DETERMINATION OF FRUIT YIELD AND FRUIT QUALITY IN MARULA (*SCLEROCARYA BIRREA* SUBSP*. CAFFRA*) SELECTIONS

BY

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DECLARATION

I, the undersigned, declare that the mini-dissertation, which I hereby submit for the M.Inst. Agrar (Horticulture) at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

Kgomoamogodi Petje

Signed in Pretoria on August 2008

DEDICATION

I dedicate this mini-dissertation to my late father **HUBELA PHAKA PETJE** who passed away on the 18 March 2003. I shall never forget the support he gave to me. I wish he was here to share this moment.

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Abbreviations and acronyms used

Conc.	= Concentration
CS	= Canopy size
DFSC	= Danida Forest Seed Centre
DFID	= Department for International Development
g	= grams
ICRAF	= International Centre for Research in Agroforestry
Max.	= Maximum
Min.	= Minimum
ml	= millilitre
mm	= millimeter
P	= Pharulani
Pa	= per annum
S	= Swarula
TA	= Titratable acidity
T	= Toularula
TSS	= Total soluble solids
WM	= Wild marula

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Determination of fruit yield and fruit quality in marula (Sclerocarya *birrea* subsp. *caffra*) selections

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ABSTRACT

The marula tree has already become a very important alternative crop in South Africa with a great potential for further improvement. There are, however, no accurate records that have been reported on the fruit yield and quality of marula tree in Southern Africa. To utilise the fruit fully, to make proper selections from the wild trees and to develop new selections/cultivars, there is a need to have information on yield potential and fruit quality aspects. The overall objective was to determine the yield potential and to evaluate the fruit quality of different marula selections putting more emphasis on fruit quality parameters such as the fruit mass, size, total soluble solids (TSS), acidity and juice content. Four marula

selections were identified during their peak production season (2004/2005/2006/2007) at Schoeman Boerdery (Orchard) between Marble-Hall and Groblersdal in Mpumalanga Province (South Africa). From each of the selections, namely; Pharulani, Toularula and Swarula, five trees were selected randomly and marked, while from the Wild marula only four trees were selected and marked. For the purpose of experimental design, the four selections were regarded as four treatments, and the marked trees per selection as the replicates. All selected trees were more or less the same in size and were in full production. The trees were growing in an orchard with planting distance of 9 m (interspacing) and 4.5 m (intraspacing). To determine yield potential, the number of fruit per square meter per tree was counted on pre-labelled branches on five positions around the tree canopy at three stages of fruit development. Collected data were converted to grams of fruit per square metre. Tree canopy size (CS), expressed as m^2, was calculated by using the radius (r) of each canopy in the following formula: CS= ($\pi.r^2$) 4. For calculating the yield per tree, the average canopy size was multiplied by the number of fruit counted per m^2. Twenty fruits from each labelled marula tree per selection were randomly selected; collected and taken to the Ecophysiology Laboratory at University of Pretoria for fruit quality traits, weight (mass), size, stone mass, peel mass, juice content, Total Soluble Solids (TSS) and Titratable acidity (TA).

The yield efficiency/potential for both tree unit and hectare (ha) basis in 2006/2007 season, showed that the Swarula selection had the highest total yield as compared to other selections. Results showed that there was a positive relationship between fruit weight and size, that is, the bigger the weight, the bigger the size and the opposite. Generally, three selections, Swarula, Toularula and Pharulani had a higher fruit mass and size than “wild” marula. Pharulani had the highest seed/stone mass whereas “wild” marula had the lowest seed mass during the 2004/2005 and 2005/2006 fruiting seasons. Pharulani selection had the highest juice mass during both seasons whereas Swarula selection had the lowest juice mass. Results also showed that ‘wild’ marula had the highest TSS/TA ratio during both seasons whereas Pharulani had the lowest TSS/TA ratio. Optimal traits were therefore found in different selections and not in the same selections as envisaged.

Keywords: Selections, total soluble solids, acidity, fruit quality, fruit yield

CHAPTER ONE

GENERAL INTRODUCTION

Marula tree, *Sclerocarya birrea* (A. Rich.) Hochst. Subsp. caffra (Sond.) Kokwaro belongs to the Anacardiaceae family and the genus name *Sclerocarya* derived from the Greek word *skleros,* meaning hard, and *karyon*, meaning a nut which refers to the hard stone of the fruit" (Shone, 1979). The World Agroforestry Centre stated that 'Birrea' comes from 'birr', the common name for the tree in Senegal, and caffra from 'Kaffaria' (Eastern Cape, South Africa). The name *"caffra*" was derived from the Hebrew word, 'kafri' meaning a 'countryman'. The word "caffra" also refers to the British Caffraria, where the first collection of the tree had taken place.

The marula tree is one of Africa's botanical treasures. There are thousands of different indigenous fruit trees in Africa, but only a few produce "food for all seasons". The fleshy mesocarp of ripe marula fruit is rich in minerals and vitamins and is edible when fresh from mid-to-late rainy season to early dry season. The single large stone contains 'nut-like' seeds, rich in protein and oil that can be eaten fresh, mixed and cooked with other foods or stored for consumption later in the dry season (Hall *et al*., 2000). Marula forms an integral part of diet, tradition and culture of rural communities in southern Africa and also is central for various commercial initiatives (Wynberg *et al*., 2002). In Limpopo Province, the 'Marula Nut Collectors Close Cooperation' was formed as a business with the aim of exporting marula oil to overseas markets.

This in turn provides job opportunities to the communities around Tzaneen and also economic growth in South Africa. Data from Bushbuckridge, South Africa, indicated that *S. birriea* is amongst the most commonly used wild fruit species, with 59-77% of household consuming marula fruits between four to five times per week during fruiting season (Shackleton, 1996; Shackleton *et al*., 2002 c). If post harvest quality can be improved through this study, this will lead to more economic growth of marula fruits, which in turn will boost the rural poor (especially women) to earn more income for livelihood. Women are mainly involved in trading in marula products and income from sales tends to be highly variable. In Bushbuckridge (South Africa), it was found that some 15% of households surveyed were trading in various indigenous fruit (both processed and raw), earning on average between US$87 and US$149 per annum. (Shackleton *et al*., 2002 c).

The marula tree is native to Southern Africa. It is a large, dioecious, “utility” tree and the female tree produce generous amounts of small, mango-like, edible fruits with oil-bearing seeds. It is extremely drought resistant and salt tolerant and grows quickly making the tree valuable as a shade tree and windbreaker as well (DFSC, 2003).

Almost the entire marula tree and its fruit can be utilised. This offers considerable opportunities in the development of agriculturally based industries in Southern and Eastern Africa. Because of its importance, a significant amount of research

has been done on the domestication of this tree by a few organizations. This is due to realization that it has great commercial potential and socio-economic importance (Taylor *et al*., 1995).

In South Africa , production and marketing of marula liqueurs and fruit juice arose from wild marula fruits being collected and it has been recorded that in 1987, 2000 tons of fruit were processed into liqueur, 500 tons into fruit juice and 40 000 bottles of marula jelly were made (Van Wyk, 1987 quoted in Lawes *et al* ., 2004). Marula fruits abscise before ripening, when the skin colour is still green and the fruit is firm (Nerd and Mizrahi, 1993). The ripe fruits have a thick yellow peel and a translucent whitish flesh. Fruit is widely consumed, particularly by children, providing a rich source of vitamin C. Fruits are also collected and processed into juice, alcoholic beverages and jam, extending the shelf life of the product and prolonging availability and consumption beyond two to three month of fruiting season. It has been reported that marula beer can be stored for up to three years if sealed in clay or plastic containers and buried underground (Shackleton *et al.,* 2002 c).

Little information is available regarding the fruit quality and yield of marula trees. There are no accurate records that have been reported on the fruit quality and yield of marula trees in Southern Africa. In order to utilise the fruit and/or to make proper selections from the wild and to develop new selections or cultivars, there is a need to have adequate information about the production potential/yield and

fruit quality such as total soluble solids (TSS), acid content (TA), fruit size and mass and fruit juice percentage.

The main objective of this research study was to determine the production potential and fruit quality of marula fruits. The main emphasis was on fruit size, weight, TSS, acidity, seed size and juice mass. These traits will be essential for future selection, programmes aimed at producing fruit of high commercial value or quality.

CHAPTER TWO

LITERATURE REVIEW

Due to the fact that there is hardly any literature available on the fruit yield and quality of the marula as well as the absence of a proper overview covering the distribution, phenology and uses of the tree, this review was deemed necessary and will include aspects that might not be directly related to the rest of the thesis.

2.1. DISTRIBUTION

The marula tree occurs throughout Africa in warm frost-free climates. Occasionally it may grow in high-lying areas, which experience very short sub-zero spells in winter (Gous *et al*., 1988). It is found throughout Eastern and Southern Africa (Taylor *et al.*, 1995), and occurs in 29 countries, from the west to east and north to south countries such as, Senegal, Guinea Bissau, Ivory Coast, Mauritania, Mali, Burkina, Ghana, Togo, Benin, Niger, Nigeria, Chad and Sudan, in low Africa; Eritrea, Ethiopia, Uganda, Kenya, and Tanzania, in eastern High Africa; and Angola, southern Congo, Zambia, Malawi, Mozambique, Namibia, Botswana, Zimbabwe, South Africa, Lesotho and Swaziland in southern Africa (Fig. 2.1) (Hall *et al*., 2000). In general, marula trees commonly occur at moderate to low elevations throughout its range (between 0 - 4 500 m) (Fig. 2.2)

(Hall *et al*., 2000; Taylor *et al.*, 1995). The distribution in South Africa is clearly controlled by climatic conditions. The species is abundant in warmer parts and where conditions are suitable, almost pure stands may be found. The controlling factor concerning its distribution is frost (Shone, 1979).

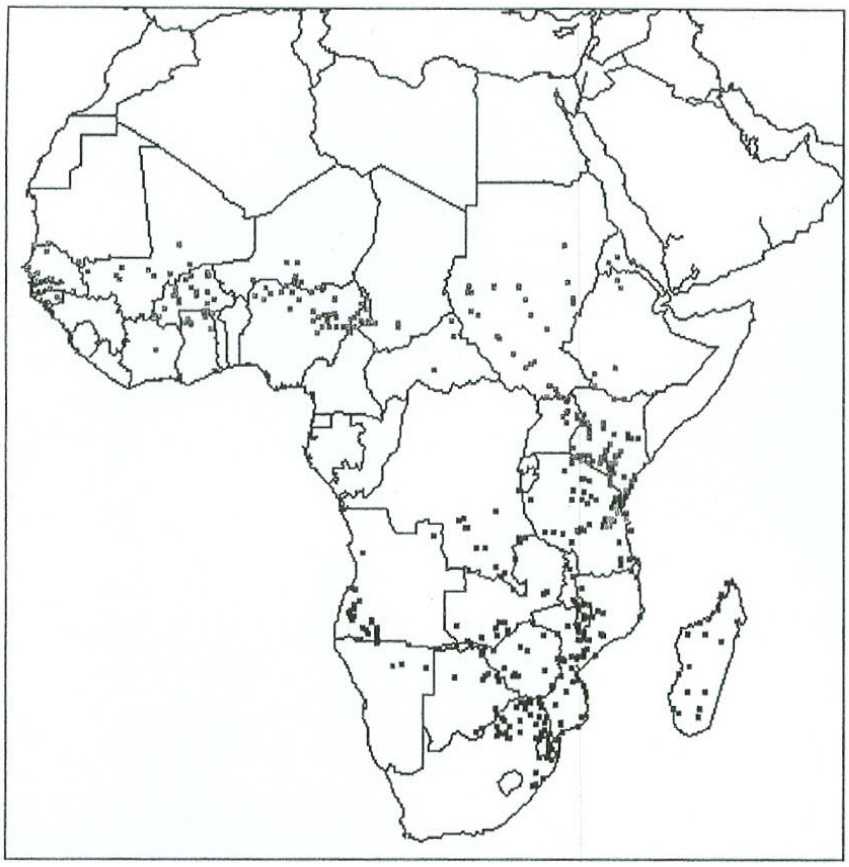

Figure 2.1: Distribution of *Sclerocarya birrea* (Hall *et al*., 2000). Adapted from Herbaria: Royal Botanic Garden

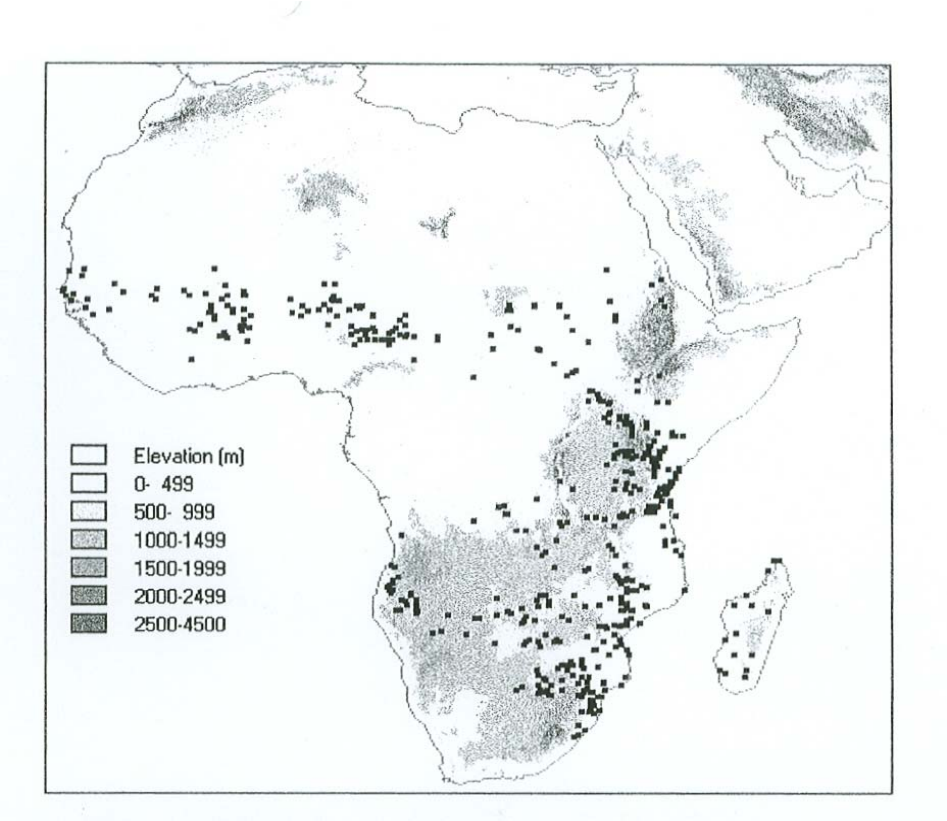

Figure 2.2: Distribution of *Sclerocarya birrea* in relation to elevation (Hall *et al*., 2000). Adapted from Herbaria: Royal Botanic Garden.

2.2. PLANT DESCRIPTION

Tree

The marula tree is a medium to large tree, usually 9-12 m tall and it is single stemmed with short bole, up to 120 cm in diameter, dense, spreading crown and deciduous foliage (Fig. 2.3). The bark is grey and usually peels off in flat, round disks, exposing the underlying light yellow tissues (Marula Net Database, 2003). The marula tree is considered dioecious, but individual trees may have both male and female flowers (Shone, 1979; Weinert *et al.*, 1990).

Figure 2.3 Marula tree (Toularula) growing in an orchard at Schoeman's Boerdery in Groblersdal.

Roots

The germinating seed sends out a well-developed slightly swollen taproot. This can be pruned without affecting the plant. The well-developed root system is characteristic of the species, which can therefore withstand fairly prolonged droughts (Shone, 1979). The longest lateral root recorded from marula tree *is* 58 m, with a maximum depth for taproots of 2.4 m (Hall *et al*., 2000).

Leaves and Bark

The bark is grey, rough, flaking in patchy sections, thus giving a mottled appearance (Fig. 2.4). The bark of a mature tree is also rough and greyish brown in colour. The flakes peel off sporadically and expose the underlying bark as

angular depressions, which gradually turn to a brown-grey colour (Shone, 1979). The bark is used to make a bitter brandy tincture and is also the source of red dye (Duke, 1989).The leaves are unevenly, pinnately compound with 7-13 pairs of leaflets plus a terminal one. They are alternately arranged, but crowded near the ends of branches as depicted in Fig. 2.4. (Venter and Venter, 2005). The leaflets are dark green above, much paler and blueish-green below (DFSC, 2003).

Figure 2.4 A close-up photo of marula tree branch (A) with small fruits and the bark (B).

Flower

Marula tree is considered dioecious, that is, the plant has either staminate (male) or pistillate (female) flowers, but usually not both. Male flowers are borne in racemes (Fig. 2.5A) below new leaves, dark red when young, turning pink or

white when open. The female flowers are blood red but change colour to pink or white after opening (Fig. 2.5B). They occur below the leaves on long pedicles and consist of four curling petals, numerous infertile stamens and elongated, shiny ovary (Marula Net Database, 2003). The floral parts are in fours to fives, sepals are red, and petals are yellow. The male flowers each contains 15 to 25 fertile stamens, and a vestigial ovary, while the female flowers consist of 15 to 25 staminodes and the ovary almost spherical with 3-5 separate stigmas (Palgrave, 1995). Flowering takes place during spring season when the trees are producing new leaves (Hall *et al*., 2000). In the Sahel, flowering occurs in January-March, fruiting in March-April; in the Sudan, flowering is in January-April, fruiting in April-June (DFSC, 2003). In southern Arica flowering is in September-November and fruiting in February-June (DFSC, 2003).

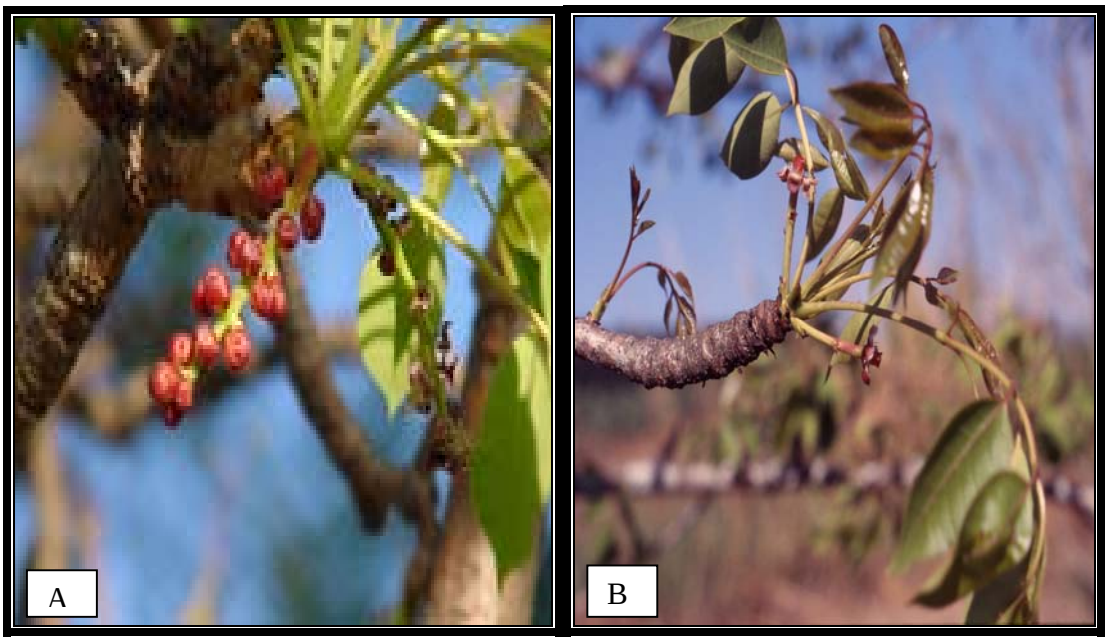

Figure 2.5 The male (A) and the female (B) flowers of marula tree.

Fruits

The marula fruit (Fig. 2.6) is a specialised stone consisting of 2-5 carpels with separate stigmas (Hall *et al*., 2000). They are borne on female trees, plum-sized each with a thick peel (exocarp) and a translucent, white, highly aromatic sweet-sour pulp (mesocarp), and a woody endocarp protecting the seed. The pulp is eaten fresh, like a small mango, or used to prepare juices, jams, conserves, dry fruit rolls and alcoholic beverages (Mizrahi & Nerd, 1996). Fruits are up to 3, 5 cm in diameter when mature (Palgrave, 1995). They drop from tree when they are fully developed but still green and ripen on the ground, making harvesting relatively easy (Hall *et al*., 2000; Shackleton *et al*., 2002 c). Fruit is relished by many game animals (elephants, baboons etc.) and fed to livestock, including goats and sheep. In all cases, the stone, with its edible seed, is passed and can be collected for human consumption. Fruit is used as a sweetener of local foods and curdling agent for milk (Hall *et al*., 2000).

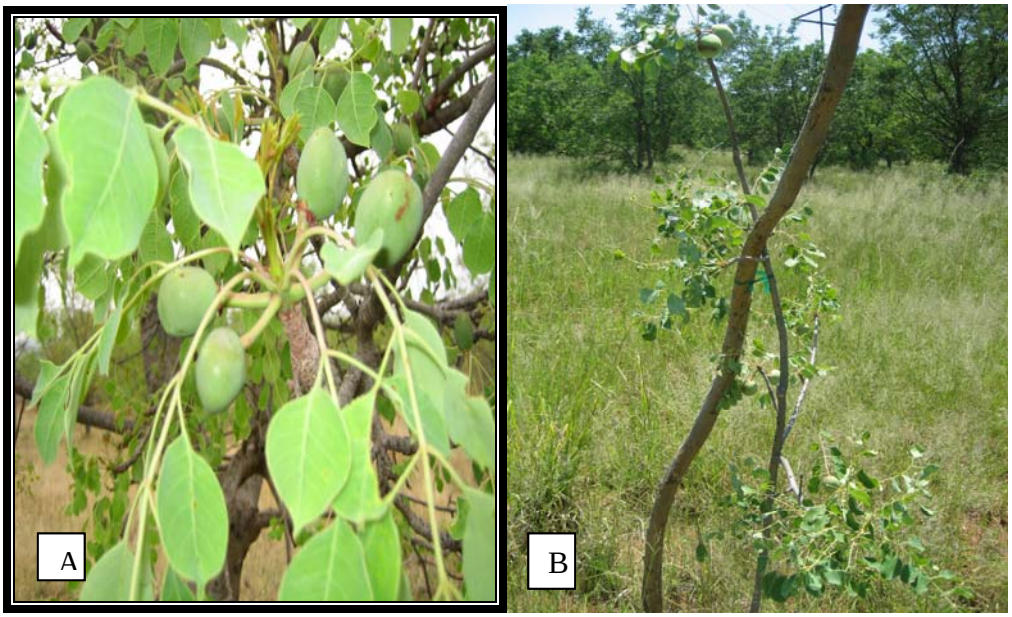

Figure 2.6 Marula fruits at the early stage of development (A) and three year old grafted marula tree bearing first fruits (B).

Seed/Nut

The seed consist of seed coat, embryo without endosperm. The seeds are encased in a hard, light brown, smooth oval-shaped stone (endocarp), each containing 1- 4 seeds 1 to 1.5 cm in length (Hall *et al*., 2000). Each seed cavity is covered by an operculum that needs to be removed during seed extraction. The seeds can be eaten raw or roasted as nuts, especially by children. It has a delicious taste and is regarded by many indigenous people as a delicacy, a 'Food of Kings' (Hall *et al*., 2000; Mizrahi & Nerd, 1996; Shone, 1979). The seeds are high in protein and fat and constitute an important emergency supplement (Jaenickie & Thiong'o, 1999). The seeds are commonly used to supplement the diet during winter or drought periods, being pounded and mixed with vegetables or meat (Hall *et al*., 2000; Shone, 1979). The seed, also referred to as the nut,

has high nutritive value and a high oil content with very good nutritional ratio of saturated to unsaturated fatty acids (Mizrahi & Nerd, 1996). The hard endocarp encasing the seeds is usually cracked between two stones, anvil-and-hammer style, and the nuts are then picked from the debris (Hall *et al*., 2000).

Figure 2.7 Women cracking the nuts against a stone slab and it was recorded that it takes approximately 24 working hours to fill an 800g tin with kernels (A) **(***www.marula.org.za***)** and the marula nuts after they have broken-out of hard shell (B).

Selections

Research into the domestication and improvement of *S. birrea* was first started by Prof. Holtzhausen of the University of Pretoria, who started to establish selections from 'plus-trees' taken from the wild using grafting techniques. The second initiative was by Veld Products Research in Botswana, whereas the third was an external domestication programme, initiated by Ben Gurion University in Israel, using material obtained in southern Africa and planted in Negev Desert. A fourth programme was launched in 1995 by the international Centre for Research in Agroforestry (ICRAF), now the World Agroforestry Centre, with a participatory mandate, in which subsistence farmers were the planned beneficiaries in the domestication activities (Leakey *et al.*, 2003;Taylor *et al.*, 1995).

Wynberg *et al*. (2002) and Holtzhausen (1980) listed the existing selections of marula tree as follows,

- Pharulani, originating from Phalaborwa.
- Swarula, found by the South West African Police (now Namibia) station near Ondangwa (and initially named 'Koevoet' meaning 'crowbar', after the notorious unit which fought against the South West African Police's Organisation-SWAPO).
- Toularula, originating on the farm Toul near Trichardsdal.
- Mpandlarula and Chopperula, found at the gate of the helicopter hangar at Skukuza airport. The average maximum and minimum monthly temperature is 29.5 ^{o}C and 15.5 ^{o}C respectively. Rainfall varies between

530 – 600 mm per year (Gertenbash, 1983). The uplands soils are sandy with between 6 and 15% clay and the dominant soil forms are Hutton (orthic A over red apedal B) and Clovelly (orthic A over yellow brown apedal B). Where the slopes become steeper Glenrosa soils (orthic A over lithocutanic B) can be expected (Gertenbash, 1983).

- Mphodorula and Mametjierula were planted at Schoeman Boerdery (Groblersdal) marula orchard by Prof. Robbertse in 2004. Schoeman Boerdery is one of the biggest suppliers of citrus fruit in South Africa. This picturesque farm (Moosrivier) is situated near Groblersdal in Mpumalanga and extends over more than 5 000 hectares. The marula plantation where the research was done was established in August 1981 where the following selections, namely Swarula, Toularula, Pharulani and Wild marula were planted. Rainfall (on the farm) varies between 300 – 500 mm per year and the soils are sandy loam with 10% clay; the dominant soil forms are Hutton Kelvin or Hutton red with the soil depth of 5 m and the altitude of 900 m.

2.3. ENVIRONMENTAL EFFECTS

Soil type

The marula tree occurs in a very wide range of well-drained soils, especially sandy soils or occasionally sandy loam soils (Duke, 1989; Hall *et al*., 2000). It prefers well-drained soils and loams but is often found growing on rocky soils (DFSC, 2003). The marula tree also grows well on sandy granite soil. The

farmers in the Northern Transvaal (Limpopo) will tell you that the tree does not grow on “hardeveld”. Swampy and clay soils do not suit this species. Due to its importance and outstanding appearance, the species is used as an indicator of mixed bushveld type. In its natural environment the tree is found in the open veld or bushveld country, but never occurs in dense stands or in population forests (Shone, 1979).

Soil pH

The marula tree is known to be highly salt tolerant and fairly drought resistant but sensitive to frost (Hall *et al*., 2000; Taylor *et al.*, 1995).

Temperature

The marula tree prefers a warm, frost-free climate but is also found at high altitudes where temperatures may drop below freezing point for a very short period in winter. The tree is frost sensitive and moderately drought resistant (Marula Net Database, 2003). The marula tree, as a subtropical plant, has a high optimum germination temperature between 27 ^{o}C and 37 ^{o}C (Lewis, 1987). The species in general occurs where temperatures range from as little as 10 ^{o}C (at high elevations) to over 40 ^{o}C at low elevations with average temperature of 20.6 to 27.4 ^{o}C (Duke, 1989) and temperatures during the coolest time of the year are rarely below 10 ^{o}C (Hall *et al*., 2000). Trees were badly damaged after a spell of sub-freezing temperatures of -6 ^{o}C and -7 ^{o}C, all recovered but did not set fruits,

and therefore this species is not recommended for areas with such low temperatures (Mizrahi & Nerd, 1996).

Rainfall

Generally, Marula is found in rainfall regimes typical of sub humid to semi-humid conditions (Fig. 2.8) (Shone, 1979). Marula is a fast growing plant and fairly drought-resistant, reaching 3.5 m in 8 years on the 600 mm mean annual rainfall (Hall *et al*., 2000; Marula Net Database, 2003). Trees are also found at low to medium altitudes in areas with 200-1600 mm rain per year (DFSC, 2003). Rain and humidity during the growing season have a number of adverse effects. Rain and cool weather during bloom can reduce bee activity and cross-pollination and thus diminish the crop load. Rain and high humidity favours fungus and bacterial diseases that can decrease the crop (Jaynes, 1969). According to Shone (1979), marula tree is best suited to the drier areas receiving an annual rainfall of between 250 mm and 800 mm per annum. It has been reported that the marula grows in savanna grasslands where annual rainfall is as follows: Mozambique - 200 to 900 m, 630 to 1000 mm; South Africa-Mozambique 300 to 1000 m, 250 to 500 mm; South Zimbabwe - 450 to 1000 m, 380 to 640 mm; Angola – 80 to 1000 m, 600 to 710 mm; South Africa - 600 to 1500 m, 380 to 640 mm (Duke, 1989).

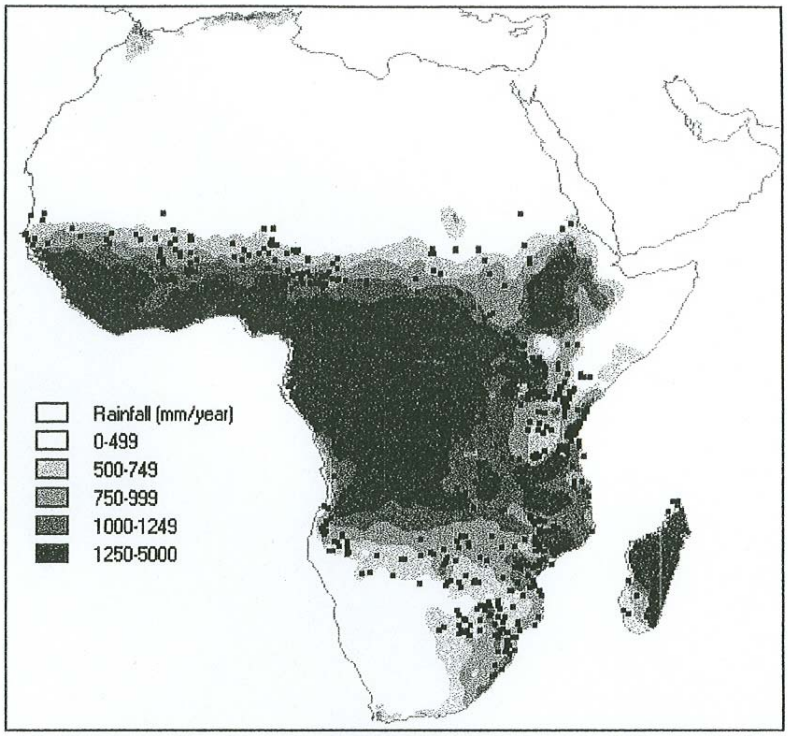

Figure 2.8 Distribution of *Sclerocarya birrea* in relation to rainfall (Hall *et al*., 2000). Adapted from Herbaria: Royal Botanic Garden.

2.4. PLANT USES

Marula has the potential of an industrial fruit crop because of the high spectrum of valuable products that can be prepared from its fruits and because of its high yields. In addition, harvesting can be easily mechanised (fruits are collected from the ground); yielding period lasts for several months (Nerd & Mizrahi, 2000). Because of its high potential fruit production and uses, the marula tree has been identified as a key species to support the rural development enterprises based on the fruit, beer, oil and nuts and thus making it a species with high potential domestication value (Shackleton *et al*., 2002 c; Shone, 1979).

The following information summarizes the discussion in depth the different plant parts used from marula tree:

Fresh Juice/Pulp

The flesh contains up to 2 mg of vitamin C per gram (Table 2.1), which is four times that of orange juice (Shone, 1979). Vitamin C is an important anti-oxidant, helps protect against cancers, heart disease, stress, helps in maintaining a healthy immune system, it aids in neutralizing pollutants, is needed for antibody production, acts to increase the absorption of nutrients (including iron) in the gut and thins the blood, it is essential for sperm production and for making the collagen protein involved in the building and health of cartilage, joints, skin and blood vessels (Anon; 2004). Taylor *et al.* (1995) stated that the high vitamin C content in the fruit as well as the oils and other nutrients in the nuts provide people, especially children, with important nutritional requirements and the fruit can be used to make chutneys and pie fillings. The juice of fruits is pleasantly acidic, sour-tasting and refreshing (Hall *et al*., 2000).

The highest vitamin C content was found in the fruit juice of Marula by Fox and Stone (1938) cited by Anon (2004), giving the following interesting comparison:

Table 2.1 Milligram of Vitamin C present in 100 ml of different beverages (Anon; 2004)

Milk	2.0
Home-brewed beer	0.8
Orange juice	50.0
Marula “beer”	100.0
Marula fruit juice	200.0

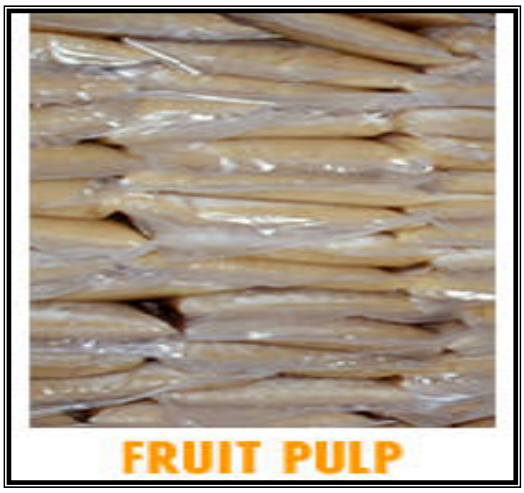

Figure 2.9 Packed fruit pulp ready for storage or transportation (*www.marula.org.za*).

Jelly

The fruits with their skins are placed in a pot and covered with water and boiled for a couple of hours until a mushy mixture is obtained. The mixture is then strained through a colander to remove the skins (exocarp) and stones (endocarp) and then sugar is added and the mixture boiled again (Shone, 1979).

Figure 2.10 Various marula products (fruit jelly, chutneys and jams, liqueurs and commercial beers, massage oil, skin creams, lotions, soaps and candles) **(***www.marula.org.za***).**

Seed oil

The seed is rich in protein and oil, magnesium, phosphorus and potassium, which make it important to an African diet. The seeds are eaten, dried or ground and added to soups, stews and vegetables, to which they are reputed to give a delicious flavour. Fresh seeds are also added to newly–boiled meat, which is then eaten immediately (Shackleton *et al.,* 2002 c; Shone, 1979).

The seed contain about 60% of non-drying oil, which is rich in protein. The oil from the nuts is used for cooking, for flavouring in porridge, as a skin moisturiser, medicine and insecticide. It is especially valued by the cosmetic industry (Fig 2.15) due to its slow oxidizing properties (Duke, 1989; Hall *et al*., 2000).

The Venda pounds the ground seeds into lean sinewless meat and shapes it into cakes which are then dried and stored away and this is called Venda biltong (Shone, 1979). The marula seed can also be turned into oil or snacks and some communities, especially in Namibia, use most parts of the marula tree to make various medicines (City Press, 2003). In the past this oil was used to preserve and soften the traditional skin shirts (*sidwaba*) that they used to wear (Shackleton *et al.,* 2002 c). The Phalaborwa people subsist largely on the nut in winter, which may be mixed with spinach or meat and in summer with “green mealies” (Taylor *et al.*, 1995). Marula seeds are rich in protein (28-31% or 30, 9 g/100 g); oil (56-61% or 57, 0 g/100 g, magnesium (467 mg/100 g), phosphorus (836 mg/100 g) and potassium (677 mg/100 g) which contributes to the importance of these nuts in the diets of some rural communities (Wynberg *et al*., 2002).

The Venda people use the preservative properties of the oil in treating meat, which keeps it fresh for some time (Duke, 1989; Shone, 1979). Marula oil is naturally produced and cold-pressed (Fig 2.11) from the seed of the marula fruit (Lombard, 2002). The use of marula oil confers to personal care products

moisturising features, protection against transepidermal water loss, and improvement in skin smoothness and uniqueness (Houghton, 1999). Other features of marula oil, relate to the presence of antioxidants in specially processed marula oil, which is used as cooking oil and as a base for cosmetic red ochre (Duke, 1989; Lombard, 2002). Zulus crush the nuts and boil them with water; skimming off the oil, which they massage into the skin as a cosmetic (Taylor *et al.*, 1995). Marula oil is rich in oleic acid, which is an essential component in the maintenance of healthy skin. Marula oil has also been found to significantly improve skin hydration and smoothness, showing that it is absorbed well through the skin. The combination of high nutritional value and excellent stability makes it an ideal choice for modern cosmetic formulas (Anon; 2004). Marula oil is 10 times more stable than olive oil or sunflower oils (Burger *et al.*, 1987).

Data on the use of the nut resource are very variable across the region. In some areas, kernels appear to be little used despite their nutritional properties and potential cash value. For example, in Limpopo Province, South Africa marula fruits, were extracted and stored by 11% of households (Shackleton *et al*., 2000). In Zimbabwe found only one household (2% of the sample) that extracted *S. birrea* seeds and this was on an occasional basis (McGregor, 1995). In Okavango (Namibia) the nuts are almost never used (Shackleton *et al.*, 2002 c).

Figure 2.11 Oil processing machine (A); processed oil pouring into the container (B); seed cakes produced from pressed kernels (C) and twenty litre of processed marula oil (D).

Marula beer

Marula beer (Fig 2.12) has always formed an integral part of local culture and the drinking of marula beer is both a social and cultural activity (Shackleton, 2002 b). Marula beer is believed by Africans to have distinct aphrodisiacal power (Shackleton *et al*., 2002 c; Shone, 1979; Sunday Times, 2000). The UK Department for International Development's (DFID) studies on marula usage in rural communities of South Africa and Namibia have shown that marula beer and wine brings some financial relief to poor families, who earn an average monthly income of R250 (City Press, 2003). The 'shelf life' of the beer is very short, only 2-4 days, depending on the ambient temperature, which during the summer months is generally above 30 ^{o}C during the day (Shackleton, 2002 b), but it has been reported that marula beer can be stored for up to two to three years if sealed in clay or plastic containers and buried underground (Shackleton *et al*., 2002 c; Shone, 1979). Table 2.2 shows the composition of marula beer.

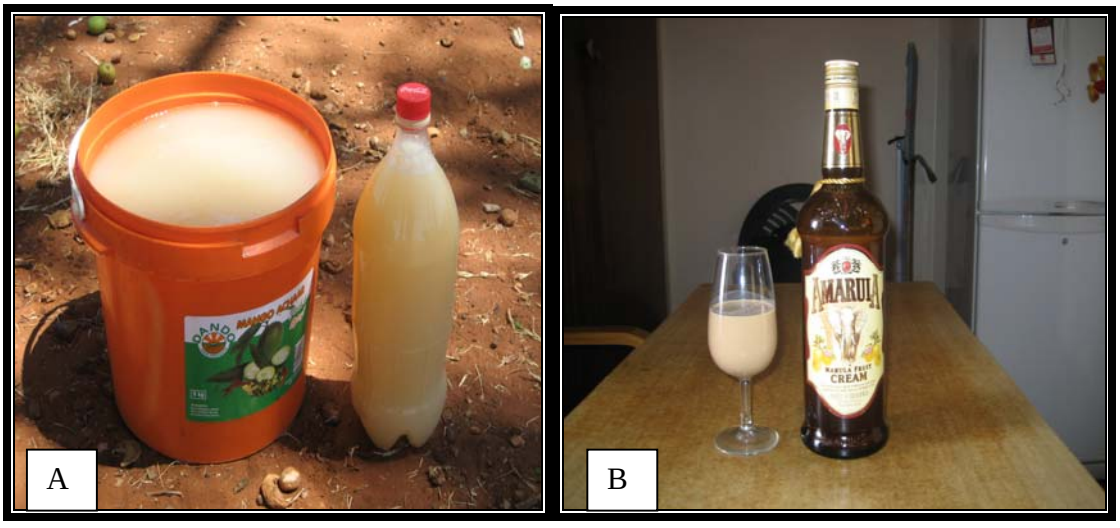

Figure 2.12 Freshly produced marula beer ready for consumption (A) and Amarula Cream, the natural fruit cream produced from fresh and unique marula fruit (B).

Table 2.2 Composition of Marula beer

Parameter	Values
pH	3.6
Total titratable acidity (g/100g)	1.1
Fixed acidity (g/100g)	0.1
Volatile acidity (g/100g)	0.9
Total soluble solids (%)	9.0
Total solids (%)	7.6
Ash (%)	0.4
Alcohol content (%v/v)	5.8
Carbohydrate (%)	10.0
Crude protein (% per litre)	2.6

Hall *et al*., 2000: Taken from Shongwe (1996).

Wood

The wood does not burn well, but is traditionally used for firewood and to make charcoal. It is also used in construction of “kraals”, to make beehives for honey and to mortars for pounding grains, for woodmaking - graving utensils, plates, bowls and to make equipment (axe handles etc.) and for carving drums (Hall *et al*., 2000; Lawes *et al*., 2004) stools, making musical instruments (Shackleton *et al*., 2002 c). There are various reports that marula tree was used extensively during colonial times for manufacturing tomato boxes and toilet seats (Shackleton *et al*., 2002 c; Shone, 1979). Other uses for the wood include furniture, panelling and flooring, laminated products, box shooks and manufactured articles such as shoe heels (Shackleton *et al*., 2002 c). The marula

tree (4% of carvings counted), is used primarily to carve warthogs and rhinos, and is selected because it does not crack easily (Lawes *et al*., 2004). World-wide, mistletoe is known for its use in medicine and as Christmas decorations but less well known is its curious ability to produce woodroses. The marula tree is the principal host for two mistletoe species, accounting for 71% of *Erianthemum dregei* and 42% of *Pedistylis galpinii* infection (Dzerefos *et al.,* 1999).

Medicinal Uses

The marula tree is used as a medicinal plant throughout its distribution range. Almost all parts of the plant, but especially the bark and leaves, are exploited for medicinal uses (Hall *et al*., 2000). The stem-bark aqueous extract was given to rats to control diabetes and the results of the study indicate that aqueous extract of marula tree possesses hypoglycaemic activity and thus lend credence to the suggested folkloric use of the plant in the management and control of adult-onset, type-2 diabetic mellitus in some African communities (Ojewole, 2003). The medicinal properties of the bark is used widely in treating dysentery, and diarrhoea, rheumatism, gangrenous rectitis, insect bites, burns and a variety of other ailments (Shackleton *et al.,* 2002 c ; Hall *et al*., 2000). The bark is also used as an anal suppository (powder) for treating haemorrhoids. Powdered bark mixed in a drink of milk or millet water is used to reduce fevers (Hall *et al*., 2000). A red dye is also obtained from the bark (Shone, 1979). Thirty-six woodland tree species with medicinal uses were recorded as having had bark harvested from

one to more individuals. The bark of marula and four other tree species is traded commercially for traditional medicine at *muthi* markets in Durban in South Africa (Cunningham, 1993). Decoctions, infusions or steam from boiled roots is used to treat heavy menstruation, bilharzia, coughs, weakness, sore eyes, heart pains and as an antiemetic (Shackleton *et al.,* 2002 c). Essence from the leaves provides a remedy for abscesses, spider bites and burns. The leaves are also used as a sedative (Shackleton *et al.,* 2002 c). A German company is making a tablet from the bark of the tree which prevents ulcer (Holtzhausen, 1980).

Other Uses

Leaves can also be used in compost-making (Sunday Sun, 2003). The leaves and leafy stems/branches make good animal feed, both for wild game and livestock especially during the winter months (Duke, 1989; Hall *et al*., 2000; Shackleton *et al.*, 2002 c; Shone, 1979). One of the reasons why marula is protected is because buffalo grass, *Panicum maximum*, grows under the tree. Buffalo grass is one of the most valuable fodder grasses in the tropical and subtropical regions (Shone, 1979). The gum secreted by marula is used to make ink by dissolving it into water and adding soot (Marula Net Database, 2003) and fibres from the inner bark for making ropes (DFSC, 2003).

The larvae of Mopane worm (*Imbrasia belina*) have been reported to occur on many different indigenous and exotic plant species, as well as on the marula

tree. Interplanting of marula tree in mopane (*Colophosepermum mopane)* stands might alleviate the defoliation pressure of the Mopane moth and would also benefit the community as they could harvest the fruits of marula for beer production and selling (Lawes *et al*., 2004).

CHAPTER 3

DETERMINATION OF FRUIT PRODUCTION AND QUALITY

3.1 Introduction

As can be seen from the previous chapters, the marula tree, especially the fruit has a great potential to become a major fruit crop. However, more information about precocity, production potential and fruit quality are required before the establishment of commercial orchards can be considered. Despite the economic importance of marula several critical of fruit production potential (yield efficiency) and fruit quality have not yet been adequately investigated and documented. The main purpose of this study was to fill some of the identified gaps such as yield efficiency in relation to post-harvest fruit quality aspects, namely; fruit size, weight, total soluble solids, titratable acid, stone and juice mass. The findings from this study will help to enhance and support farmers and rural communities as the production of marula juice and beer contribute immensely in making their livelihood and also for further development of selection by the breeders. This will further give a clear relation between the fruit size, mass and yield which will be essential for further studies as far as the selection and breeding programs are concerned.

3.2 Materials and methods

The study was conducted during the 2004/2005 and 2006/2007 growing seasons in a 14 years old orchard at Schoeman Boerdery (EDMS) in the Marble-Hall/ Groblersdal area in Mpumalanga Province (24^0 lat. and 29^0 long.), South Africa. From each of the selections, Pharulani, Toularula and Swarula, five trees each were selected randomly and marked, while from the Wild marula only four trees were selected and marked. For the purpose of experimental design, the four selections were regarded as four treatments, and the marked trees per selection as the replicates. All selected trees were more or less the same in size and were in full production. The first objective was to determine yield efficiency according to the method of Westwood (1978).

To determine yield potential, the number of fruit per square meter per tree was counted on pre-labelled branches on five positions around the tree canopy at three stages of fruit development. On three occasions (November 2006, December 2006 and January 2007) just after initial fruit set, five replicates of bearing shoots per m^2 per tree (from all nineteen selected trees) were selected randomly and marked to determine the fruit mass and size on the three stages of fruit development before the physiological maturity is reached. Collected data were converted to grams of fruit per square metre. Tree canopy size (CS), expressed as m^2, was calculated by using the radius (r) of each canopy in the following formula: CS= ($\pi.r^2$) 4. For calculating the yield per tree, the average

canopy size was multiplied by the number of fruit counted per m^2 .Twenty fruits from each labelled marula tree per selection were randomly selected; collected and taken to the Ecophysiology Laboratory at University of Pretoria for fruit quality analysis. The average tree canopy size for all selections was calculated and the data was collected and recorded. Data collected were used for yield analysis and also to determine fruit yield per selection. The following formula was used to calculate the yield efficiency (ha basis) (Westwood, 1978);

- Yield efficiency [ha basis] = tree yield X no. of tree per ha

For determining mature fruit size and quality, fruit were collected in 2004 and again in 2005, during traditional harvesting period. Since marula fruit drop from the tree after reaching physiological maturity, twenty (20) fruit per replication per selection (20 x 5x 19 fruit) were collected from underneath the trees and the samples clearly labelled and taken to the laboratory for determining the following fruit quality parameters: (See appendix 2)

Fruit mass

Each of the 20 fruits per sample was weighed separately, using a digital electronic scale. Data were listed in appendix 2 from Table 14.1 -21.5.

Fruit size

A digital venier calliper was used to measure the diameter of each fruit between the pedicel scar and the stylar end. Data were listed in appendix 2 from Table 14.1 -21.5.

Fruit parts (Peel, stone and pulp)

Separation of fruit parts was done according to traditional procedures for making marula beer. An incision was made in the peel of each fruit and the sap and stone squeezed out. The stones were then separated from the sap after which the peels, sap and stones of each fruit were weighed separately. The sap was used for determining total soluble solids (TSS) by digital hand-held refractometer and acid content by titration against 0.1562N Sodium Hydroxide with Mettler DL25 Titrator (Fig. 5.5). The first drops of each fruit sap were placed on the refractometer and within three seconds the ^{0}Brix value (sugar content/concentration) was displayed and recorded. After each reading, the prism of the refractometer was cleaned with tissue paper and 50% methanol, rinsed with distilled water and dried before re-use. The refractometer was standardised against distilled water (0% TSS). Titratable acid was determined by applying an acid base titration method using a 20 ml sample and 0.1562N Sodium Hydroxide (Mettler DL25 titrator). After titrations were completed, the results were recorded in millilitre (ml). The stone mass was obtained by weighing

each stone separately. The sap mass was obtained by subtracting the reamed peel and stone weight from the original fruit weight.

The experimental design was a completely randomised design (RCD) with five treatments (selections) and 4 or 5 replicates (trees) per treatment. The analyses of variance (ANOVA) were performed by the Statistical Analysis System (SAS) programme package and statistical differences between means were estimated and separated by Tukey's Studentized Range (HSD) test (SAS Institute, 1999).

3.3 Results

Yield Efficiency

The results show that fruit drop between final fruit set and harvesting in marula is not a serious problem, since the number of fruit per shoot showed no significant drop over the three collecting dates (Table 3.1). The relationship between the fruit mass and fruit age (time of collection) as well as the relationship between fruit size and age (Fig. 3.1 & 3.2) was linear to curvilinear. On the initial date of fruit collection, significant differences on fruit growth (size) among all selections were observed but on the last date there were no statistical differences on fruit size between all selections (Fig. 3.1) which is the opposite to fruit mass (Fig. 3.2). The highest total number of fruit per tree of 9944 fruits was obtained by Wild marula followed by Swarula with the total number of fruit per tree of 7684 fruits,

Pharulani recorded total number of fruits per tree of 6780 fruits and Toularula with the lowest total number of fruits per tree of 4520 fruits. The highest yield of 346 kg per tree was obtained by Swarula , followed by Pharulani with the total yield per tree of 328 kg, Wild marula with the total yield of 311 kg and 'Toularula' had the lowest total yield per tree of 203 kg. The expected fruit production in an orchard, using female trees and a planting distance of 9 m row spacing and 4.5 m in-row spacing the yield efficiency (ha basis) could be as follows, based on the number of fruit counted per m^{-2}, Swarula, 83732 kg/ha or 83.7 tons/ha; Pharulani, 79376 kg/ ha or 79.4 tons/ha; Wild marula, 75262 kg/ha or 72.2 tons/ha and Toularula, 49126 kg/ha or 49 tons/ha, although 10% should be subtracted to accommodate interplanting of male trees.

Fruit production data for wild trees are scanty and often unreliable. Some reports of numbers of fruits per tree include; 9601 fruits or 270.3 kg from one tree near Tzaneen in the north-eastern Transvaal was recorded (Shone, 1979) ; 226000 fruits in one month (April) (not entire season) from 111 trees tagged trees in Luangwa, Zambia (Lewis, 1987). An average of 35000 fruits in the wild tree in Botswana (Taylor *et al.,* 1996). Recent data for 122 trees in the 1999/2000 season gave a mean yield of 17.4 kg of fruit per tree, although it was noted that some fruit may have already been collected at some sites (Shackleton *et al.,* 2002 c). Swarula selection have a better yield efficiency both per tree as well as per ha compared to other selections whereas 'Toularula' has the lowest yield efficiency (tree unit and ha basis) (Table 3.2). Nakosone *et al.* (1998) stated that

fruit yields vary with cultivars used; climatic and edaphic conditions of the production site, cultural practises and other factors such as diseases and insect pests. Yields per tree over many years exhibit a sigmoidal curve, initially with low yields, increasing more rapidly and then dropping off as trees become crowded especially pistachio nuts (Nakosone *et al.,* 1998).

Considering the figures mentioned in Figures 3.1 and 3.2, it can be argued that between March to June, fruits of wild marula had grown up to 35 mm in diameter and approximately 30 g in weight matured, and fallen to the ground. According to Lewis (1987) wild marula can bear as many as 8000 fruits per tree. The maximum expected yield per tree for wild marula should therefore be between 240 kg (8000 x 30 g). The 2 tons per tree as mentioned by Duke (1989) is therefore questionable because it will mean that, with a fruit weight of 30 grams, a wild tree will have to bear 67000 fruits on a canopy of about 838 m^2. Even the 35000 fruit per tree as mentioned by Taylor *et al*. (1996) at 30 g per fruit would mean 1.5 tons per tree. The maximum estimated yield per tree in this investigation (Table 3.2) was less than half ton. For a yield of half ton per tree, a canopy size of at least 200 m^{-2} would be required.

The period of maximum production depends upon precocity, tree age and growth rate. Rapidly growing cultivars is more likely to show decreasing yields earlier due to crowding (Nakosone *et al.,* 1998). The fruit of the Pharulani selection showed a six-fold increase in mass over the period of two months (Fig. 3.2),

while the fruit of the other selections showed less increase. The fruit diameter less than doubled over the same period (Fig. 3. 1).

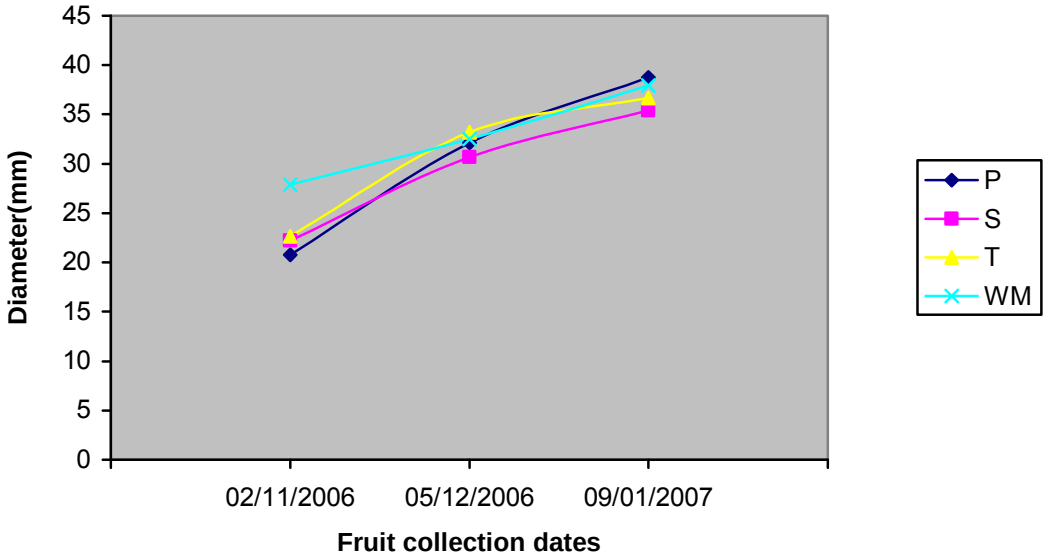

Fig 3. 1 Relationship between fruit size and fruit age (Collection date) of four marula selections.

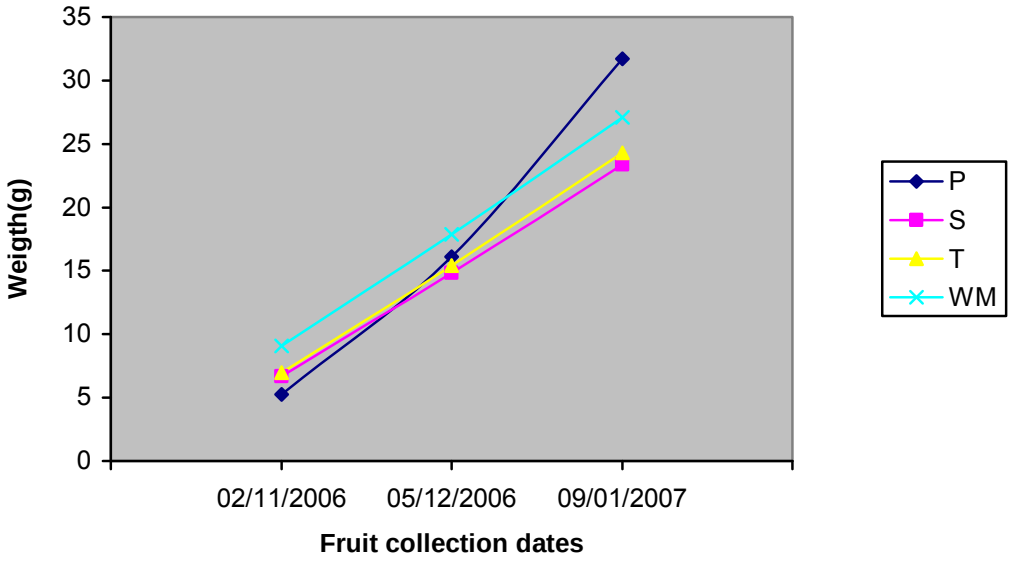

Fig 3. 2 Relationship between fruit mass and fruit age of four marula selections.

Table 3.1 Number of fruit per m^{-2} at different dates and % fruit retention*

Selections	Fruit/m^{-2} on 02/11/2006	Fruit m^{-2} on 02/12/2006	Fruit/m^{-2} On 09/01/2006	% Fruit retention
P	72	68	60	83
S	52	44	40	77
T	80	76	72	90
WM	96	96	88	92

***Tree were flowering in October

Table 3.2 Yield Efficiency of four marula selections

Selections	Number of Fruit per m^{-2}	*Tree Canopy size in m^{-2}	Total number of fruit per tree	Average fruit mass (g)	Total Yield [g/Tree]	Total Yield [kg/Tree]
P	60b	113	6780	48.42	328287.60	328
T	40d	113	4520	44.89	202902.80	203
S	68ab	113	7684	45.06	346241.04	346
WM	88a	113	9944	31.31	311346.64	311

Values followed by the same letter in a column are not significantly different at P≤ 0, 05 according to HSD-test.

***** Canopy size of the trees in the experimental orchard was very uniform and for the sake of comparison the same average canopy was chosen for all selections.

Fruit qualities

Fruit Mass

The average figures calculated from tables supplied in appendix 2, are summarised in Table 3.3. The results show that the highest mass was recorded for Pharulani (P), that is, 46.96 g and 49.88 g in 2004 and 2005 seasons respectively whereas the lowest mass was recorded for Wild marula selection

(WM) , that is, 34.14 g and 28.48 g (2004/2005) (Table 3.3). The statistical analysis revealed that there was a significant difference between Wild Marula (WM) and other selections (Pharulani, Toularula and Swarula).

Fruit size

The wild marula selection had the lowest fruit size of 37.57 mm and 35.61 mm in 2004 /2005 seasons respectively. This is significantly smaller than in the case of the other selections. There were no significant differences between Pharulani, Toularula and Swarula in all seasons.

Table 3.3 Fruit quality aspects of four marula selections

Selections	*Fruit mass (g)		Fruit size (mm)		Peel mass (g)		Juice mass (g)		Stone mass (g)	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
P	46.96 a	49.88 a	43.00 a	43.28 a	14.71b	16.75a	11.44a	12.94a	20.58a	19.97a
T	46.68 a	43.10 a	43.85 a	41.73 a	17.36a	16.10a	10.28a	10.28a	18.82a	16.58ab
S	45.12 a	45.01 a	43.62 a	43.28 a	18.95a	19.06a	9.14a	10.21a	16.79a	15.60ab
WM	34.14 b	28.48 b	37.57 b	35.61 b	11.67c	9.55b	6.68b	6.60b	15.39a	12.09 b

Values followed by the same letter in a column are not significantly different at P≤ 0, 05 according to HSD-test.
* Fallen fruit collected underneath the tree.

Fruit parts (Peel, stone and pulp)

Peel

The peel mass of all marula selections showed slight differences in 2004/2005 seasons. Swarula had the highest peel/rind mass of 18.95 g and 19.06g (2004/2005) whereas WM had the lowest peel/rind mass of 11.67 g and 9.55 g (2004/2005) seasons (Table3.3). In both seasons, there were significant differences between selections. Table 3.4 showed that Swarula selection had a slight high peel percentage than other selections.

Stone

The results as illustrated in Table 3.3, Pharulani, Toularula and Swarula had the highest average stone mass between 20.58 g and 15.60 g for 2004/2005 seasons whereas Wild marula (WM) had the lowest average stone seed mass of 15.39 g and 12.09 g (2004/2005 seasons). Statistical analysis for stone mass revealed that there were significant differences between wild marula and 'Pharulani' for 2005 season. The nut quality and size of other nut trees as outlined by Jaynes (1969) stated that nut size is a variety trait, but is greatly influenced by the environment. The main environmental factor is tree nutrition. The larger nuts came from trees growing on better soil. A heavy crop will also cause nut size to be smaller than normal. Jaynes (1969) concluded that tree age is another factor that influences nut size; that is; young trees usually bear larger nuts than mature trees of the same variety, but frequently produce fewer nuts per

unit leaf area than mature trees. Consequently, it is difficult to accurately estimate the quality or quantity of the crop before harvest time.

The number of the seeds per stone that fails to develop varies from year to year and appears to be associated with pollination. In marula tree, pollination can also have a major effect on the number of seeds formed per stone due to the fact that each carpel has its own stigma. This is recognised as an important problem wherever pistachio nuts are grown (Crane *et al*., 1998). Table 3.4 illustrated that Wild marula selection had a considerable higher stone percentage as compared other selections.

Juice

Pharulani recorded the highest juice mass of 11.44 g and 12.94 g as compared to Wild marula that recorded the lowest juice mass of 6.68 g and 6.60 g for 2004/2005 seasons respectively. For both seasons, there were significant differences between Wild marula and other selections. With two tons of fruit, one might possibly obtain more than 6000 litres of beer, distilling down to possibly 300 litres of ethanol or 3000 litres assuming 100 trees per hectare (Duke, 1989). Table 3.4 showed that Pharulani selection had higher juice percentage as compared to other selections.

As seen above; fruit quality can vary and to work with mass figures can be confusing, for this reason in Tables 3.4 and 3.5, the fruit qualities of the

investigated selections were compared on a percentage base. The findings on percentage bases show the inverse relationship between peel and juice percentage of different selections. Pharulani selection may be selected for both high juice content and lower peel percentage; WM can be selected for high stone percentage(mass) and Swarula can be selected for high peel mass especially for those farmers producing jams, jellies and chutney. Looking into the peel percentage of all selections, it may be concluded that the higher the peel percentage the lower the juice content (%) and *vice versa.*

Table 3.4 Peel, stone and juice percentage of four marula selections

Selections	% Peel	% Stone	% Juice
P	32.6	42.1	25.3
T	37.4	39.6	23
S	42.4	36	21.6
WM	34	44	22

TSS and TA

The results of TSS and TA for all selections are summarised in Table 3.5. Although not statistically different, Pharulani had the highest average ^{o}Brix (2004) whereas Swarula had the lowest average ^{o}Brix. Pharulani also had the highest acid content of 1.91% and 2.45% for 2004/2005 seasons respectively whereas Swarula had the lowest acid content of 0.87% (2004) and WM had the lowest

acid content of 0.64% (2005). The most important findings from this analysis is that the fact that the TSS/TA ratio for Pharulani was significantly lower than the other selections for both 2004 and 2005 while for Wild Marula it was significantly higher than all the selections. TSS/TA ratio determines the palatability of the juice, meaning that WM juice has a more acceptable taste excellent for brewing very potent alcoholic beverages. Ready to serve mango beverage has a TSS/TA of 50% (Litz, 1997).

Table 3.5 Comparison between TSS (^{o}Brix), TA and TSS/TA Ratio for different selections

Selections	TSS (^{o}Brix) Average		Acid %		TSS/TA Ratio	
	2004	2005	2004	2005	2004	2005
P	13.54 a	12.56 a	1.91 a	2.45 a	7.3:1 b	5.4:1 c
T	13.02 a	12.15 a	1.36 ab	1.48 ab	11.2:1 ab	8.2:1 bc
S	12.63 a	12.59 a	0.87 b	0.96 b	14.5:1 a	13.1:1 b
WM	13.17 a	13.09 a	0.89 b	0.64 b	15.9:1 a	20.9:1 a

Values followed by the same letter in a column are not significantly different at P≤ 0, 05 according to HSD-test.

3.4 Discussion

The indigenous fruits such as Marula play a vital role in improving the nutrition (Vit. C) in the rural communities and especially amongst children who are the main consumers. Domestication and on-farm cultivation of indigenous species is one way to ensure reliable supplies of non-timber forest products while at the same time reducing harvesting pressure in forests and woodlands. Shackleton (2002 a) stated that 78.9% of rural households in the Bushbuckridge region in the Limpopo Province grow *Sclerocarya birrea* in their homestead gardens for its fruit, fuelwood and seeds/nuts. Any future breeding or selection program aimed at producing fruits with better quality (superior fruits) should depend on a thorough knowledge of cultivar selection for higher production and quality fruit, as well as post-harvest aspects and this study aimed to achieve that. The use of the Pharulani selection is recommended for future breeding program as it gave superior fruit with high mass, size and juice content although the juice quality needs to be improved. Wild Marula has a better taste (sweet) than others (Table 3.5).

Holtzhausen (1988) believes that the ultimate marula (100 g fruit size; 60% juice; 20% TSS; very high vitamin C content) is still to be found, possibly within the Kruger National Park, which is thought to contain the largest gene pool of wild marula variants. Archaeological studies in the Kruger Park showed that ancient inhabitants in this area consumed marula fruit and it is not impossible that they

have brought in genetic material from outside sources. From the study, it is clear that the investigated selections are still below par as reported by Holtzhausen (1988) and confirmed with study (Table 3.4). This means that further investigation and development of all selections is vital to improve their juice content/ percentages as well as the juice quality.

Selections in marula are not a new concept altogether, it was long ago done by women who know from their experience which tree bears the sweetest and the largest fruit. They also knew which tree gave the best fruits for beer-making. The fruits from Wild marula trees ripen from late December until early February while the other selections ripen from late February until early April. Planting of these other selections to maintain continuous production is very essential and this can be used as a positive method of generating profit for rural communities.

In Table 3.6.; the qualities of the highest yielder (Pharulani) and the lowest yielder (Swarula) are compared and it is clear that although the external fruit qualities of Pharulani is much better than those of WM, the quality of the juice needs to be improved.

Table 3.6 The fruit quality aspects comparing Pharulani and Wild marula

Quality aspects	Pharulani	Wild Marula
Fruit mass (g)	46.96	34.14
Fruit size (mm)	43.85	37.57
% Peel	32.6	34
% Stone	42.1	44
% Juice	25.3	22
^{0}Brix	13.54	13.17
Acid percentage (%)	1.91	0.89
TSS/TA ratio	5.1:1	20.5:1

This research study support the aims or ideas of ICRAF, that is, bringing indigenous fruits into cultivation by multiplying the superior trees, which produce large and sweet fruits while still young. More future studies or researches are needed of which improved fruit quality is vital. Other aspects are production methods such as planting distances, fertilizer and irrigation programmes for increased productivity of marula fruits, the study of the reproductive biology of marula flowers, control of mistletoe which is a problematic parasite that affects the yield of marula trees and the proper storage of marula fruits to extend the shelf life especially for the wild marula selections that have higher sugar content. Disease incidence after fruit-drop (after physiological maturity) to ripening temperatures can be reduced by storing fruit at temperatures that inhibit softening and ground skin colour development. Marula fruit are clearly climacteric and if fruit are placed in cold storage without delay after collection ripening can

be slowed down (Litz, 1997). The development of new products and better trees should, however, be complimented with a strong focus on marketing. Some of the gaps that were identified in the current domestication initiatives taking place in Southern African Development Community (SADC) countries include formal market research on the bulk of indigenous tree fruits; post harvest handling and storage; value adding and the development of formal markets for the resulting products (Shumba *et al*., 2000). There is no logic in developing award winning products and breeding perfect trees if the products cannot earn an income for the farmer or community at whom this domestication work is directed (Lawes *et al*., 2004).

Awareness programmes are important to encourage the utilization of indigenous fruit or wild fruits since they are vital for good nutritional status and well-being of the nation. For example, many wild fruits are high in vitamin A (Lawes *et al*., 2004). Vitamin A deficient mothers have a significantly greater possibility of transmitting HIV to their unborn children and thus promotion of wild fruits in the diet may have a considerable contribution to play in overall health and resistance to illness and diseases such as HIV (Lawes *et al*., 2004).

There is not much research being done on the domestication of indigenous fruit trees in South Africa. The most well-known research effort is probably the domestication work on Marula tree by Holtzhausen (1980) and his team at the University of Pretoria. The Institute for Tropical and Subtropical Crops of the

Agricultural Research Council is currently busy with cultivation work and genetic selection of *Dovyalis caffra, Englerophytum magalismontamum, Mimusops zeyheri, Vangueria infausta and Parinari curatellifolia* (Lawes *et al.,* 2004). All of these marula selections has the highest potential and should receive more attention.

3.5 Conclusions

Fruit production data for wild trees are scanty and often unreliable. Comparing the investigated selections with the previous literature as recorded as 9601 fruits or 270, 3 kg per tree (Shone, 1979); an average of 35000 fruits per tree (Taylor *et al*, 1996); 8000 fruits per tree (Lewis, 1987) and 2 tons per tree (Duke, 1989). The Swarula selection produced the higher total yield of 346 kg/tree as compared to other selections but the question still remains whether the production per tree can be increased or improved to yield 35000 fruits per tree or 2 tons per tree which is extremely high.

Pharulani was found to be the selection of choice based on the investigated characteristics except for low TSS percentage (TSS/TA ratio 5.1:1). The wild marula showed superior sugar content (20, 5% TSS) and Swarula recorded high yield efficiency (kg/tree) on both tree unit and hectare basis as compared to other selections. The commercialization of marula products have been seen as the way of increasing livelihood in the rural communities. Although they depend on the collection of wild fruits, more work done were focused on developmental projects rather than the research projects on cultural and production practice. Although the result showed that the fruit drop was not much of a problem in marula tree, there are three distinct fruit drop stages in nut /fruit tree as stated by Nakosone *et al.* (1998). The first drop takes place just before, during or shortly

after bloom and consists largely of defective buds or flowers. This drop may be associated with, among other factors, stresses (such as lack of soil moisture or insufficient chilling) during bud development. The second drop takes place within a month after bloom and consists of flowers with pea-sized ovaries that have not shed after floral tubes and the last stages takes place 6 to 7 weeks after bloom and consists of larger fruits that have shed their floral tubes. More research work is needed on the flowering, pollination, fruit set and fruit ablactation to validate the above-findings.

Despite the economic importance of marula, no cultivars has been developed or registered and this signify that the work done so far is too little and therefore the research on physiology and production of marula tree is recommended to enhance and support increased production of marula products and thus in resultant economic upliftment. Continuous evaluation of the related four selections should continue to prove beyond any doubt their superiority and stability.

In this study, the Pharulani selection was found to be the selection that could be recommended to the farmers as it is illustrated in table 3.5. It had the superior fruit quality as compared to other selections with the exception of sugar content. Swarula had high production/yield efficiency (kg/tree) and wild marula had high TSS % (20, 5%). The future studies are recommended in order to improve the fruit quality.

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APPENDIX 1

ANALYSIS OF VARIANCE (ANOVA) TABLES.

Table 1: FRUIT MASS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	473.02	157.67	6.33	0.0055*
ERROR	15	373.56	24.90		
CORRECTED TOTAL	18	846.59			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

Table 2: FRUIT SIZE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	112.51	37.50	15.56	< .0001**
ERROR	15	36.15	2.41		
CORRECTED TOTAL	18	148.66			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

Table 3: BRIX

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	2.10	0.70	2.47	0.1015ns
ERROR	15	4.56	0.28		
CORRECTED TOTAL	18	6.36			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

Table 4: PEEL AND SEED MASS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	229.02	76.34	5.98	0.0069*
ERROR	15	191.51	12.76		
CORRECTED TOTAL	18	420.54			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

Table 5: PEEL MASS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	136.03	45.34	30.37	<.0001**
ERROR	15	22.39	1.49		
CORRECTED TOTAL	18	158.43			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

Table 6: SEED MASS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	71.01	23.67	2.44	0.1044ns
ERROR	15	145.41	9.69		
CORRECTED TOTAL	18	216.43			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

Table 7: JUICE MASS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	54.26	18.08	6.50	0.0049*
ERROR	15	41.73	2.78		
CORRECTED TOTAL	18	96.00			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

Table 8: PEEL FRUIT MASS RATIO

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	0.03	0.01	7.04	0.0035*
ERROR	15	0.02	0.00		
CORRECTED TOTAL	18	0.05			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

Table 9: SEED FRUIT MASS RATIO

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	0.01	0.00	8.56	0.0015*
ERROR	15	0.01	0.00		
CORRECTED TOTAL	18	0.02			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

Table 10: JUICE FRUIT MASS RATIO

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	0.005	0.00	4.66	0.0171*
ERROR	15	0.005	0.00		
CORRECTED TOTAL	18	0.01			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

Table 11: ACID

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	3.49	1.16	6.47	0.0050*
ERROR	15	2.69	0.17		
CORRECTED TOTAL	18	6.19			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

Table 12: TSS: ACID RATIO

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	207.74	69.24	6.35	0.0054*
ERROR	15	163.70	10.91		
CORRECTED TOTAL	18	371.44			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

Table 13: JUICE RATIO

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR > F
TREATMENT	3	83.55	27.85	4.02	0.0277*
ERROR	15	103.92	6.92		
CORRECTED TOTAL	18	187.68			

*, ** = significantly different at P≤0.05 and P≤0.01, respectively.

Ns =not significant

APPENDIX 2

Raw data of analyses done on the five marula selections during 2004.

Table 14.1: Fruit qualities of selection Wild marula, tree no: 1.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	43.97	42.00	13.0	35.16	13.47	21.35	8.81	0.30	0.48	0.20
2	39.75	40.00	12.0	31.78	11.78	19.82	7.97	0.29	0.49	0.20
3	42.43	44.00	13.0	33.73	12.62	20.78	8.70	0.29	0.48	0.20
4	39.50	40.00	11.8	31.08	11.7	19.08	8.42	0.29	0.48	0.21
5	40.36	39.00	13.0	31.65	12.55	18.83	8.71	0.31	0.46	0.22
6	43.21	40.00	14.0	33.97	13.12	20.70	9.24	0.30	0.47	0.21
7	49.23	45.00	12.6	38.60	15.55	22.88	10.63	0.31	0.46	0.22
8	41.51	41.00	12.2	31.91	12.87	18.73	9.60	0.31	0.45	0.23
9	41.51	41.00	12.2	31.91	12.87	18.73	9.60	0.31	0.45	0.23
10	46.34	43.00	12.4	36.32	14.43	21.76	10.02	0.31	0.47	0.22
11	46.50	43.00	13.0	37.79	14.55	23.03	8.71	0.31	0.50	0.19
12	41.25	39.00	12.2	31.96	13.24	18.56	9.29	0.32	0.45	0.23
13	42.14	39.00	12.6	33.55	12.59	20.81	8.59	0.30	0.49	0.20
14	41.12	40.00	13.6	31.55	13.01	18.58	9.57	0.32	0.45	0.23
15	39.59	40.00	12.2	32.00	12.04	19.80	7.59	0.30	0.50	0.19
16	38.99	38.00	13.2	29.71	11.52	18.34	9.28	0.30	0.47	0.24
17	40.29	40.00	11.0	32.70	13.02	19.35	7.59	0.32	0.48	0.19
18	37.91	36.00	12.2	28.68	11.34	17.25	9.23	0.30	0.46	0.24
19	40.31	37.00	13.0	31.06	12.95	17.96	9.25	0.32	0.45	0.23
20	33.31	36.00	12.4	25.14	10.2	14.71	8.71	0.31	0.44	0.25
Total	831.37	805.00	251.8	652.18	255.86	392.83	179.5	6.12	9.38	4.33
Average	41.57	40.25	12.5	32.61	12.79	19.64	8.98	0.31	0.47	0.22

Titration Result (ml): 14.61

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 14.61/20 *0.1562/0.1562
= 0.73

Juice %= Fruit weight -Peel and Seed weight * 100/Fruit weight
= 831.37 - 652.18 * 100/831.37
= 21.55

Ratio = TSS/Acid %
= 12.5/0.73
=17.1:1

Table 14.2: Fruit qualities of selection Wild marula, tree no: 2.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	31.43	37.00	14.2	23.49	10.92	12.3	7.94	0.35	0.39	0.25
2	35.70	39.00	13.8	28.68	11.72	16.7	7.02	0.33	0.47	0.20
3	35.00	40.00	14.0	28.12	12.72	15.21	6.88	0.36	0.44	0.20
4	37.94	40.00	14.0	30.59	12.8	17.56	7.35	0.34	0.46	0.19
5	30.02	36.00	15.2	24.09	10.65	13.23	5.93	0.36	0.44	0.20
6	35.39	37.00	13.0	27.99	12.31	15.54	7.40	0.35	0.44	0.21
7	32.59	38.00	16.0	26.33	11.09	14.98	6.26	0.34	0.46	0.19
8	31.31	38.00	15.0	25.93	11.35	14.16	5.38	0.36	0.45	0.17
9	34.30	38.00	14.6	27.78	10.57	17.18	6.52	0.31	0.50	0.19
10	28.32	35.00	14.4	22.42	8.97	13.23	5.90	0.32	0.47	0.21
11	28.70	35.00	13.8	24.09	10.04	12.48	4.61	0.35	0.44	0.16
12	37.08	40.00	14.2	29.69	11.83	17.80	7.39	0.32	0.48	0.20
13	31.35	36.00	13.0	23.94	10.43	13.36	7.41	0.33	0.43	0.24
14	30.24	34.00	13.8	22.53	10.00	12.37	7.71	0.33	0.41	0.26
15	31.85	36.00	13.2	24.8	10.48	14.07	7.05	0.33	0.44	0.22
16	33.20	37.00	13.0	25.75	10.94	14.62	7.45	0.33	0.44	0.22
17	31.24	37.00	13.6	24.32	9.85	14.36	6.92	0.32	0.46	0.22
18	33.92	36.00	14.0	26.08	11.13	14.85	7.84	0.33	0.44	0.23
19	33.42	36.00	13.0	26.35	11.30	14.98	7.07	0.34	0.45	0.21
20	28.60	37.00	13.0	22.09	9.57	12.01	6.51	0.34	0.42	0.23
Total	651.6	742	278.8	491.57	218.67	290.99	136.5	6.74	8.93	4.20
Average	32.58	37.10	13.9	25.87	10.93	14.55	6.83	0.34	0.45	0.21

Titration Result (ml): 14.81

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
=14.81/20 *0.1562/0.1562
=0.74

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
=651.6-491.57*100/651.6
=24.55

Ratio = TSS/Acid%
= 13.9/0.74
=18.8:1

Table 14.3: Fruit qualities of selection Wild marula, tree no: 3.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	30.60	37.00	13.6	25.43	10.87	14.22	5.17	0.36	0.47	0.17
2	26.92	34.00	14.0	21.69	8.96	12.37	5.23	0.33	0.46	0.19
3	31.81	36.00	14.0	25.95	10.90	14.56	5.86	0.34	0.46	0.18
4	28.37	35.00	13.8	23.34	9.89	13.26	5.03	0.35	0.47	0.18
5	25.75	34.00	13.0	20.29	8.96	11.15	5.46	0.35	0.43	0.21
6	27.84	34.00	13.4	22.93	9.90	12.65	4.91	0.36	0.45	0.18
7	22.47	35.00	14.6	18.13	7.91	9.95	4.34	0.35	0.44	0.19
8	27.41	38.00	14.0	23.07	9.68	13.27	4.34	0.35	0.48	0.16
9	32.50	38.00	14.6	26.19	11.12	14.87	6.31	0.34	0.46	0.19
10	31.92	38.00	13.8	26.00	10.79	14.97	5.92	0.33	0.47	0.19
11	31.23	37.00	14.6	25.74	11.14	14.22	5.49	0.36	0.46	0.18
12	32.87	39.00	14.0	27.21	11.23	15.76	5.66	0.34	0.48	0.17
13	29.00	38.00	14.4	23.62	10.55	12.74	5.38	0.36	0.44	0.19
14	29.34	40.00	14.8	23.46	10.12	13.14	5.88	0.35	0.45	0.20
15	29.65	35.00	14.4	23.85	10.65	13.00	5.80	0.36	0.44	0.20
16	32.81	38.00	14.2	26.6	11.58	14.68	6.21	0.35	0.45	0.19
17	25.66	35.00	15.0	21.11	9.16	11.79	4.55	0.36	0.46	0.18
18	29.30	37.00	14.8	23.18	10.46	12.44	6.12	0.36	0.43	0.21
19	30.49	38.00	14.4	25.41	11.54	13.45	5.08	0.38	0.44	0.17
20	28.60	39.00	14.6	21.60	9.91	1.60	7.00	0.35	0.41	0.24
Total	584.5	735	284	474.8	205.32	264.09	109.7	7.03	9.05	3.77
Average	29.23	36.75	14.2	23.74	10.27	13.20	5.49	0.35	0.45	0.19

Titration Result (ml): 14.91

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
=14.91/20 * .1562/ 0.1562
=0.74

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 584.54- 474.8 *100/584.54
= 18.77

Ratio = TSS/Acid%
=14.2/0.74
=19.1:1

Table 14.4: Fruit qualities of selection Wild marula, tree no: 4.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	34.72	33.00	13.0	28.65	11.79	16.78	6.07	0.34	0.48	0.17
2	31.61	37.00	12.2	26.58	12.15	14.31	5.03	0.38	0.45	0.16
3	38.76	38.00	12.0	32.48	15.01	17.19	6.28	0.39	0.44	0.16
4	34.37	35.00	12.0	27.91	13.18	14.60	6.46	0.38	0.43	0.19
5	35.06	35.00	12.2	29.00	13.96	14.93	6.06	0.40	0.43	0.17
6	36.91	35.00	12.0	31.61	13.86	16.90	5.30	0.38	0.46	0.14
7	29.87	37.00	12.8	23.73	10.90	12.54	6.14	0.36	0.42	0.21
8	31.89	36.00	11.8	25.93	12.87	12.78	5.96	0.40	0.40	0.19
9	26.18	35.00	12.2	21.34	10.22	10.97	4.84	0.39	0.42	0.18
10	30.93	35.00	11.6	26.36	11.81	13.86	4.57	0.38	0.45	0.15
11	33.04	38.00	11.2	29.18	13.54	15.14	3.86	0.41	0.46	0.12
12	33.53	37.00	12.0	28.72	12.79	15.47	4.81	0.38	0.46	0.14
13	29.41	37.00	12.0	23.30	10.31	12.71	6.11	0.35	0.43	0.21
14	30.39	35.00	12.0	24.79	11.75	12.76	5.60	0.39	0.42	0.18
15	38.00	40.00	11.2	32.27	13.44	18.34	5.73	0.35	0.48	0.15
16	34.13	37.00	10.2	29.07	14.28	14.44	5.06	0.42	0.42	0.15
17	32.69	35.00	11.6	27.22	11.96	14.70	5.47	0.37	0.45	0.17
18	33.96	35.00	13.0	29.11	14.17	14.29	4.85	0.42	0.42	0.14
19	36.74	40.00	12.0	31.97	13.13	18.42	4.77	0.36	0.50	0.13
20	34.01	36.00	14.0	28.46	12.96	14.73	5.55	0.38	0.42	0.16
Total	666.2	726	241	557.68	254.08	295.86	108.5	7.63	8.84	3.27
Average	33.31	36.30	12.0	27.88	12.70	14.79	5.43	0.38	0.44	0.16

Titration Result (ml): 26.99

Acid % = Titration/Weight * 0.1562/0.1562 (NaOH)
= 26.99/20 * 0.1562/0.1562
= 1.35

Juice %= Fruit weight -Peel and Seed weight * 100/Fruit weight
= 6666.20 – 557.68 * 100/666.20
= 16.29

Ratio = TSS/Acid %
= 12.0/1.35
= 8.9:1

Table 15.1: Fruit qualities of selection Swarula, tree no: 1.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	57.48	47.18	12.2	46.72	24.02	22.11	10.76	0.42	0.39	0.19
2	56.08	45.87	14.4	45.01	24.42	20.56	11.07	0.43	0.37	0.20
3	46.21	43.54	12.8	35.33	19.08	15.98	10.88	0.41	0.35	0.24
4	49.82	44.51	12.9	39.42	20.22	18.84	10.40	0.41	0.38	0.21
5	53.56	45.89	13.0	42.34	22.20	20.10	11.22	0.41	0.38	0.21
6	50.71	44.30	12.8	39.61	20.05	19.42	11.10	0.40	0.38	0.22
7	44.90	43.36	12.9	35.65	18.89	15.91	9.25	0.42	0.35	0.21
8	52.54	45.91	13.1	42.12	21.34	20.26	10.42	0.41	0.39	0.20
9	50.74	45.98	12.6	40.96	21.89	18.70	9.78	0.43	0.37	0.19
10	58.20	47.62	12.2	46.75	24.93	21.48	11.45	0.43	0.37	0.20
11	45.93	43.21	12.3	35.56	19.28	15.96	10.37	0.42	0.35	0.23
12	49.41	47.32	12.7	39.90	20.70	19.02	9.51	0.42	0.39	0.19
13	48.29	43.62	12.8	38.14	20.43	17.26	10.15	0.42	0.36	0.21
14	58.75	48.07	13.8	47.30	24.27	22.94	11.45	0.41	0.39	0.20
15	38.08	41.80	14.5	30.77	15.88	14.59	7.31	0.42	0.38	0.19
16	48.30	44.41	12.5	37.57	19.33	18.07	10.73	0.40	0.37	0.22
17	49.12	45.15	12.4	38.86	20.27	18.29	10.26	0.41	0.37	0.21
18	43.60	42.82	13.2	34.81	18.88	15.61	8.79	0.43	0.36	0.20
19	44.28	42.52	13.0	34.35	18.16	15.90	9.93	0.41	0.36	0.22
20	51.77	45.95	13.7	42.46	22.98	19.01	9.31	0.44	0.37	0.18
Total	997.77	899.03	259.8	793.63	417.22	370.01	204.1	8.35	7.43	4.12
Average	49.88	44.95	12.9	39.68	20.86	18.50	10.21	0.42	0.37	0.20

Titration Result (ml): 17.29

Acid % =Titration/Weight * 0.1562/0.1562 (NaOH)
=17.29/20 *0.1562/0.1562
= 0.86

Juice %= Fruit weight -Peel and Seed weight * 100/Fruit weight
= 997.77-793.63 *100/ 997.77
= 20.45

Ratio = TSS/Acid %
= 12.9/0.86
= 15:1

Table 15.2: Fruit qualities of selection Swarula, tree no: 2.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	44.05	41.73	13.4	36.42	18.83	17.15	7.63	0.43	0.39	0.17
2	40.20	42.21	12.1	31.18	16.30	14.61	9.02	0.41	0.36	0.22
3	37.85	40.19	14.6	30.14	15.51	14.42	7.71	0.41	0.38	0.20
4	40.78	39.63	11.9	33.41	17.45	15.81	7.37	0.43	0.39	0.18
5	40.26	42.27	12.0	31.11	16.38	14.47	9.15	0.41	0.36	0.23
6	36.22	40.04	12.2	28.94	15.16	13.57	7.28	0.42	0.37	0.20
7	42.84	45.36	12.4	35.31	18.63	16.71	7.53	0.43	0.39	0.18
8	43.17	43.56	12.0	34.35	16.85	17.35	8.82	0.39	0.40	0.20
9	41.68	40.84	13.9	32.42	17.81	14.29	9.26	0.43	0.34	0.22
10	43.52	42.00	13.1	33.86	18.00	15.62	9.66	0.41	0.36	0.22
11	46.35	44.48	12.5	37.28	19.60	17.44	9.07	0.42	0.38	0.20
12	47.56	41.99	12.8	38.46	20.01	18.13	9.10	0.42	0.38	0.19
13	42.52	43.23	12.4	32.35	17.85	14.36	10.17	0.42	0.34	0.24
14	47.52	43.92	13.0	38.53	20.47	17.71	8.99	0.43	0.37	0.19
15	39.48	42.23	13.7	32.67	17.47	14.96	6.81	0.44	0.38	0.17
16	43.46	43.03	13.0	35.03	18.48	16.27	8.43	0.43	0.37	0.19
17	40.43	40.60	12.2	33.27	17.57	15.19	7.16	0.43	0.38	0.18
18	40.58	42.20	12.9	33.20	18.85	13.92	7.38	0.46	0.34	0.18
19	42.75	41.36	10.8	34.73	17.99	16.64	8.02	0.42	0.39	0.19
20	35.95	38.69	12.5	28.02	15.22	12.72	7.93	0.42	0.35	0.22
Total	837.17	839.56	253.4	670.68	354.43	311.34	166.5	8.46	7.42	3.97
Average	41.86	41.98	12.67	33.53	17.72	15.57	8.32	0.42	0.37	0.20

Titration Result (ml): 18.92

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 18.92/20 *0.1562/0.1562
= 0.95

%=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 794.33-670.68 *100/794.33
= 15.56

Ratio = TSS/Acid %
= 12.6/0.95
= 13.2:1

Table 15.3: Fruit qualities of selection Swarula, tree no: 3.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	45.44	46.08	11.5	35.79	18.72	16.79	9.76	0.41	0.37	0.21
2	44.18	41.83	13.4	35.76	18.05	17.22	8.42	0.42	0.39	0.19
3	54.25	46.54	12.7	44.23	23.37	20.41	10.02	0.43	0.37	0.18
4	44.3	45.51	12.6	34.68	17.55	16.78	9.62	0.40	0.38	0.22
5	48.33	46.08	12.9	37.79	20.01	17.57	10.54	0.41	0.36	0.22
6	45.74	42.4	13.2	35.34	19.41	15.71	10.40	0.42	0.34	0.23
7	57.87	46.68	11.9	48.17	24.58	23.21	9.70	0.43	0.40	0.17
8	51.40	48.94	11.9	41.13	20.99	19.88	10.27	0.42	0.38	0.20
9	54.38	48.07	10.9	43.26	23.82	19.18	11.12	0.44	0.35	0.20
10	56.58	46.39	13.3	45.15	23.9	20.78	11.43	0.42	0.37	0.20
11	43.64	43.52	12.9	35.24	20.05	14.66	8.40	0.45	0.34	0.19
12	48.05	48.62	12.8	40.83	21.88	18.87	7.22	0.45	0.39	0.15
13	53.84	49.71	12.2	41.21	23.12	18.05	12.63	0.43	0.34	0.23
14	43.62	43.28	13.1	34.07	18.15	15.82	9.55	0.42	0.36	0.22
15	48.72	47.81	12.4	39.01	20.56	18.19	9.71	0.42	0.37	0.20
16	45.71	44.9	12.8	35.73	18.97	16.57	9.98	0.42	0.36	0.22
17	54.70	45.88	13.9	43.72	23.21	20.21	10.98	0.42	0.37	0.20
18	43.18	45.13	12.8	34.89	17.52	17.07	8.29	0.41	0.40	0.19
19	43.48	42.29	12.0	34.42	19.31	14.81	9.06	0.44	0.34	0.21
20	40.78	40.80	13.9	32.4	17.34	14.72	8.38	0.43	0.36	0.21
Total	968.19	910.46	253.1	772.82	410.51	356.5	195.5	8.49	7.34	4.04
Average	48.40	45.52	12.6	38.64	20.52	17.82	9.77	0.42	0.37	0.20

Titration Result (ml): 15.13

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 15.13/20 *0.1562/0.l562
= 0.75

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 968.19-772.82 *100/968.19
= 20.17

Ratio = TSS/Acid%
= 12.6/0.75
= 16.8:1

Table 15.4: Fruit qualities of selection Swarula, tree no: 4.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	47.35	43.99	13.0	39.46	20.65	18.59	7.71	0.45	0.39	0.16
2	41.31	42.07	13.9	33.17	17.33	15.64	8.14	0.42	0.38	0.20
3	47.73	44.73	12.6	40.22	21.00	18.99	7.51	0.44	0.40	0.16
4	39.44	42.88	13.9	32.61	17.48	14.93	6.83	0.44	0.38	0.17
5	47.21	45.01	12.4	37.49	19.99	17.33	9.72	0.42	0.37	0.21
6	47.15	42.96	12.2	37.77	20.09	17.55	9.38	0.43	0.37	0.20
7	42.20	42.90	12.7	33.03	16.74	16.14	9.17	0.40	0.38	0.19
8	42.91	42.07	12.6	33.36	17.83	15.34	9.55	0.42	0.36	0.22
9	38.40	40.15	14.0	29.25	15.74	13.41	9.15	0.41	0.35	0.24
10	51.78	47.50	12.0	41.36	22.77	18.39	10.42	0.44	0.36	0.20
11	41.60	43.67	12.9	33.53	16.55	16.87	8.07	0.40	0.41	0.19
12	50.01	47.68	12.0	39.22	20.98	18.03	10.79	0.42	0.36	0.22
13	39.69	41.02	13.0	32.63	17.72	14.87	7.06	0.45	0.37	0.18
14	36.57	40.18	12.6	28.25	14.65	13.58	8.32	0.40	0.37	0.23
15	41.10	41.04	12.0	33.49	17.58	15.70	7.61	0.43	0.38	0.19
16	40.02	41.10	12.6	32.34	17.31	15.27	7.68	0.43	0.38	0.19
17	47.49	42.71	12.5	38.96	20.49	18.24	8.53	0.43	0.38	0.18
18	40.99	41.61	13.7	32.01	17.13	14.83	8.98	0.42	0.36	0.22
19	39.72	41.06	12.7	31.86	16.04	15.70	7.86	0.40	0.40	0.20
20	42.97	44.58	12.4	34.30	18.26	15.87	8.67	0.42	0.37	0.20
Total	865.64	858.91	255.7	704.31	375.33	325.27	171.2	8.47	7.52	3.95
Average	43.28	42.94	12.7	35.21	18.76	16.26	8.55	0.42	0.38	0.19

Titration Result (ml): 19.45

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 19.45/20 *0.1562/0.1562
= 0.97

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 865.64-704.31* 100/865.64
= 18.63

Ratio = TSS/Acid%
= 12.7/0.97
= 13:1

Table 15.5: Fruit qualities of selection Swarula, tree no: 5.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	42.83	43.48	12.7	34.00	18.27	15.45	8.83	0.43	0.36	0.21
2	46.55	44.16	12.7	36.70	19.35	17.11	9.85	0.42	0.37	0.21
3	46.65	44.21	11.7	36.35	19.36	16.9	10.3	0.42	0.36	0.22
4	45.68	44.21	12.6	35.71	18.63	16.74	9.97	0.41	0.36	0.22
5	40.23	42.97	12.6	32.13	16.65	15.37	8.10	0.41	0.38	0.20
6	49.60	44.95	12.0	38.32	19.94	18.21	11.28	0.40	0.37	0.23
7	39.30	43.57	13.0	31.80	16.46	15.09	7.50	0.42	0.38	0.19
8	43.85	43.13	12.0	35.19	18.37	16.68	8.66	0.42	0.38	0.20
9	43.07	42.93	11.9	33.63	16.5	16.92	9.44	0.38	0.39	0.22
10	47.08	43.29	12.7	37.72	19.46	17.98	9.36	0.41	0.38	0.20
11	49.55	45.19	11.6	38.88	20.82	17.87	10.67	0.42	0.36	0.22
12	37.02	40.98	13.1	30.63	15.71	14.64	6.39	0.42	0.40	0.17
13	37.20	39.14	12.0	29.02	14.94	13.99	8.18	0.40	0.37	0.22
14	41.27	40.99	12.3	33.8	16.62	16.75	7.47	0.40	0.41	0.18
15	40.52	40.80	11.7	30.94	16.73	14.05	9.58	0.41	0.35	0.24
16	40.28	42.62	12.0	32.26	16.81	15.43	8.02	0.42	0.38	0.19
17	38.96	41.72	12.4	30.64	16.08	15.47	8.32	0.41	0.39	0.21
18	43.23	44.26	12.0	33.45	17.67	15.72	9.78	0.41	0.36	0.23
19	35.18	41.05	12.6	26.72	14.45	12.16	8.46	0.41	0.35	0.24
20	36.16	40.82	12.7	28.54	14.45	14.07	7.62	0.40	0.39	0.21
Total	844.21	854.47	246.3	666.43	347.27	316.6	177.8	8.22	7.49	4.21
Average	42.21	42.72	12.3	33.32	17.36	15.83	8.88	0.41	0.37	0.21

Titration Result (ml): 17.16

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 17.16/20 *0.1562/0.1562
= 0.85

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 844.21-666.43 *100/844.21
= 21.05

Ratio = TSS/Acid%
= 12.3/0.85
= 14.4:1

Table 16.1: Fruit qualities of selection Toularula, tree no:1.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	66.15	50.11	12.2	49.20	19.02	29.87	16.95	0.29	0.45	0.26
2	46.76	43.94	14.3	34.67	15.09	19.32	12.09	0.32	0.41	0.26
3	49.11	44.83	13.7	37.29	16.03	20.88	11.82	0.33	0.43	0.24
4	51.97	44.58	14.7	39.7	15.79	23.56	12.27	0.30	0.45	0.23
5	53.24	46.00	12.7	41.02	16.48	24.86	12.22	0.31	0.46	0.23
6	58.81	47.34	13.7	45.08	17.63	26.94	13.73	0.29	0.46	0.23
7	57.40	45.15	12.7	41.21	17.36	23.66	16.19	0.30	0.41	0.28
8	56.73	45.61	13.2	42.03	17.02	24.75	14.70	0.30	0.44	0.26
9	49.43	42.71	13.7	38.23	16.63	21.44	11.20	0.34	0.44	0.23
10	52.82	44.32	11.9	42.18	18.01	23.75	10.64	0.34	0.45	0.20
11	57.59	46.80	12.2	42.47	16.79	25.58	15.12	0.29	0.44	0.26
12	63.58	50.25	14.9	48.87	19.41	29.40	14.71	0.31	0.46	0.23
13	48.43	42.68	12.1	35.09	15.81	19.20	13.34	0.33	0.40	0.27
14	62.50	48.28	12.4	48.21	19.35	28.62	14.29	0.31	0.46	0.23
15	55.77	44.80	12.8	40.84	17.15	23.60	14.93	0.31	0.42	0.27
16	49.07	44.05	12.7	36.48	15.26	21.04	12.59	0.31	0.43	0.26
17	52.54	45.02	14.1	40.80	16.66	23.56	11.74	0.32	0.45	0.22
18	49.58	44.54	12.5	35.72	15.06	20.67	13.86	0.30	0.42	0.28
19	56.84	46.85	14.6	45.47	18.88	26.48	11.37	0.33	0.46	0.20
20	53.91	44.16	13.2	39.60	17.11	22.84	14.31	0.32	0.42	0.26
Total	1092.23	872.02	264.3	824.16	340.54	480.02	268.1	6.25	8.76	4.90
Average	54.61	43.60	13.2	41.20	17.02	24.00	13.40	0.31	0.44	0.24

Titration Result (ml): 34.76

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 34.76/20 *0.1562/0.1562
= 1.73

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 1092.23-824.16 *100/1092.23
= 24.54

Ratio = TSS/Acid%
= 13.2/1.73
= 7.6:1

Table 16.2: Fruit qualities of selection Toularula, tree no:2.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	50.83	45.57	14.2	40.11	16.12	23.84	10.72	0.32	0.47	0.21
2	59.43	45.59	13.2	49.57	18.07	31.27	9.86	0.30	0.53	0.16
3	53.09	45.28	13.8	38.98	16.02	22.76	14.11	0.30	0.43	0.27
4	57.00	45.47	12.7	44.70	17.14	22.39	12.30	0.30	0.39	0.22
5	55.73	45.76	14.1	45.40	17.17	28.05	10.33	0.31	0.50	0.19
6	54.72	44.17	13.2	42.05	16.19	25.56	12.67	0.30	0.47	0.23
7	53.20	44.62	14.9	39.70	15.86	23.71	13.50	0.30	0.45	0.25
8	48.39	44.25	13.0	36.96	15.34	21.28	11.43	0.32	0.44	0.24
9	57.84	45.8	12.7	42.98	17.08	25.78	14.86	0.29	0.45	0.26
10	56.72	45.87	12.6	42.61	16.65	25.98	14.11	0.29	0.46	0.25
11	52.13	45.05	12.5	38.15	15.72	22.25	13.98	0.30	0.43	0.27
12	42.53	43.03	14.1	29.46	12.40	17.01	13.07	0.29	0.40	0.31
13	48.52	44.81	13.8	37.07	16.06	20.92	11.45	0.33	0.43	0.24
14	47.90	42.41	13.0	37.02	15.23	21.74	10.88	0.32	0.45	0.23
15	48.13	42.69	14.1	35.02	13.83	21.02	13.11	0.29	0.44	0.27
16	48.99	44.56	13.2	38.49	15.67	22.6	10.50	0.32	0.46	0.21
17	58.66	46.81	13.8	44.86	17.91	26.54	13.80	0.31	0.45	0.24
18	52.85	45.48	13.8	39.08	16.31	22.58	13.77	0.31	0.43	0.26
19	51.72	44.36	13.1	39.75	16.12	23.45	11.97	0.31	0.45	0.23
20	57.10	46.42	12.6	42.45	17.49	24.78	14.65	0.31	0.43	0.26
Total	1055.48	898	268.4	804.41	322.38	473.51	251.1	6.12	8.96	4.80
Average	52.77	44.9	13.4	40.22	16.11	23.67	12.55	0.31	0.45	0.24

Titration Result (ml): 46.88

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 46.88/20 *0.1562/0.1562
= 2.34

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 1055.48-804.41 *100/1055.48
= 23.78

Ratio = TSS/Acid%
= 13.2/2.34
= 5.7:1

Table 16.3: Fruit qualities of selection Toularula, tree no:3.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	45.32	44.53	12.0	34.30	17.73	16.42	11.02	0.39	0.36	0.24
2	44.08	43,89	12.3	34.93	17.64	17.03	9.15	0.40	0.39	0.21
3	44.11	43.77	13.0	35.23	18.72	16.14	8.80	0.42	0.37	0.20
4	46.20	44.27	11.1	36.74	20.07	16.37	9.46	0.43	0.35	0.20
5	48.47	44.26	11.5	39.68	20.42	19.12	8.79	0.42	0.40	0.18
6	43.46	45.04	12.8	33.95	17.78	16.07	9.15	0.41	0.37	0.22
7	42.76	44.49	13.3	33.40	17.60	15.53	9.36	0.41	0.36	0.22
8	47.89	48.46	12.8	36.44	19.53	16.81	11.45	0.41	0.35	0.24
9	43.14	42.82	13.4	33.78	17.62	16.03	9.36	0.41	0.37	0.22
10	42.92	45.03	12.1	35.18	19.84	15.08	7.74	0.46	0.35	0.18
11	44.75	41.27	12.2	36.25	19.42	16.62	8.50	0.43	0.37	0.19
12	44.22	44.81	13.1	35.53	18.99	16.37	8.69	0.43	0.37	0.20
13	39.37	43.14	14.1	30.06	16.62	13.35	9.31	0.42	0.34	0.24
14	39.20	42.95	13.1	30.40	16.37	13.85	8.80	0.42	0.35	0.23
15	39.68	40.65	14.0	31.01	16.31	14.60	8.67	0.41	0.37	0.22
16	42.04	43.08	13.0	32.70	17.40	15.09	9.34	0.41	0.36	0.22
17	38.00	42.22	13.6	29.59	15.79	13.54	8.41	0.42	0.36	0.22
18	45.57	43.85	12.7	36.69	19.53	16.87	8.88	0.43	0.37	0.20
19	44.43	45.56	13.1	34.80	18.52	16.19	9.63	0.42	0.36	0.22
20	44.97	41.30	12.1	35.57	17.67	17.75	9.40	0.39	0.40	0.21
Total	870.58	875.39	255.3	686.23	363.57	318.83	183.9	8.34	7.32	4.26
Average	43.52	43.76	12.7	34.31	18.17	15.94	9.19	0.42	0.37	0.21

Titration Result (ml): 17.46

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 17.46/20 *0.1562/0.1562
= 0.87

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 870.58- 686.23 *100/870.58
= 21.17

Ratio = TSS/Acid%
= 12.7/0.87
= 14.5:1

Table 16.4: Fruit qualities of selection Toularula, tree no:4.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	40.87	43.85	12.4	31.83	18.19	13.42	9.04	0.45	0.33	0.22
2	38.47	42.04	12.7	29.42	17.29	11.97	9.05	0.45	0.31	0.24
3	38.82	43.58	12.7	32.27	18.10	13.89	6.55	0.47	0.36	0.17
4	43.39	45.97	13.7	34.53	18.83	15.54	8.86	0.43	0.36	0.20
5	43.71	42.27	13.3	34.88	19.32	15.36	8.35	0.45	0.35	0.19
6	43.23	42.88	12.4	34.95	19.58	15.20	8.20	0.45	0.36	0.19
7	43.74	42.87	13.1	34.91	19.60	15.20	8.67	0.45	0.34	0.24
8	43.58	43.68	12.4	34.38	18.97	15.13	9.20	0.44	0.35	0.21
9	44.27	44.10	13.0	34.91	19.27	15.54	9.36	0.44	0.35	0.21
10	37.61	40.34	13.2	29.88	17.56	12.27	7.73	0.47	0.33	0.21
11	42.03	42.70	12.4	32.91	18.35	14.30	9.12	0.44	0.34	0.27
12	37.50	42.99	14.0	29.35	17.14	11.97	8.15	0.46	0.32	0.22
13	35.89	39.73	13.3	28.28	16.19	11.92	7.61	0.45	0.33	0.21
14	41.92	42.57	12.9	34.79	19.11	15.47	7.13	0.46	0.37	0.17
15	40.44	43.48	12.0	32.56	18.37	18.37	7.88	0.45	0.35	0.20
16	44.06	43.70	12.2	35.10	20.14	14.82	8.96	0.46	0.34	0.20
17	36.71	39.11	13.4	29.61	16.69	12.58	7.17	0.45	0.34	0.20
18	39.78	40.08	12.6	30.64	16.98	13.48	9.14	0.43	0.34	0.23
19	41.07	43.61	13.1	33.28	18.35	14.80	7.79	0.45	0.36	0.19
20	41.17	40.44	12.6	32.94	18.11	14.63	8.23	0.44	0.36	0.20
Total	818.3	849.99	257.4	651.42	366.1	285.43	166.2	8.99	6.89	4.17
Average	40.91	42.49	12.8	32.57	18.30	14.27	8.31	0.45	0.34	0.20

Titration Result (ml): 16.19

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 16.19/20 * 0.1562/0.1562
= 0.80

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 818.30-651.42 *100/818.30
= 20.39

Ratio = TSS/Acid%
= 12.8/0.80
= 16:1

Table 16.5: Fruit qualities of selection Toularula, tree no:5.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	36.80	43.37	12.2	29.95	15.04	14.69	6.85	0.41	0.40	0.19
2	45.47	42.50	12.9	38.21	18.39	19.68	7.26	0.40	0.43	0.16
3	46.03	42.90	12.6	37.50	18.91	18.43	8.53	0.41	0.40	0.19
4	46.57	45.56	12.1	37.39	19.02	17.82	9.18	0.41	0.39	0.20
5	39.70	40.64	12.6	34.01	16.97	16.41	5.69	0.43	0.41	0.14
6	41.35	41.48	13.0	34.23	17.20	16.94	7.12	0.42	0.41	0.17
7	41.19	40.66	12.8	32.92	17.70	15.08	8.27	0.43	0.37	0.20
8	36.02	41.65	15.4	31.64	16.21	15.12	4.38	0.45	0.42	0.12
9	41.24	42.66	14.2	33.11	17.04	15.61	8.13	0.41	0.38	0.20
10	47.38	46.59	12.6	39.51	20.37	18.92	7.87	0.43	0.40	0.17
11	35.26	40.11	14.0	28.94	14.60	14.28	6.32	0.41	0.41	0.18
12	45.67	43.10	12.1	36.65	18.10	18.39	9.02	0.40	0.40	0.20
13	45.70	43.80	12.1	35.57	18.38	16.95	10.13	0.40	0.37	0.22
14	40.25	41.39	13.0	31.44	15.95	15.31	8.81	0.41	0.38	0.22
15	40.01	42.44	13.1	32.31	16.60	15.62	7.70	0.42	0.39	0.19
16	43.10	40.68	13.2	32.93	17.62	15.24	10.17	0.41	0.35	0.24
17	38.28	42.07	12.5	29.32	15.48	13.79	8.96	0.40	0.36	0.23
18	42.50	44.50	13.4	32.65	17.89	14.60	9.85	0.42	0.34	0.23
19	38.05	39.50	14.1	31.92	16.32	15.54	6.13	0.43	0.41	0.16
20	41.28	44.92	13.1	32.33	16.52	15.65	8.95	0.40	0.38	0.22
Total	831.85	850.52	261	672.53	513.31	324.07	159.3	8.3	7.8	3.83
Average	41.59	42.52	13.0	33.62	25.66	16.20	7.96	0.42	0.39	0.19

Titration Result (ml): 21.57

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 21.57/20 *0.1562/0.1562
= 1.07

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 831.85-672.53 *100/813.85
= 17.36

Ratio = TSS/Acid%
= 13.0/1.07
= 12.1:1

Table 17.1: Fruit qualities of selection Pharulani, tree no: 1.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	36.14	38.41	14.7	27.97	12.07	14.89	8.17	0.33	0.41	0.23
2	37.63	40.56	13.0	26.49	12.05	14.31	11.14	0.32	0.38	0.30
3	47.14	43.48	12.4	37.04	15.69	21.18	10.10	0.33	0.45	0.21
4	36.00	38.04	15.6	28.44	12.52	15.71	7.56	0.35	0.44	0.21
5	41.70	40.42	13.3	31.09	13.18	17.69	10.61	0.32	0.42	0.25
6	39.70	40.22	13.0	29.50	12.89	16.33	10.20	0.32	0.41	0.26
7	40.04	41.19	14.0	29.70	13.44	16.33	10.34	0.34	0.41	0.26
8	41.14	39.69	12.8	29.85	13.49	16.21	11.29	0.33	0.39	0.27
9	38.60	41.66	14.7	27.97	13.04	14.51	10.63	0.34	0.38	0.28
10	39.31	39.62	13.8	27.85	12.66	14.99	11.46	0.32	0.38	0.29
11	39.55	39.79	12.3	28.05	12.37	15.45	11.50	0.31	0.39	0.29
12	39.43	40.69	14.1	32.14	13.56	17.90	7.29	0.34	0.45	0.19
13	47.93	41.79	12.7	36.26	15.48	20.62	11.67	0.32	0.43	0.24
14	38.87	39.11	13.7	27.50	13.07	14.44	11.37	0.34	0.37	0.29
15	40.73	40.55	12.8	29.37	12.73	16.48	11.12	0.31	0.41	0.27
16	40.49	39.27	14.8	30.38	13.49	16.66	10.11	0.33	0.41	0.25
17	41.83	41.29	13.2	29.95	13.50	16.29	11.88	0.32	0.39	0.28
18	41.14	40.64	11.7	28.77	13.62	14.98	12.37	0.33	0.36	0.30
19	49.59	43.42	12.1	37.94	15.52	22.24	11.65	0.31	0.45	0.23
20	40.57	39.56	12.4	31.49	13.36	17.83	9.08	0.33	0.44	0.22
Total	817.53	809.4	267.1	607.75	267.73	335.04	209.5	6.54	8.17	5.12
Average	40.87	40.47	13.3	30.38	13.38	16.75	10.48	0.33	0.41	0.25

Titration Result (ml): 30.02

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 30.02/20 0.1562/0.1562
= 1.50

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 817.53-607.75 *100/817.53
= 25.66

Ratio = TSS/Acid%
= 13.3/1.50
= 8.8:1

Table 17.2: Fruit qualities of selection Pharulani, tree no: 2.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	56.33	47.20	14.6	40.71	15.39	25.16	15.62	0.27	0.45	0.28
2	58.57	47.40	12.2	41.46	16.06	25.32	17.11	0.27	0.43	0.29
3	50.02	44.60	11.7	35.94	14.54	21.26	12.62	0.29	0.42	0.25
4	48.56	44.11	11.4	34.69	13.74	20.65	13.87	0.28	0.43	0.29
5	57.35	45.23	12.3	40.35	15.60	24.56	17.00	0.27	0.43	0.30
6	46.44	43.13	13.1	35.98	14.12	21.50	10.46	0.30	0.46	0.23
7	50.22	43.93	12.8	37.85	14.79	22.79	12.37	0.29	0.45	0.25
8	57.00	45.37	12.2	41.72	16.70	25.05	15.28	0.29	0.44	0.27
9	45.15	41.93	14.5	35.08	14.70	20.32	10.07	0.33	0.45	0.22
10	49.81	44.47	13.6	38.73	16.28	22.25	11.08	0.33	0.45	0.22
11	47.64	44.57	16.1	35.05	13.92	21.02	12.59	0.29	0.44	0.26
12	53.22	45.81	12.8	39.33	14.99	23.95	13.89	0.28	0.45	0.26
13	44.50	44.47	12.7	40.56	15.36	24.92	3.94	0.34	0.56	0.10
14	52.07	43.68	15.0	39.40	15.28	23.27	12.67	0.29	0.45	0.24
15	51.64	43.75	12.8	38.24	15.71	22.47	13.40	0.30	0.44	0.26
16	44.30	42.13	13.9	33.37	12.53	20.75	10.93	0.28	0.47	0.25
17	53.81	46.14	13.0	41.48	15.56	25.73	12.33	0.29	0.48	0.23
18	52.81	45.33	13.1	39.52	15.60	23.80	13.29	0.29	0.45	0.25
19	62.41	47.79	12.2	45.30	17.22	27.95	17.11	0.28	0.45	0.27
20	44.78	42.67	12.0	33.43	14.19	19.02	11.35	0.32	0.42	0.25
Total	1026.63	893.71	262	768.19	302.28	461.74	257	5.88	9.02	4.97
Average	51.33	44.68	13.1	38.40	15.11	23.08	12.85	0.29	0.45	0.24

Titration Result (ml): 37.32

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 37.32/20 *0.1562/0.1562
= 1.86

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 1026.63-768.19 *100/1026.63
= 25.17
Ratio = TSS/Acid%
= 13.1/1.86
= 7:1

Table 17.3: Fruit qualities of selection Pharulani, tree no: 3.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	46.53	43.03	11.7	36.36	14.94	21.17	10.17	0.32	0.45	0.22
2	41.44	40.56	14.7	34.72	14.34	20.09	6.72	0.35	0.48	0.16
3	48.07	43.39	13.8	35.97	14.77	21.09	12.10	0.31	0.44	0.25
4	40.27	41.19	14.7	31.88	13.86	17.93	8.39	0.34	0.45	0.21
5	41.05	40.74	12.8	30.48	13.02	17.39	10.57	0.32	0.42	0.26
6	47.45	44.40	15.0	37.15	14.68	22.43	10.30	0.31	0.47	0.22
7	54.19	46.26	12.0	41.06	15.92	25.02	13.13	0.29	0.46	0.24
8	38.00	40.87	11.7	29.92	13.66	16.21	8.08	0.36	0.43	0.21
9	44.00	42.58	12.9	36.69	14.49	22.06	7.31	0.33	0.50	0.17
10	46.97	42.72	16.8	37.37	15.74	21.36	7.60	0.35	0.45	0.20
11	56.04	45.79	13.2	43.38	17.97	25.32	12.66	0.32	0.45	0.23
12	48.42	46.13	14.7	37.14	14.54	22.41	11.28	0.30	0.46	0.23
13	50.83	44.22	12.5	39.48	16.31	22.97	11.35	0.32	0.45	0.22
14	46.18	43.49	14.8	35.54	14.50	20.85	10.64	0.31	0.45	0.23
15	48.57	44.59	14.0	37.68	15.33	22.12	10.89	0.32	0.46	0.22
16	51.15	43.69	13.4	39.59	15.42	23.90	11.47	0.30	0.47	0.22
17	47.65	44.11	15.3	37.58	15.07	22.18	10.07	0.32	0.47	0.21
18	45.36	41.26	14.6	33.68	14.57	19.02	11.68	0.32	0.42	0.26
19	40.84	39.55	15.3	32.71	13.35	19.16	8.13	0.33	0.47	0.20
20	43.25	40.97	14.3	32.93	14.13	18.67	10.32	0.33	0.43	0.24
Total	926.26	859.54	278.2	721.31	296.61	421.35	202.9	6.45	9.08	4.4
Average	46.31	42.97	13.9	36.06	14.83	21.06	10.14	0.32	0.45	0.22

Titration Result (ml): 48.86

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 48.86/20 *0.1562/0.1562
= 2.44

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 926.26-721.31 *100/926.26
= 22.12

Ratio = TSS/Acid%
= 13.9/2.44

= 5.9:1

Table 17.4: Fruit qualities of selection Pharulani, tree no: 4.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	49.37	42.82	14.5	36.40	15.00	21.12	12.97	0.30	0.43	0.26
2	51.31	43.93	13.3	38.54	15.29	23.13	12.77	0.30	0.45	0.25
3	48.15	43.78	13.9	36.95	14.68	22.21	11.20	0.31	0.46	0.23
4	47.22	41.16	13.6	35.55	14.69	20.69	11.67	0.31	0.44	0.25
5	55.39	46.83	13.9	44.04	17.78	25.99	11.35	0.32	0.47	0.21
6	46.87	43.14	12.8	35.92	15.03	20.74	10.95	0.32	0.44	0.23
7	49.19	43.70	13.1	38.04	15.48	22.21	11.15	0.32	0.45	0.23
8	61.53	47.51	13.1	46.04	19.50	26.50	15.49	0.32	0.43	0.25
9	61.92	50.66	14.5	50.00	19.90	29.84	11.92	0.32	0.48	0.19
10	46.92	43.32	14.4	36.63	14.91	21.51	10.29	0.32	0.46	0.22
11	43.03	42.00	14.2	33.15	13.88	19.05	9.88	0.32	0.44	0.23
12	47.50	42.74	13.8	36.81	14.94	21.62	10.69	0.32	0.46	0.22
13	51.11	42.88	12.5	38.27	16.27	22.01	12.84	0.32	0.43	0.25
14	48.71	43.88	13.1	35.93	15.33	20.58	12.78	0.32	0.42	0.26
15	58.98	46.44	14.4	46.53	18.79	27.55	12.45	0.32	0.47	0.21
16	54.40	44.77	14.4	43.10	17.44	25.52	11.3	0.32	0.47	0.21
17	43.05	40.84	14.7	36.27	14.63	21.47	6.78	0.34	0.50	0.16
18	47.71	42.41	14.0	37.05	15.69	21.07	10.66	0.33	0.44	0.23
19	52.02	43.68	13.3	40.13	16.98	23.07	11.92	0.33	0.44	0.23
20	39.44	39.31	14.9	31.38	13.77	17.69	8.06	0.35	0.45	0.20
Total	1004	875.8	276.4	766.73	319.98	453.57	227.1	6.41	9.03	4.52
Average	50.19	43.79	13.8	38.34	16.00	22.68	22.68	11.36	0.32	0.45

Titration Result (ml): 44.20

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 44.20/20 *0.1562/0.1562
= 2.21

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 1004-766.73 *100/1004
= 23.63

Ratio = TSS/Acid%
= 13.8/2.21
= 6.2:1

Table 17.5: Fruit qualities of selection Pharulani, tree no: 5.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	44.23	42.46	12.1	30.95	13.7	17.17	13.28	0.31	0.39	0.30
2	50.49	45.47	12.0	35.26	14.69	20.44	15.23	0.29	0.40	0.30
3	44.39	43.27	12.4	31.96	13.64	18.09	12.43	0.31	0.41	0.28
4	44.78	43.10	13.1	31.60	13.25	18.15	13.18	0.30	0.41	0.29
5	45.12	42.62	14.7	33.15	12.97	19.89	11.97	0.29	0.44	0.27
6	47.01	43.67	14.7	35.92	13.92	22.22	11.09	0.29	0.47	0.24
7	51.25	43.40	15.5	38.64	16.45	22.09	12.61	0.32	0.43	0.25
8	46.87	42.79	12.8	33.34	13.79	19.35	13.53	0.29	0.41	0.29
9	48.64	42.50	12.8	34.38	14.76	19.53	14.26	0.30	0.40	0.29
10	47.05	43.65	14.5	34.48	14.40	20.04	12.57	0.31	0.42	0.27
11	45.79	44.10	12.6	32.21	13.77	18.32	13.58	0.30	0.40	0.30
12	54.97	45.48	14.4	40.04	16.47	23.45	14.93	0.30	0.43	0.27
13	42.39	43.94	14.6	32.41	14.25	17.98	9.98	0.34	0.42	0.24
14	49.04	42.73	11.8	35.90	15.81	19.98	13.14	0.32	0.41	0.27
15	43.81	42.45	15.5	35.54	14.97	20.31	8.27	0.34	0.46	0.19
16	43.77	43.44	14.6	31.97	13.36	18.17	11.8	0.31	0.42	0.27
17	43.08	42.53	14.5	31.52	13.76	17.63	11.56	0.32	0.41	0.27
18	46.24	43.39	12.6	32.72	13.97	18.64	13.52	0.30	0.40	0.29
19	38.81	40.00	13.4	30.98	13.59	17.20	7.83	0.35	0.44	0.20
20	44.64	40.88	14.4	31.90	13.61	18.25	12.74	0.31	0.41	0.28
Total	922.4	861.87	273	674.87	284.84	386.9	247.5	6.2	8.38	5.36
Average	46.11	43.09	13.6	33.74	14.24	19.34	12.38	0.31	0.42	0.26

Titration Result (ml): 31.78

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 31.78/20 *0.1562/0.1562
= 1.58

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 922.40 – 674.87 *100/922.40
= 26.83

Ratio = TSS/Acid%
= 13.6/1.58
= 8.6:1

Raw data of analyses done on the five marula selections during 2005.

Table 18.1: Fruit qualities of selection Wild marula, tree no: 1.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	38.44	41.17	12.2	28.73	10.24	18	9.71	0.27	0.47	0.25
2	35.61	41.8	11.8	25.72	10.27	14.97	9.89	0.29	0.42	0.28
3	28.85	38.18	11.9	20.7	8.04	12.39	8.15	0.28	0.43	0.28
4	32.98	42.07	12.3	24.05	9.65	14.08	8.93	0.29	0.43	0.27
5	34.77	40.01	12.6	27.48	11.37	15.57	7.29	0.33	0.45	0.21
6	36.99	43.92	12.9	28.38	10.94	17.15	8.61	0.3	0.46	0.23
7	35.04	39.48	10.4	26.15	10.77	14.97	8.89	0.31	0.43	0.25
8	36.87	40.75	11.3	27.66	10.6	16.67	9.21	0.29	0.45	0.25
9	31.85	38.54	12	24.47	10.28	13.83	7.38	0.32	0.43	0.23
10	30.45	38.52	12.3	21.04	8.67	12.07	9.41	0.29	0.4	0.31
11	39.38	41.7	11.5	27.74	11.37	16.25	11.64	0.29	0.41	0.3
12	30.57	40.13	12.1	22.39	9.12	13.01	8.18	0.32	0.43	0.27
13	33.16	41.22	12.7	24.16	9.38	14.41	9	0.28	0.43	0.27
14	31.77	38.1	11.7	22.91	9	13.56	8.86	0.28	0.43	0.28
15	29.85	40.33	12.9	22.5	8.66	13.51	7.35	0.29	0.45	0.25
16	27.94	37.48	12.1	19.55	7.8	11.47	8.39	0.28	0.41	0.3
17	33.4	37.95	12.1	24.62	9.84	14.56	8.78	0.3	0.44	0.26
18	34.2	41.45	12.7	24.66	10.49	13.8	9.54	0.31	0.4	0.28
19	32.85	40.9	12.5	24.39	9.993	14.1	8.46	0.3	0.43	0.26
20	33.97	40.32	12.4	25.59	9.91	15.26	8.38	0.29	0.45	0.25
Total	668.94	804.02	242.4	492.89	196.393	289.63	176.05	5.91	8.65	5.28
Average	33.447	40.201	12.12	24.6445	9.81965	14.4815	8.8025	0.2955	0.4325	0.264

Titration Result (ml): 8.68

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 8.68/20 *0.1562/0.1562
= 0.43

Juice %= Fruit weight -Peel and Seed weight * 100/Fruit weight
= 668.94-492.89/668.94*100
= 26.31

Ratio = TSS/Acid %
=12.12/0.43
= 28.1:1

Table 18.2: Fruit qualities of selection Wild marula, tree no: 2.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	32.69	40	11.1	27.14	11.91	15.21	5.55	0.36	0.47	0.17
2	24.72	37.08	11.3	18.67	9.27	9.46	6.05	0.38	0.38	0.24
3	23.65	36.44	10.4	19.01	9.39	9.6	4.64	0.4	0.4	0.2
4	28.52	39.1	12	21.56	9.08	12.43	6.96	0.32	0.44	0.24
5	25.67	37.16	12.8	19.85	9.46	10.34	5.85	0.37	0.4	0.23
6	27.59	38.27	13	20.33	9.08	11.2	7.26	0.33	0.41	0.26
7	21.17	34.41	10.8	16.23	7.85	8.34	4.94	0.37	0.39	0.23
8	26.25	36.39	12.3	19.54	8.48	11.03	6.71	0.32	0.42	0.26
9	23.58	36.64	11.4	18.44	8.57	9.86	5.14	0.36	0.42	0.22
10	33.5	39.84	12	26.33	11.55	14.72	7.17	0.35	0.44	0.21
11	29.18	39.07	12.2	22.03	9.55	12.4	7.15	0.33	0.42	0.25
12	25.27	37.65	13	19.62	8.49	11.12	5.65	0.34	0.44	0.22
13	25.25	36.76	12.5	20	9.54	10.4	5.25	0.38	0.41	0.21
14	29.63	39.07	12.4	22.15	9.96	12.14	7.48	0.34	0.41	0.25
15	28.26	36.88	12.8	20.66	8.8	11.82	7.6	0.31	0.42	0.27
16	32.36	39.44	14	23.36	9.9	13.43	9	0.31	0.42	0.28
17	26.69	37.44	12.5	20.67	9.02	11.64	6.02	0.34	0.33	0.23
18	25.31	37.57	11.3	19.05	9.74	9.25	6.25	0.38	0.37	0.25
19	25.37	38.74	11.6	20.27	9.76	10.46	5.1	0.39	0.41	0.2
20	29.01	39.32	12.5	21.89	9.23	12.63	7.12	0.32	0.44	0.24
Total	543.67	757.27	241.9	416.8	188.63	227.48	126.89	7	8.24	4.66
Average	27.1835	37.8635	12.095	20.84	9.4315	11.374	6.3445	0.35	0.412	0.233

Titration Result (ml): 11.94

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
=14.81/20 *0.1562/0.1562
= 0.74

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
=651.6-491.57*100/651.6
=24.55

Ratio = TSS/Acid%
= 13.9/0.74
=18.8:1

Table18.3: Fruit qualities of selection Wild marula, tree no: 3.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	23.76	37	15.8	18.63	8.15	10.4	5.13	0.34	0.44	0.22
2	21.37	35.27	10	16.18	7.12	9.02	5.19	0.33	0.42	0.24
3	24.41	34.6	14.9	19.09	8.31	10.72	5.32	0.34	0.44	0.22
4	25.57	35.02	16.5	21.29	9.05	12.19	4.28	0.35	0.48	0.17
5	20.74	33.21	15.3	16.81	7.16	9.54	3.93	0.35	0.46	0.19
6	21.68	32.14	17.5	17.89	7.63	10.17	3.79	0.35	0.47	0.18
7	22.29	33.35	16	18.59	8.1	10.4	3.7	0.36	0.47	0.17
8	23.73	35.46	15.1	19.7	8.33	11.1	4.03	0.35	0.47	0.17
9	24.19	35	16.2	19.95	8.33	11.48	4.24	0.34	0.48	0.18
10	25.21	36.66	15.9	20.19	8.74	11.32	5.02	0.35	0.45	0.2
11	23.41	36.47	14.7	18.93	8.17	10.62	4.48	0.35	0.45	0.19
12	21.27	37	16.2	18.21	7.54	10.54	3.06	0.35	0.5	0.14
13	25.03	37.72	12.9	20.81	8.6	12.12	4.22	0.34	0.48	0.17
14	27.08	36.08	23.35	10.11	13.14	3.73	3.73	0.37	0.49	0.14
15	22.76	33.4	15.8	18.55	8.05	10.39	4.21	0.35	0.46	0.19
16	19.82	32.51	17.6	16.26	6.72	9.46	3.56	0.34	0.48	0.18
17	20.79	36.76	16.7	17.93	7.33	10.49	2.86	0.35	0.51	0.14
18	22.54	33.74	14.5	18.47	7.95	10.35	4.07	0.35	0.46	0.18
19	26.25	37.52	14.5	20.51	8.73	11.65	5.71	0.33	0.44	0.22
20	20.88	35.01	15	16.68	7.62	8.95	4.2	0.36	0.43	0.2
Total	462.78	703.92	314.45	364.78	164.77	204.64	84.73	6.95	9.28	3.69
Average	23.139	35.196	15.7225	18.239	8.2385	10.232	4.2365	0.3475	0.464	0.1845

Titration Result (ml): 14.91

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 14.94/20* 0.1562/0.1562
= 0.74

Juice %= Fruit weight -Peel and Seed weight * 100/Fruit weight
= 584.54-474.80* 100/584.54
= 18.77

Ratio = TSS/Acid%
= 14.2/0.74
= 19.1:1

Table 18.4: Fruit qualities of selection Wild marula, tree no: 4.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	26.42	35.56	13.4	20.13	9.81	10.15	6.29	0.37	0.38	0.24
2	33.99	39.19	10.8	25.76	11.54	14.77	8.23	0.34	0.42	0.24
3	32.27	38.42	14.6	24.51	11.35	13	7.76	0.35	0.4	0.24
4	26.41	35.28	12.9	21.03	10.85	10.08	5.38	0.41	0.38	0.2
5	28.9	36.74	12.8	22.43	11.17	10.96	6.47	0.39	0.38	0.22
6	33.39	38.2	12.3	24.55	10.87	13.51	8.84	0.33	0.4	0.27
7	31.45	37.72	12.5	22.64	9.81	12.79	8.81	0.31	0.41	0.28
8	30.95	36.94	12.3	24.83	12.55	11.97	6.12	0.41	0.39	0.2
9	36.56	40.47	12	29.26	13.09	16.14	7.3	0.36	0.44	0.2
10	25.91	36.82	13	18.51	8.11	10.29	7.4	0.31	0.4	0.29
11	26.94	35.12	11.3	20.34	9.82	10.48	6.6	0.36	0.39	0.25
12	30.08	40	12.5	23.22	10.6	12.53	6.86	0.35	0.42	0.23
13	29.09	36.47	13.2	20.75	9.98	10.65	8.34	0.34	0.37	0.27
14	30.45	38.57	12.3	23.53	10.92	12.49	6.92	0.36	0.41	0.23
15	30.89	38.13	12.3	23.66	11.3	12.33	7.23	0.37	0.4	0.23
16	29.57	39.19	12.3	23.44	10.99	12.38	6.13	0.37	0.42	0.21
17	31.55	37.51	12.6	23.15	10	13.07	8.4	0.32	0.41	0.27
18	32.27	38.97	11.8	26.21	11.84	14.29	6.06	0.37	0.44	0.19
19	30.39	38.17	12.7	23.78	11.6	12.14	6.61	0.38	0.4	0.22
20	25.13	34.91	11	20.07	8.24	11.81	5.06	0.33	0.47	0.2
Total	602.61	752.38	248.6	461.8	214.44	245.83	140.81	7.13	8.13	4.68
Average	30.1305	37.619	12.43	23.09	10.722	12.2915	7.0405	0.3565	0.4065	0.234

Titration Result (ml): 16.02

Acid % = Titration/Weight * 0.1562/0.1562 (NaOH)
= 26.99/20 * 0.1562/0.1562
= 1.35

Juice %= Fruit weight -Peel and Seed weight * 100/Fruit weight
= 6666.20 – 557.68 * 100/666.20
= 16.29

Ratio = TSS/Acid %
= 12/1.35
= 8.9:1

Table 19.1: Fruit qualities of selection Swarula, tree no: 1.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	39.06	41.27	10.9	29.5	15.73	13.63	9.56	0.4	0.35	0.25
2	38.17	42.03	12.3	28.95	15.92	12.86	9.22	0.42	0.34	0.24
3	35.56	41.65	12.3	26.98	14.22	12.61	8.58	0.4	0.35	0.24
4	47.52	45.38	11.3	36.41	19.27	16.9	11.11	0.41	0.36	0.23
5	46.17	46.76	11.9	35.06	18.14	16.63	11.11	0.39	0.36	0.24
6	46.08	45.02	12	34.67	17.61	16.89	11.41	0.38	0.37	0.25
7	39.23	42.09	12.3	30.14	15.59	14.32	9.09	0.4	0.37	0.23
8	48.14	44.97	11.9	38.74	21.21	17.28	9.4	0.44	0.36	0.2
9	39.59	43.27	12.3	29.27	15.72	13.45	10.32	0.4	0.34	0.26
10	42.42	45.11	12.2	33.39	17.12	15.93	9.03	0.4	0.38	0.21
11	43.94	44.89	13.4	32.67	17.3	15.19	11.27	0.39	0.35	0.26
12	42.4	42.99	11.7	31.8	17.07	14.35	10.6	0.4	0.34	0.25
13	39.37	41.74	12.9	30.46	16.41	13.84	8.91	0.42	0.35	0.23
14	42.27	44.75	12.7	32.73	17.31	15.18	9.54	0.41	0.36	0.23
15	53.94	43.82	12.6	41.25	22.36	18.56	12.69	0.42	0.34	0.24
16	48.43	45.21	13.3	36.88	19.72	16.82	11.55	0.41	0.35	0.24
17	44.06	41.61	12.6	32.45	16.46	15.68	11.61	0.37	0.36	0.26
18	42.81	43	12.8	33.25	17.57	15.51	9.56	0.41	0.36	0.22
19	49.21	45.27	12.6	37.13	19.27	17.53	12.08	0.39	0.36	0.25
20	37.85	39.86	12.7	27.93	15.24	12.38	9.92	0.4	0.32	0.26
Total	866.22	870.69	246.7	659.66	349.24	305.54	206.56	8.06	7.07	4.79
Average	43.311	43.5345	12.335	32.983	17.462	15.277	10.328	0.403	0.3535	0.2395

Titration Result (ml): 19.48

Acid % =Titration/Weight * 0.1562/0.1562 (NaOH)
=17.29/20 *0.1562/0.1562
= 0.86

Juice %= Fruit weight -Peel and Seed weight * 100/Fruit weight
= 997.77-793.63* 100/997.77
= 20.45

Ratio = TSS/Acid %
= 12.9/0.86
= 15:1

Table 19.2: Fruit qualities of selection Swarula, tree no: 2.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed : Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	53.13	45.09	12.3	41.13	22.47	18.37	12	0.42	0.35	0.23
2	44.99	42.61	13.4	34.72	19.18	15.39	10.27	0.43	0.34	0.23
3	57.29	47.7	12.5	45.3	24.47	20.48	11.99	0.43	0.36	0.21
4	44.21	42.58	13.8	34.61	19.48	14.92	9.6	0.44	0.34	0.22
5	40.55	40.71	13.2	31.66	16.86	14.59	8.89	0.42	0.36	0.22
6	38.04	40.92	14.3	28.84	15.95	12.71	9.2	0.42	0.33	0.24
7	42.95	43.58	13.1	34.91	18.86	15.87	10.04	0.42	0.35	0.22
8	50.25	45.8	12.7	39.46	23.02	16.2	10.79	0.46	0.32	0.22
9	46.17	46.16	13.5	35.7	19.46	15.96	10.47	0.42	0.35	0.23
10	57.11	47.26	13.2	45.24	24.49	20.39	11.87	0.42	0.36	0.21
11	46.01	41.58	13.6	35.83	19.41	16.19	10.18	0.42	0.35	0.22
12	63.11	48.45	12.7	49.8	27.08	22.55	13.31	0.43	0.36	0.21
13	53.01	47.4	13.9	42.77	22.62	19.9	10.24	0.43	0.38	0.19
14	47.2	44.03	12.9	40.56	23.7	16.57	6.64	0.5	0.35	0.14
15	54.56	46.7	12.4	42.88	23.46	19.02	11.68	0.43	0.35	0.21
16	47.33	43.89	13.7	37.62	21.83	15.23	9.71	0.46	0.32	0.21
17	44.05	44.69	14.3	33.76	18.04	15.54	10.29	0.41	0.35	0.23
18	44.85	43.7	14.1	35.73	19.36	16.15	9.12	0.43	0.36	0.2
19	51.28	45	13.4	41.97	23.25	18.61	9.31	0.45	0.36	0.18
20	41.36	39.67	11.6	31.59	17.01	14.21	9.77	0.41	0.34	0.24
Total	967.45	887.52	264.6	764.08	420	338.85	205.37	8.65	6.98	4.26
Average	48.3725	44.376	13.23	38.204	21	16.9425	10.2685	0.4325	0.349	0.213

Titration Result (ml): 18.92

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 18.92/20*0.1562/0.1562
= 0.95

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 794.33-670.68* 100/794.33
= 15.56

Ratio = TSS/Acid %
= 12.6/0.95
= 13.2:1

Table 19.3: Fruit qualities of selection Swarula, tree no: 3.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	45.44	46.08	11.5	35.79	18.72	16.79	9.76	0.41	0.37	0.21
2	44.18	41.83	13.4	35.76	18.05	17.22	8.42	0.42	0.39	0.19
3	54.25	46.54	12.7	44.23	23.37	20.41	10.02	0.43	0.37	0.18
4	44.3	45.51	12.6	34.68	17.55	16.78	9.62	0.4	0.38	0.22
5	48.33	46.08	12.9	37.79	20.01	17.57	10.54	0.41	0.36	0.22
6	45.74	42.4	13.2	35.34	19.41	15.71	10.4	0.42	0.34	0.23
7	57.87	46.68	11.9	48.17	24.58	23.21	9.7	0.43	0.4	0.17
8	51.4	48.94	11.9	41.13	20.99	19.88	10.27	0.42	0.38	0.2
9	54.38	48.07	10.9	43.26	23.82	19.18	11.12	0.44	0.35	0.2
10	56.58	46.39	13.3	45.15	23.9	20.78	11.43	0.42	0.37	0.2
11	43.64	43.52	12.9	35.24	20.05	14.66	8.4	0.45	0.34	0.19
12	48.05	48.62	12.8	40.83	21.88	18.87	7.22	0.45	0.39	0.15
13	53.84	49.71	12.2	41.21	23.12	18.05	12.63	0.43	0.34	0.23
14	43.62	43.28	13.1	34.07	18.15	15.82	9.55	0.42	0.36	0.22
15	48.72	47.81	12.4	39.01	20.56	18.19	9.71	0.42	0.37	0.2
16	45.71	44.9	12.8	35.73	18.97	16.57	9.98	0.42	0.36	0.22
17	54.7	45.88	13.9	43.72	23.21	20.21	10.98	0.42	0.37	0.2
18	43.18	45.13	12.8	34.89	17.52	17.07	8.29	0.41	0.4	0.19
19	43.48	42.29	12	34.42	19.31	14.81	9.06	0.44	0.34	0.21
20	40.78	40.8	13.9	32.4	17.34	14.72	8.38	0.43	0.36	0.21
Total	968.19	910.46	253.1	772.82	410.51	356.5	195.48	8.49	7.34	4.04
Average	48.4095	45.523	12.655	38.641	20.5255	17.825	9.774	0.4245	0.367	0.202

Titration Result (ml): 15.13

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 15.13/20 *0.1562/0.l562
= 0.75

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 968.19-772.80*100/968.19
= 20.17

Ratio = TSS/Acid%
= 12.6/0.75
= 16.8:1

Table 19.4: Fruit qualities of selection Swarula, tree no: 4.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	47.35	43.99	13	39.46	20.65	18.59	7.71	0.45	0.39	0.16
2	41.31	42.07	13.9	33.17	17.33	15.64	8.14	0.42	0.38	0.2
3	47.73	44.73	12.6	40.22	21	18.99	7.51	0.44	0.4	0.16
4	39.44	42.88	13.9	32.61	17.48	14.93	6.83	0.44	0.38	0.17
5	47.21	45.01	12.4	37.49	19.99	17.33	9.72	0.42	0.37	0.21
6	47.15	42.96	12.2	37.77	20.09	17.55	9.38	0.43	0.37	0.2
7	42.2	42.9	12.7	33.03	16.74	16.14	9.17	0.4	0.38	0.19
8	42.91	42.07	12.6	33.36	17.83	15.34	9.55	0.42	0.36	0.22
9	38.4	40.15	14	29.25	15.74	13.41	9.15	0.41	0.35	0.24
10	51.78	47.5	12	41.36	22.77	18.39	10.42	0.44	0.36	0.2
11	41.6	43.67	12.9	33.53	16.55	16.87	8.07	0.4	0.41	0.19
12	50.01	47.68	12	39.22	20.98	18.03	10.79	0.42	0.36	0.22
13	39.69	41.02	13	32.63	17.72	14.87	7.06	0.45	0.37	0.18
14	36.57	40.18	12.6	28.25	14.65	13.58	8.32	0.4	0.37	0.23
15	41.1	41.04	12	33.49	17.58	15.7	7.61	0.43	0.38	0.19
16	40.02	41.1	12.6	32.34	17.31	15.27	7.68	0.43	0.38	0.19
17	47.49	42.71	12.5	38.96	20.49	18.24	8.53	0.43	0.38	0.18
18	40.99	41.61	13.7	32.01	17.13	14.83	8.98	0.42	0.36	0.22
19	39.72	41.06	12.7	31.86	16.04	15.7	7.86	0.4	0.4	0.2
20	42.97	44.58	12.4	34.3	18.26	15.87	8.67	0.42	0.37	0.2
Total	865.64	858.91	255.7	694.31	366.33	325.27	171.15	8.47	7.52	3.95
Average	43.282	42.9455	12.785	34.7155	18.3165	16.2635	8.5575	0.4235	0.376	0.1975

Titration Result (ml): 19.45

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 19.45/20* 0.1562/0.1562
= 0.97

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 865.64-704.31* 100/865.64
= 18.63

Ratio = TSS/Acid%
= 12.7/0.97
= 13:1

Table 19.5: Fruit qualities of selection Swarula, tree no: 5.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	42.83	43.48	12.7	34	18.27	15.45	8.83	0.43	0.36	0.21
2	46.55	44.16	12.7	36.7	19.35	17.11	9.85	0.42	0.37	0.21
3	46.65	44.21	11.7	36.35	19.36	16.9	10.3	0.42	0.36	0.22
4	45.68	44.21	12.6	35.71	18.63	16.74	9.97	0.41	0.36	0.22
5	40.23	42.97	12.6	32.13	16.65	15.37	8.1	0.41	0.38	0.2
6	49.6	44.95	12	38.32	19.94	18.21	11.28	0.4	0.37	0.23
7	39.3	43.57	13	31.8	16.46	15.09	7.5	0.42	0.38	0.19
8	43.85	43.13	12	35.19	18.37	16.68	8.66	0.42	0.38	0.2
9	43.07	42.93	11.9	33.63	16.5	16.92	9.44	0.38	0.39	0.22
10	47.08	43.29	12.7	37.72	19.46	17.98	9.36	0.41	0.38	0.2
11	49.55	45.19	11.6	38.88	20.82	17.87	10.67	0.42	0.36	0.22
12	37.02	40.98	13.1	30.63	15.71	14.64	6.39	0.42	0.4	0.17
13	37.2	39.14	12	29.02	14.94	13.99	8.18	0.4	0.37	0.22
14	41.27	40.99	12.3	33.8	16.62	16.75	7.47	0.4	0.41	0.18
15	40.52	40.8	11.7	30.94	16.73	14.05	9.58	0.41	0.35	0.24
16	40.28	42.62	12	32.26	16.81	15.43	8.02	0.42	0.38	0.19
17	38.96	41.72	12.4	30.64	16.08	15.47	8.32	0.41	0.39	0.21
18	43.23	44.26	12	33.45	17.67	15.72	9.78	0.41	0.36	0.23
19	35.18	41.05	12.6	26.72	14.45	12.16	8.46	0.41	0.35	0.24
20	36.16	40.82	12.7	28.54	14.45	14.07	7.62	0.4	0.39	0.21
Total	844.21	854.47	246.3	666.43	347.27	316.6	177.78	8.22	7.49	4.21
Average	42.2105	42.7235	12.315	33.3215	17.3635	15.83	8.889	0.411	0.3745	0.2105

Titration Result (ml): 17.16

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 17.16/20 * 0.1562/0.1562
= 0.85

Juice %= Fruit weight -Peel and Seed weight * 100/Fruit weight
= 844.21-66.43* 100/844.21
= 21.05

Ratio = TSS/Acid%
= 12.3/0.85
= 14.4:1

Table 20.1: Fruit qualities of selection Toularula, tree no: 1.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed : Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	66.15	50.11	12.2	49.2	19.02	29.87	16.95	0.29	0.45	0.26
2	46.76	43.94	14.3	34.67	15.09	19.32	12.09	0.32	0.41	0.26
3	49.11	44.83	13.7	37.29	16.03	20.88	11.82	0.33	0.43	0.24
4	51.97	44.58	14.7	39.7	15.79	23.56	12.27	0.3	0.45	0.23
5	53.24	46	12.7	41.02	16.48	24.86	12.22	0.31	0.46	0.23
6	58.81	47.34	13.7	45.08	17.63	26.94	13.73	0.29	0.46	0.23
7	57.4	45.15	12.7	41.21	17.36	23.66	16.19	0.3	0.41	0.28
8	56.73	45.61	13.2	42.03	17.02	24.75	14.7	0.3	0.44	0.26
9	49.43	42.71	13.7	38.23	16.63	21.44	11.2	0.34	0.44	0.23
10	52.82	44.32	11.9	42.18	18.01	23.75	10.64	0.34	0.45	0.2
11	57.59	46.8	12.2	42.47	16.79	25.58	15.12	0.29	0.44	0.26
12	63.58	50.25	14.9	48.87	19.41	29.4	14.71	0.31	0.46	0.23
13	48.43	42.68	12.1	35.09	15.81	19.2	13.34	0.33	0.4	0.27
14	62.5	48.28	12.4	48.21	19.35	28.62	14.29	0.31	0.46	0.23
15	55.77	44.8	12.8	40.84	17.15	23.6	14.93	0.31	0.42	0.27
16	49.07	44.05	12.7	36.48	15.26	21.04	12.59	0.31	0.43	0.26
17	52.54	45.02	14.1	40.8	16.66	23.56	11.74	0.32	0.45	0.22
18	49.58	44.54	12.5	35.72	15.06	20.67	13.86	0.3	0.42	0.28
19	56.84	46.85	14.6	45.47	18.88	26.48	11.37	0.33	0.46	0.2
20	53.91	44.16	13.2	39.6	17.11	22.84	14.31	0.32	0.42	0.26
Total	1092.23	912.02	264.3	824.16	340.54	480.02	268.07	6.25	8.76	4.9
Average	54.6115	45.601	13.215	41.208	17.027	24.001	13.4035	0.3125	0.438	0.245

Titration Result (ml): 34.76

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 34.76/20* 0.1562/0.1562
= 1.73

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 1092.23-824.16*100/1092.23
= 24.54

Ratio = TSS/Acid%
= 13.2/1.73
= 7.6:1

Table 20.2: Fruit qualities of selection Toularula, tree no: 2.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	50.83	45.57	14.2	40.11	16.12	23.84	10.72	0.32	0.47	0.21
2	59.43	45.59	13.2	49.57	18.07	31.27	9.86	0.3	0.53	0.16
3	53.09	45.28	13.8	38.98	16.02	22.76	14.11	0.3	0.43	0.27
4	57	45.47	12.7	44.7	17.14	22.39	12.3	0.3	0.39	0.22
5	55.73	45.76	14.1	45.4	17.17	28.05	10.33	0.31	0.5	0.19
6	54.72	44.17	13.2	42.05	16.19	25.56	12.67	0.3	0.47	0.23
7	53.2	44.62	14.9	39.7	15.86	23.71	13.5	0.3	0.45	0.25
8	48.39	44.25	13	36.96	15.34	21.28	11.43	0.32	0.44	0.24
9	57.84	45.8	12.7	42.98	17.08	25.78	14.86	0.29	0.45	0.26
10	56.72	45.87	12.6	42.61	16.65	25.98	14.11	0.29	0.46	0.25
11	52.13	45.05	12.5	38.15	15.72	22.25	13.98	0.3	0.43	0.27
12	42.53	43.03	14.1	29.46	12.4	17.01	13.07	0.29	0.4	0.31
13	48.52	44.81	13.8	37.07	16.06	20.92	11.45	0.33	0.43	0.24
14	47.9	42.41	13	37.02	15.23	21.74	10.88	0.32	0.45	0.23
15	48.13	42.69	14.1	35.02	13.83	21.02	13.11	0.29	0.44	0.27
16	48.99	44.56	13.2	38.49	15.67	22.6	10.5	0.32	0.46	0.21
17	58.66	46.81	13.8	44.86	17.91	26.54	13.8	0.31	0.45	0.24
18	52.85	45.48	13.8	39.08	16.31	22.58	13.77	0.31	0.43	0.26
19	51.72	44.36	13.1	39.75	16.12	23.45	11.97	0.31	0.45	0.23
20	57.1	46.42	12.6	42.45	17.49	24.78	14.65	0.31	0.43	0.26
Total	1055.48	898	268.4	804.41	322.38	473.51	251.07	6.12	8.96	4.8
Average	52.774	44.9	13.42	40.2205	16.119	23.6755	12.5535	0.306	0.448	0.24

Titration Result (ml): 46.88

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 46.88/20* 0.1562/0.1562
= 2.34

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 1055.48-804.41*100/1055.48
= 23.78

Ratio = TSS/Acid%
= 13.2/2.34
= 5.7:1

Table 20.3: Fruit qualities of selection Toularula, tree no: 3.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	45.32	44.53	12	34.3	17.73	16.42	11.02	0.39	0.36	0.24
2	44.08	43,89	12.3	34.93	17.64	17.03	9.15	0.4	0.39	0.21
3	44.11	43.77	13	35.23	18.72	16.14	8.8	0.42	0.37	0.2
4	46.2	44.27	11.1	36.74	20.07	16.37	9.46	0.43	0.35	0.2
5	48.47	44.26	11.5	39.68	20.42	19.12	8.79	0.42	0.4	0.18
6	43.46	45.04	12.8	33.95	17.78	16.07	9.15	0.41	0.37	0.22
7	42.76	44.49	13.3	33.4	17.6	15.53	9.36	0.41	0.36	0.22
8	47.89	48.46	12.8	36.44	19.53	16.81	11.45	0.41	0.35	0.24
9	43.14	42.82	13.4	33.78	17.62	16.03	9.36	0.41	0.37	0.22
10	42.92	45.03	12.1	35.18	19.84	15.08	7.74	0.46	0.35	0.18
11	44.75	41.27	12.2	36.25	19.42	16.62	8.5	0.43	0.37	0.19
12	44.22	44.81	13.1	35.53	18.99	16.37	8.69	0.43	0.37	0.2
13	39.37	43.14	14.1	30.06	16.62	13.35	9.31	0.42	0.34	0.24
14	39.2	42.95	13.1	30.4	16.37	13.85	8.8	0.42	0.35	0.23
15	39.68	40.65	14	31.01	16.31	14.6	8.67	0.41	0.37	0.22
16	42.04	43.08	13	32.7	17.4	15.09	9.34	0.41	0.36	0.22
17	38	42.22	13.6	29.59	15.79	13.54	8.41	0.42	0.36	0.22
18	45.57	43.85	12.7	36.69	19.53	16.87	8.88	0.43	0.37	0.2
19	44.43	45.56	13.1	34.8	18.52	16.19	9.63	0.42	0.36	0.22
20	44.97	41.3	12.1	35.57	17.67	17.75	9.4	0.39	0.4	0.21
Total	870.58	831.5	255.3	686.23	363.57	318.83	183.91	8.34	7.32	4.26
Average	43.529	43.76316	12.765	34.3115	18.1785	15.9415	9.1955	0.417	0.366	0.213

Titration Result (ml): 17.46

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 17.46/20* 0.1562/0.1562
= 0.87

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 870.58-686.23 *100/870.58
= 21.17

Ratio = TSS/Acid%
= 12.7/0.87
= 14.5:1

Table 20.4: Fruit qualities of selection Toularula, tree no: 4.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	40.87	43.85	12.4	31.83	18.19	13.42	9.04	0.45	0.33	0.22
2	38.47	42.04	12.7	29.42	17.29	11.97	9.05	0.45	0.31	0.24
3	38.82	43.58	12.7	32.27	18.1	13.89	6.55	0.47	0.36	0.17
4	43.39	45.97	13.7	34.53	18.83	15.54	8.86	0.43	0.36	0.2
5	43.71	42.27	13.3	34.88	19.32	15.36	8.35	0.45	0.35	0.19
6	43.23	42.88	12.4	34.95	19.58	15.2	8.2	0.45	0.36	0.19
7	43.74	42.87	13.1	34.91	19.6	15.2	8.67	0.45	0.34	0.24
8	43.58	43.68	12.4	34.38	18.97	15.13	9.2	0.44	0.35	0.21
9	44.27	44.1	13	34.91	19.27	15.54	9.36	0.44	0.35	0.21
10	37.61	40.34	13.2	29.88	17.56	12.27	7.73	0.47	0.33	0.21
11	42.03	42.7	12.4	32.91	18.35	14.3	9.12	0.44	0.34	0.27
12	37.5	42.99	14	29.35	17.14	11.97	8.15	0.46	0.32	0.22
13	35.89	39.73	13.3	28.28	16.19	11.92	7.61	0.45	0.33	0.21
14	41.92	42.57	12.9	34.79	19.11	15.47	7.13	0.46	0.37	0.17
15	40.44	43.48	12	32.56	18.37	18.37	7.88	0.45	0.35	0.2
16	44.06	43.7	12.2	35.1	20.14	14.82	8.96	0.46	0.34	0.2
17	36.71	39.11	13.4	29.61	16.69	12.58	7.17	0.45	0.34	0.2
18	39.78	40.08	12.6	30.64	16.98	13.48	9.14	0.43	0.34	0.23
19	41.07	43.61	13.1	33.28	18.35	14.8	7.79	0.45	0.36	0.19
20	41.17	40.44	12.6	32.94	18.11	14.63	8.23	0.44	0.36	0.2
Total	818.26	849.99	257.4	651.42	366.14	285.86	166.19	8.99	6.89	4.17
Average	40.913	42.4995	12.87	32.571	18.307	14.293	8.3095	0.4495	0.3445	0.2085

Titration Result (ml): 16.19

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 16.19/20* 0.1562/0.1562
= 0.8

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 818.30-651.42*100/818.30
= 20.39

Ratio = TSS/Acid%
= 12.8/0.80
= 16:1

Table 20.5: Fruit qualities of selection Toularula, tree no: 5.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed : Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	36.8	43.37	12.2	29.95	15.04	14.69	6.85	0.41	0.4	0.19
2	45.47	42.5	12.9	38.21	18.39	19.68	7.26	0.4	0.43	0.16
3	46.03	42.9	12.6	37.5	18.91	18.43	8.53	0.41	0.4	0.19
4	46.57	45.56	12.1	37.39	19.02	17.82	9.18	0.41	0.39	0.2
5	39.7	40.64	12.6	34.01	16.97	16.41	5.69	0.43	0.41	0.14
6	41.35	41.48	13	34.23	17.2	16.94	7.12	0.42	0.41	0.17
7	41.19	40.66	12.8	32.92	17.7	15.08	8.27	0.43	0.37	0.2
8	36.02	41.65	15.4	31.64	16.21	15.12	4.38	0.45	0.42	0.12
9	41.24	42.66	14.2	33.11	17.04	15.61	8.13	0.41	0.38	0.2
10	47.38	46.59	12.6	39.51	20.37	18.92	7.87	0.43	0.4	0.17
11	35.26	40.11	14	28.94	14.6	14.28	6.32	0.41	0.41	0.18
12	45.67	43.1	12.1	36.65	18.1	18.39	9.02	0.4	0.4	0.2
13	45.7	43.8	12.1	35.57	18.38	16.95	10.13	0.4	0.37	0.22
14	40.25	41.39	13	31.44	15.95	15.31	8.81	0.41	0.38	0.22
15	40.01	42.44	13.1	32.31	16.6	15.62	7.7	0.42	0.39	0.19
16	43.1	40.68	13.2	32.93	17.62	15.24	10.17	0.41	0.35	0.24
17	38.28	42.07	12.5	29.32	15.48	13.79	8.96	0.4	0.36	0.23
18	42.5	44.5	13.4	32.65	17.89	14.6	9.85	0.42	0.34	0.23
19	38.05	39.5	14.1	31.92	16.32	15.54	6.13	0.43	0.41	0.16
20	41.28	44.92	13.1	32.33	16.52	15.65	8.95	0.4	0.38	0.22
Total	831.85	850.52	261	672.53	344.31	324.07	159.32	8.3	7.8	3.83
Average	41.5925	42.526	13.05	33.6265	17.2155	16.2035	7.966	0.415	0.39	0.1915

Titration Result (ml): 21.57

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 21.57/20* 0.1562/0.1562
= 1.07

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 831.85-672.53*100/831.85
= 19.15
Ratio = TSS/Acid%
= 13.0/1.07
= 12.1:1

Table 21.1: Fruit qualities of selection Pharulani, tree no: 1.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	36.14	38.41	14.7	27.97	12.07	14.89	8.17	0.33	0.41	0.23
2	37.63	40.56	13	26.49	12.05	14.31	11.14	0.32	0.38	0.3
3	47.14	43.48	12.4	37.04	15.69	21.18	10.1	0.33	0.45	0.21
4	36	38.04	15.6	28.44	12.52	15.71	7.56	0.35	0.44	0.21
5	41.7	40.42	13.3	31.09	13.18	17.69	10.61	0.32	0.42	0.25
6	39.7	40.22	13	29.5	12.89	16.33	10.2	0.32	0.41	0.26
7	40.04	41.19	14	29.7	13.44	16.33	10.34	0.34	0.41	0.26
8	41.14	39.69	12.8	29.85	13.49	16.21	11.29	0.33	0.39	0.27
9	38.6	41.66	14.7	27.97	13.04	14.51	10.63	0.34	0.38	0.28
10	39.31	39.62	13.8	27.85	12.66	14.99	11.46	0.32	0.38	0.29
11	39.55	39.79	12.3	28.05	12.37	15.45	11.5	0.31	0.39	0.29
12	39.43	40.69	14.1	32.14	13.56	17.9	7.29	0.34	0.45	0.19
13	47.93	41.79	12.7	36.26	15.48	20.62	11.67	0.32	0.43	0.24
14	38.87	39.11	13.7	27.5	13.07	14.44	11.37	0.34	0.37	0.29
15	40.73	40.55	12.8	29.37	12.73	16.48	11.12	0.31	0.41	0.27
16	40.49	39.27	14.8	30.38	13.49	16.66	10.11	0.33	0.41	0.25
17	41.83	41.29	13.2	29.95	13.5	16.29	11.88	0.32	0.39	0.28
18	41.14	40.64	11.7	28.77	13.62	14.98	12.37	0.33	0.36	0.3
19	49.59	43.42	12.1	37.94	15.52	22.24	11.65	0.31	0.45	0.23
20	40.57	39.56	12.4	31.49	13.36	17.83	9.08	0.33	0.44	0.22
Total	817.53	809.4	267.1	607.75	267.73	335.04	209.54	6.54	8.17	5.12
Average	40.8765	40.47	13.355	30.3875	13.3865	16.752	10.477	0.327	0.4085	0.256

Titration Result (ml): 30.02

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 30.02/20*0.1562/0.1562
=1.5

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 817.53-607.75*100/817.53
= 25.66

Ratio = TSS/Acid%
= 13.3/1.50
= 8.8:1

Table 21.2: Fruit qualities of selection Pharulani, tree no: 2.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	56.33	47.2	14.6	40.71	15.39	25.16	15.62	0.27	0.45	0.28
2	58.57	47.4	12.2	41.46	16.06	25.32	17.11	0.27	0.43	0.29
3	50.02	44.6	11.7	35.94	14.54	21.26	12.62	0.29	0.42	0.25
4	48.56	44.11	11.4	34.69	13.74	20.65	13.87	0.28	0.43	0.29
5	57.35	45.23	12.3	40.35	15.6	24.56	17	0.27	0.43	0.3
6	46.44	43.13	13.1	35.98	14.12	21.5	10.46	0.3	0.46	0.23
7	50.22	43.93	12.8	37.85	14.79	22.79	12.37	0.29	0.45	0.25
8	57	45.37	12.2	41.72	16.7	25.05	15.28	0.29	0.44	0.27
9	45.15	41.93	14.5	35.08	14.7	20.32	10.07	0.33	0.45	0.22
10	49.81	44.47	13.6	38.73	16.28	22.25	11.08	0.33	0.45	0.22
11	47.64	44.57	16.1	35.05	13.92	21.02	12.59	0.29	0.44	0.26
12	53.22	45.81	12.8	39.33	14.99	23.95	13.89	0.28	0.45	0.26
13	44.5	44.47	12.7	40.56	15.36	24.92	3.94	0.34	0.56	0.1
14	52.07	43.68	15	39.4	15.28	23.27	12.67	0.29	0.45	0.24
15	51.64	43.75	12.8	38.24	15.71	22.47	13.4	0.3	0.44	0.26
16	44.3	42.13	13.9	33.37	12.53	20.75	10.93	0.28	0.47	0.25
17	53.81	46.14	13	41.48	15.56	25.73	12.33	0.29	0.48	0.23
18	52.81	45.33	13.1	39.52	15.6	23.8	13.29	0.29	0.45	0.25
19	62.41	47.79	12.2	45.3	17.22	27.95	17.11	0.28	0.45	0.27
20	44.78	42.67	12	33.43	14.19	19.02	11.35	0.32	0.42	0.25
Total	1026.63	893.71	262	768.19	302.28	461.74	256.98	5.88	9.02	4.97
Average	51.3315	44.6855	13.1	38.4095	15.114	23.087	12.849	0.294	0.451	0.2485

Titration Result (ml): 37.32

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 37.32/20* 0.1562/0.1562
= 1.86

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 1026.63-768.19*100/1026.63
= 25.17

Ratio = TSS/Acid%
= 13.1/1.86
= 7:1

Table 21.3: Data of Fruit qualities of selection Pharulani, tree no: 3.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	46.53	43.03	11.7	36.36	14.94	21.17	10.17	0.32	0.45	0.22
2	41.44	40.56	14.7	34.72	14.34	20.09	6.72	0.35	0.48	0.16
3	48.07	43.39	13.8	35.97	14.77	21.09	12.1	0.31	0.44	0.25
4	40.27	41.19	14.7	31.88	13.86	17.93	8.39	0.34	0.45	0.21
5	41.05	40.74	12.8	30.48	13.02	17.39	10.57	0.32	0.42	0.26
6	47.45	44.4	15	37.15	14.68	22.43	10.3	0.31	0.47	0.22
7	54.19	46.26	12	41.06	15.92	25.02	13.13	0.29	0.46	0.24
8	38	40.87	11.7	29.92	13.66	16.21	8.08	0.36	0.43	0.21
9	44	42.58	12.9	36.69	14.49	22.06	7.31	0.33	0.5	0.17
10	46.97	42.72	16.8	37.37	15.74	21.36	7.6	0.35	0.45	0.2
11	56.04	45.79	13.2	43.38	17.97	25.32	12.66	0.32	0.45	0.23
12	48.42	46.13	14.7	37.14	14.54	22.41	11.28	0.3	0.46	0.23
13	50.83	44.22	12.5	39.48	16.31	22.97	11.35	0.32	0.45	0.22
14	46.18	43.49	14.8	35.54	14.5	20.85	10.64	0.31	0.45	0.23
15	48.57	44.59	14	37.68	15.33	22.12	10.89	0.32	0.46	0.22
16	51.15	43.69	13.4	39.59	15.42	23.9	11.47	0.3	0.47	0.22
17	47.65	44.11	15.3	37.58	15.07	22.18	10.07	0.32	0.47	0.21
18	45.36	41.26	14.6	33.68	14.57	19.02	11.68	0.32	0.42	0.26
19	40.84	39.55	15.3	32.71	13.35	19.16	8.13	0.33	0.47	0.2
20	43.25	40.97	14.3	32.93	14.13	18.67	10.32	0.33	0.43	0.24
Total	926.26	859.54	278.2	721.31	296.61	421.35	202.86	6.45	9.08	4.4
Average	46.313	42.977	13.91	36.0655	14.8305	21.0675	10.143	0.3225	0.454	0.22

Titration Result (ml): 48.86

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 48.86/20* 0.1562/0.1562
= 2.44

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 926.26-721.31*100/926.26
= 22.12

Ratio = TSS/Acid%
= 13.9/2.44
= 5.9:1

Table 21.4: Fruit qualities of selection Pharulani, tree no: 4.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	49.37	42.82	14.5	36.4	15	21.12	12.97	0.3	0.43	0.26
2	51.31	43.93	13.3	38.54	15.29	23.13	12.77	0.3	0.45	0.25
3	48.15	43.78	13.9	36.95	14.68	22.21	11.2	0.31	0.46	0.23
4	47.22	41.16	13.6	35.55	14.69	20.69	11.67	0.31	0.44	0.25
5	55.39	46.83	13.9	44.04	17.78	25.99	11.35	0.32	0.47	0.21
6	46.87	43.14	12.8	35.92	15.03	20.74	10.95	0.32	0.44	0.23
7	49.19	43.7	13.1	38.04	15.48	22.21	11.15	0.32	0.45	0.23
8	61.53	47.51	13.1	46.04	19.5	26.5	15.49	0.32	0.43	0.25
9	61.92	50.66	14.5	50	19.9	29.84	11.92	0.32	0.48	0.19
10	46.92	43.32	14.4	36.63	14.91	21.51	10.29	0.32	0.46	0.22
11	43.03	42	14.2	33.15	13.88	19.05	9.88	0.32	0.44	0.23
12	47.5	42.74	13.8	36.81	14.94	21.62	10.69	0.32	0.46	0.22
13	51.11	42.88	12.5	38.27	16.27	22.01	12.84	0.32	0.43	0.25
14	48.71	43.88	13.1	35.93	15.33	20.58	12.78	0.32	0.42	0.26
15	58.98	46.44	14.4	46.53	18.79	27.55	12.45	0.32	0.47	0.21
16	54.4	44.77	14.4	43.1	17.44	25.52	11.3	0.32	0.47	0.21
17	43.05	40.84	14.7	36.27	14.63	21.47	6.78	0.34	0.5	0.16
18	47.71	42.41	14	37.05	15.69	21.07	10.66	0.33	0.44	0.23
19	52.02	43.68	13.3	40.13	16.98	23.07	11.92	0.33	0.44	0.23
20	39.44	39.31	14.9	31.38	13.77	17.69	8.06	0.35	0.45	0.2
Total	1003.82	875.8	276.4	776.73	319.98	453.57	227.12	6.41	9.03	4.52
Average	50.191	43.79	13.82	38.8365	15.999	22.6785	11.356	0.3205	0.4515	0.226

Titration Result (ml): 44.20

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 44.20/20* 0.1562/0.1562
= 2.21

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 1004-766.73*100/1004
= 23.63

Ratio = TSS/Acid%
= 13.8/2.21
= 6.2:1

Table 21.5: Fruit qualities of selection Pharulani, tree no: 5.

Fruit No.	Fruit Mass (g)	Fruit Size (mm)	Brix %	Peel & Seed Mass (g)	Peel Mass (g)	Seed Mass (g)	Juice Mass (g)	Peel: Fruit Mass Ratio	Seed: Fruit Mass Ratio	Juice: Fruit Mass Ratio
1	44.23	42.46	12.1	30.95	13.7	17.17	13.28	0.31	0.39	0.3
2	50.49	45.47	12	35.26	14.69	20.44	15.23	0.29	0.4	0.3
3	44.39	43.27	12.4	31.96	13.64	18.09	12.43	0.31	0.41	0.28
4	44.78	43.1	13.1	31.6	13.25	18.15	13.18	0.3	0.41	0.29
5	45.12	42.62	14.7	33.15	12.97	19.89	11.97	0.29	0.44	0.27
6	47.01	43.67	14.7	35.92	13.92	22.22	11.09	0.29	0.47	0.24
7	51.25	43.4	15.5	38.64	16.45	22.09	12.61	0.32	0.43	0.25
8	46.87	42.79	12.8	33.34	13.79	19.35	13.53	0.29	0.41	0.29
9	48.64	42.5	12.8	34.38	14.76	19.53	14.26	0.3	0.4	0.29
10	47.05	43.65	14.5	34.48	14.4	20.04	12.57	0.31	0.42	0.27
11	45.79	44.1	12.6	32.21	13.77	18.32	13.58	0.3	0.4	0.3
12	54.97	45.48	14.4	40.04	16.47	23.45	14.93	0.3	0.43	0.27
13	42.39	43.94	14.6	32.41	14.25	17.98	9.98	0.34	0.42	0.24
14	49.04	42.73	11.8	35.9	15.81	19.98	13.14	0.32	0.41	0.27
15	43.81	42.45	15.5	35.54	14.97	20.31	8.27	0.34	0.46	0.19
16	43.77	43.44	14.6	31.97	13.36	18.17	11.8	0.31	0.42	0.27
17	43.08	42.53	14.5	31.52	13.76	17.63	11.56	0.32	0.41	0.27
18	46.24	43.39	12.6	32.72	13.97	18.64	13.52	0.3	0.4	0.29
19	38.81	40	13.4	30.98	13.59	17.2	7.83	0.35	0.44	0.2
20	44.64	40.88	14.4	31.9	13.61	18.25	12.74	0.31	0.41	0.28
Total	922.37	861.87	273	674.87	285.13	386.9	247.5	6.2	8.38	5.36
Average	46.1185	43.0935	13.65	33.7435	14.2565	19.345	12.375	0.31	0.419	0.268

Titration Result (ml): 31.78

Acid %= Titration/Weight * 0.1562/0.1562 (NaOH)
= 31.78/20* 0.1562/0.1562
= 1.58

Juice %=Fruit weight -Peel and Seed weight * 100/Fruit weight
= 922.40 – 674.87 *100/922.40
= 26.83

Ratio = TSS/Acid%
= 13.6/1.58
= 8.6:1