SOV	df	SS	MS	F
Total	tr-1=79	174.2		
Trt	t-1 = 3	111.3	37.1	20.3143*
Blk	r-1=19	34.7	1.8263	
Error	57	28.2	0.4947	

Duncan's Multiple Range Test

$$1) S_y = \sqrt{MSE/n} = \sqrt{0.4947/4} = 0.3517$$

$$2) \alpha = 0.05 \quad p = 2, 3, 4 \\ Df_{err} = 57$$

	p		
	2	3	4
$r_\infty = 3.7690$		3.9305	4.0405
$r_\infty * S_y = 1.3255$		1.3823	1.4210

Compare the trt means with range obtained from calculation. Arrange trt mean in ascending order from small to large.

4.70^a 4.8^a 6.35^b 7.55^b

Note: Treatment under the same letter is not significantly different

Appendix Table9: The analysis of variance on color of pomegranate wine (S1), pomegranate wine mixed with vodka (S2), pomegranate wine mixed with sugar (S3), pomegranate wine mixed with sugar and vodka (S4) in different ratios.

S1 = pomegranate wine

S2 = pomegranate wine: vodka = 150:10 ml.

S3 = pomegranate wine: sugar = 300ml: 0.099g.

S4 = pomegranate wine: vodka: sugar = 300ml: 10ml: 0.099g

Blocks	Samples				$X_{.j}$	$\bar{X}_{.j}$
	S_1	S_2	S_3	S_4		
1	6	6	6	6	24	6.00
2	5	6	5	6	22	5.50
3	5	4	4	4	17	4.25
4	4	3	4	3	14	3.50
5	5	4	4	4	17	4.25
6	4	4	3	4	15	3.75
7	4	4	4	4	16	4.00
8	4	3	4	4	15	3.75
9	6	5	5	5	21	5.25
10	6	6	5	6	23	5.75
11	6	5	4	5	20	5.00
12	5	5	4	4	18	4.50
13	5	5	5	5	20	5.00
14	4	4	4	4	16	4.00
15	6	5	5	5	21	5.25
16	4	3	3	3	13	3.25
17	4	4	4	4	16	4.00
18	6	6	6	6	24	6.00
19	5	5	5	5	20	5.00
20	6	6	6	6	24	6.00
X_i	100	93	90	93	$X_{..}=376$	
\bar{X}_i	5.0	4.65	4.50	4.65	$\bar{X}_{..}=4.70$	

$$CF = (376)^2 / (20)(4) = 1,767.2$$

$$SS_{total} = (6^2 + 5^2 + \dots + 5^2 + 6^2) - CF \\ = 70.8$$

$$SS_{trt} = \{(100)^2 + (93)^2 + (90)^2 + (93)^2 / 20\} - CF \\ = 2.7$$

$$SS_{blk} = \{(24^2 + 22^2 + \dots + 24^2) / 4\} - CF \\ = 59.8$$

$$SS_e = SS_{total} - SS_{trt} - SS_{blk} \\ = 70.8 - 2.7 - 59.8 = 8.3$$

ANOVA

SOV	df	SS	MS	F
Total	tr-1=79	70.8		
Trt	t-1 = 3	2.7	0.9	0.286
Blk	r-1=19	59.8	3.1474	
Error	57	8.3	0.1456	

Duncan's Multiple Range Test

$$1) S_y = \sqrt{MSE/n} = \sqrt{0.1456/4} = 0.1908$$

$$2) \alpha = 0.05 \quad p = 2, 3, 4 \\ Df_{err} = 57$$

	p		
	2	3	4
r_∞	3.7690	3.9305	4.0405
$r_\infty * S_y$	0.7191	0.7499	0.7709

Compare the trt means with range obtained from calculation. Arrange trt mean in ascending order from small to large.

4.50^a 4.65^a 4.65^a 5.00^a

Note: Treatment under the same letter is not significantly different

Appendix Table10: The analysis of variance on clearness of pomegranate wine (S1), pomegranate wine mixed with vodka (S2), pomegranate wine mixed with sugar (S3), pomegranate wine mixed with sugar and vodka (S4) in different ratios.

S1 = pomegranate wine

S2 = pomegranate wine: vodka = 150:10 ml.

S3 = pomegranate wine: sugar = 300ml: 0.099g.

S4 = pomegranate wine: vodka: sugar = 300ml: 10ml: 0.099g

Blocks	Samples				X _j	$\bar{X}_{.j}$
	S ₁	S ₂	S ₃	S ₄		
1	8	8	7	8	25	6.25
2	8	8	7	8	27	6.75
3	8	8	7	8	26	6.50
4	7	7	7	7	24	6.00
5	8	8	8	8	21	5.25
6	7	7	6	7	25	6.25
7	7	8	7	7	19	4.75
8	9	9	8	8	24	6.00
9	9	9	7	8	25	6.25
10	8	8	7	8	22	5.50
11	9	8	8	9	22	5.50
12	7	8	8	7	24	6.00
13	7	8	8	7	26	6.50
14	8	8	8	8	23	5.75
15	8	9	8	8	25	6.25
16	8	9	8	8	19	4.75
17	9	9	8	8	19	4.75
18	8	9	8	8	28	7.00
19	8	8	7	8	20	5.00
20	8	8	7	8	24	6.00
X _i	159	164	149	156	X _{ii} = 628	
\bar{X}_i	7.95	8.20	7.45	7.80	$\bar{X}_{ii} = 7.85$	

$$CF = (628)^2 / (20)(4) = 4,929.8$$

$$SS_{total} = (8^2 + 8^2 + \dots + 8^2 + 8^2) - CF \\ = 98.2$$

$$SS_{trt} = \{(159)^2 + (164)^2 + (149)^2 + (156)^2 / 20\} - CF \\ = 5.9$$

$$SS_{blk} = \{(31^2 + 31^2 + \dots + 31^2) / 4\} - CF \\ = 18.2$$

$$SS_e = SS_{total} - SS_{trt} - SS_{blk} \\ = 98.2 - 5.9 - 18.2 = 74.1$$

ANOVA

SOV	df	SS	MS	F
Total	tr-1=79	98.2		
Trt	t-1 = 3	5.9	1.9667	2.0531
Blk	r-1=19	18.2	0.9579	
Error	57	74.1	1.3	

Duncan's Multiple Range Test

$$1) S_y = \sqrt{MSE/n} = \sqrt{1.3/4} = 0.57$$

$$2) \alpha = 0.05 \quad p = 2, 3, 4 \\ Df_{err} = 57$$

	p		
	2	3	4
$r_{\infty} = 3.7690$		3.9305	4.0405
$r_{\infty} * S_y = 2.1483$		2.2403	2.3030

Compare the trt means with range obtained from calculation. Arrange trt mean in ascending order from small to large.

7.45^a 7.80^a 7.95^a 8.20^a

Note: Treatment under the same letter is not significantly different

Appendix Table11: The analysis of variance on overall acceptance of pomegranate wine (S1), pomegranate wine mixed with vodka (S2), pomegranate wine mixed with sugar (S3), pomegranate wine mixed with sugar and vodka (S4) in different ratios.

S1 = pomegranate wine

S2 = pomegranate wine: vodka = 150:10 ml.

S3 = pomegranate wine: sugar =300ml: 0.099g.

S4 = pomegranate wine: vodka: sugar =300ml: 10ml: 0.099g

Blocks	Samples				$X_{.j}$	$\bar{X}_{.j}$
	S_1	S_2	S_3	S_4		
1	5	4	6	8	23	5.75
2	4	5	6	7	22	5.50
3	4	4	6	7	21	5.25
4	5	5	6	7	23	5.75
5	5	5	5	7	22	5.50
6	5	5	4	6	20	5.00
7	6	5	7	7	25	6.25
8	6	6	7	8	27	6.75
9	6	6	7	9	28	7.00
10	4	5	7	8	24	6.00
11	4	6	8	9	27	6.75
12	5	4	7	9	25	6.25
13	4	4	6	9	23	5.75
14	4	4	5	7	20	5.00
15	5	6	8	9	28	7.00
16	5	4	6	7	22	5.50
17	6	5	8	7	26	6.50
18	6	5	6	7	24	6.00
19	5	6	7	8	26	6.50
20	5	5	6	7	23	5.75
X_i	99	99	128	153	$X_{ii}=479$	
\bar{X}_i	4.95	4.95	6.40	7.65	$\bar{X}_{ii} = 5.9875$	

$$CF = (479)^2 / (20)(4) = 2,868.0125$$

$$SS_{total} = (5^2 + 4^2 + \dots + 8^2 + 7^2) - CF \\ = 160.99$$

$$SS_{trt} = \{(99)^2 + (99)^2 + (128)^2 + (153)^2 / 20\} - CF \\ = 101.74$$

$$SS_{blk} = \{(23^2 + 22^2 + \dots + 23^2) / 4\} - CF \\ = 29.24$$

$$SS_e = SS_{total} - SS_{trt} - SS_{blk} \\ = 160.9875 - 101.7375 - 29.2375 = 30.01$$

ANOVA

SOV	df	SS	MS	F
Total	tr-1=79	160.99		
Trt	t-1 = 3	101.74	33.91	21.33*
Blk	r-1=19	29.24	1.59	
Error	57	30.01	0.53	

Duncan's Multiple Range Test

$$1) S_y = \sqrt{MSE/n} = \sqrt{0.53/4} = 0.364$$

$$2) \alpha = 0.05 \quad p = 2, 3, 4 \\ Df_{err} = 57$$

	p		
	2	3	4
$r_\infty = 3.7690$		3.9305	4.0405
$r_\infty * S_y = 1.3719$		1.4307	1.4707

Compare the trt means with range obtained from calculation. Arrange trt mean in ascending order from small to large.

4.95^a 4.95^a 6.40^b 7.65^b

Note: Treatment under the same letter is not significantly different

