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EVOLUTION OF FRUIT PHYSICAL AND BIOCHEMICAL PARAMETERS OF SCAB RESISTANT APPLE VARIETIES DURING STORAGE

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Abstract

In a young apple orchard with scab resistant varieties on the Romanian plain, trees were planted at 3.5 x 1.0 m on a brown-reddish soil and led as vertical axe. A trellis formed with 4.0 m oak wooden poles, 2 wires and bamboo canes was used to lead and to support the trees. The inter row was cultivated with a mixture of perennial grasses and mowed mechanically. Drip irrigation was provided on the row, having a continuous line with auto compensating drippers every 0.5 m. On the row, the soil was maintained clean by hand and mechanical cultivation. Organic foliar and soil fertilization was applied. For consecutive three years, fruits from 22 varieties have been studied during fruit storage, from September until April. Fruits main physical and biochemical characteristics were analyzed: fruit weight (g), fruit calibre (mm), flesh firmness (kgf/cm^2), soluble solids (%) etc. Fruit starch content was determined, based on the conversion level in soluble solids by coloration of the fruit transversal section. Sensory analysis of fruit have been realised by appreciating the external and internal fruit characteristics using a descriptors list for the "Level 1" of the "Eurofru" fruit test. Gold Rush had the best appreciations from the taste quality point of view, 45.40% of the tasters considering it of good quality and 25.20% of them, of excellent quality. Average fruit weight ranged from 89.8 g for Red Devil up to 232 g at Topaz. Flesh firmness at harvest ranged between 4.6 kgf/cm² at Rajka up to 13.8 kgf/cm² at Gold Rush variety, being an important indicator of fruit earliness and ability to storage.

Keywords: *Malus domestica, fruit characteristics, sensorial analysis*

INTRODUCTION

The high importance of apple growing is due to nutritional, prophylactic and therapeutic fruit values, apple trees biological and technological properties and value adding cropping. Apples are one of the main components in the diet of modern human nutrition. They are available all year as a fresh product and processed in several different ways. In fruit growing world, apple occupies a proeminent place in the production of fruit, hovering among tree roots in key species in temperate areas of the globe. [2] Apple storage capacity is extremely important for the new varieties launched on the market and an objective judgement of their commercial value should include some typical biochemical and sensorial analysis. For the scab resistant varieties, reaching a high quality level, similar of the non resistant ones is a major goal. This paper presents first results from a lot of varieties resistant to scab [4], insisting on the fruit characteristics and their evolution during storage.

MATERIALS AND METHODS

The apple orchard was planted on the Romanian plain on a brown-reddish soil. Apple trees of five scab resistant varieties: Ariwa, Gold Rush, Golden Orange, Rubinola and Topaz were planted at 3.5 x 1.0 m and led as vertical axe. A trellis formed with 4.0 m oak wooden poles, 2 wires and bamboo canes was used to lead and to support the trees. The inter row was cultivated with a mixture of perennial grasses and mowed mechanically. Drip irrigation was provided on the row, having a continuous line with auto compensating drippers every 0.5 m. On the row, the soil was maintained clean by hand and mechanical cultivation.

Foto 1. Apple plantation.

Fruits were harvested in September and stored in a cold chamber with normal atmosphere at 5°C.

At the picking moment and then, every month, fruit physical and biochemical characteristics were analysed as: fruit weight (g), fruit calibre (mm), flesh firmness (kgf/cm^2), soluble solids (%).

The starch content of fruit was determined according to their conversion into substances soluble solids by cross sections of the fruit color with iodine in potassium iodide .After staining was compared with a marked with a conversion chart for the dark blue noted whith 1 at 10, white, colorless.

The fruit sensorial analysis was done by appreciating the external and internal fruit characteristics. The sensorial analysis have been realised by group tasting, with students and teachers in February, after 4 month of cold storage.

The fruit tasting have been done using spread sheets with the most important fruit organoleptical characteristics included in the descriptors list for the "Level 1" of the "Eurofru" fruit test. The votes were between 1 and 9 for each character. Votes of 1-3 are considered unsatisfying, the ones from 4 to 6 are good and from 7 to 9, very good.

RESULTS AND DISCUSSION

The observation and measurements indicated that the ripening process in apple starts before the apple picking.

At picking time, the fruits were analysed in order to register their status before storage and to indicate exactly the stage of fruit maturity.

Firmness of flesh

Storage capacity of apple fruit firmness was determined by measuring pulp expressed in kgf / cm ² executed using a penetrometer with a sample of 11 mm piston being the mean of two measurements per fruit. As can be seen in Table 1 at harvest variety Goldrush highest value recorded over the three years of study, respectively 13.6 kgf / cm ² (2009), 13.8 kgf / cm ² (2010) and 12 , 9 kgf /cm² (2011). The lowest value was recorded in Romus 3 variety whit 7.2 kgf / cm ² (2009), 6.6 kgf / cm² (2010) and 7.4 kgf / cm ² (2011). During storage of pulp firmness varied according to genotype.

After 8 months of storage can be seen that the Goldrush variety register capable of storing values 6.2kgf/cm ² (2010), 7.2 kgf / cm ² (2010) and 6.1 kgf / cm ² (2012) while the other genotypes who have lost this ability after just four months of storage, that kind Ciprian 4.0 kgf / cm ² and Redix 4.3 kgf / cm ², the value reached in January.

Soluble solid-refractometric index

The apple content in soluble solids is extremely important, that characteristic having a major influence on fruit taste. This was determined by hand refractometer BRIX 35 HP. At picking, fruit content in soluble solids varied from 14.4% (2009), 15.6% (2010) and 16.6% (2011) at Red Devil but during storage may notice a slight decrease of this value shows that the varieties which begin to lose their ability conditioning, storage and marketing as with decreasing flesh firmness. After 8 months of storage registers Goldrush variety whit a best values, respectively 17.8% (2010), 17.4% (2011) and 18.4% (2012). (Table 2)

Fruit size

Apple weight and size are important in assessing the quality of their commercial variety being attributes that can be influenced to a greater or lesser extent the quantity of production, of rootstock, the culture technology applied, tree age and conditions climate of the year [5]. The average fruit weight of the studies varieties varied from 89.8 g at Red Devil, Goldrush 173.3 g, 181.5 g at Rubinola and 232 g Topaz variety. Fruit size varies from 50-55 mm

at Red Devil, 60-65 mm, 80-85 mm at Topaz and Ariwa. (Table 3)

Photo 2. Ariwa variety

The starch content

Analyzing the fruit coloured section with iodine in potassium iodide**,** was possible to see that, at the picking moment some of the studied varieties, were already ripped, Ariwa, Rebra and Rubinola (8C). For the other varieties of blue coloration was on 70% of the section (note 4) at Goldrush or 40% of the section (Note 6). Red Devil, Florina and Redix. Ariwa, Rubinola and Rebra are early ripe varieties and they have to be picked at least one month before (at least at 5 colouration stage) (Fig. 1).

Fig.1. The starch content

Senzorial evaluation

The first step in choosing products to consumers is organoleptic. Products causing pleasant sensations are retained for home use because they produce only simple recall appetite. This attitude is explained by the fact that the consumer's first contact with food is likely taste. He evaluates the product by size, color, shape, appearance, health, state of freshness, consistency, juiciness, flavor and taste. [1]

Some fruit characteristics are presented in Table 3. In Fig. 2 can be seen that 45.40% of tasters appreciated Goldrush variety of high quality, followed by Red Devil varieties, Topaz (41%) and Generos (40%). The Goldrush variety and quality was assessed as excellent by 25.20% of the tasters, followed by Ariwa, Red Devil and Red Topaz with 12%.

CONCLUSIONS

At the picking moment in three years of study, fruits had a high flesh firmness that indicates a high storage capacity and manipulation resistance.

Of the 22 genotypes studied best results in terms of conditioning they had varieties Goldrush, Dalinette, Red Devil, Svatava, Topaz, Opal and Sirius varieties compared with Ciprian, Rajka, Redix, Rosana, Romus 3 and Generos not last more than 4-5 months losing the ability conditioning, storage and marketing. During the storage period was recorded accumulation of soluble solids (sugars), with a positive effect on the fruit eating qualities. From the all studied varieties, Goldrush had the longest storage life and was considered on the first place by taste panel.

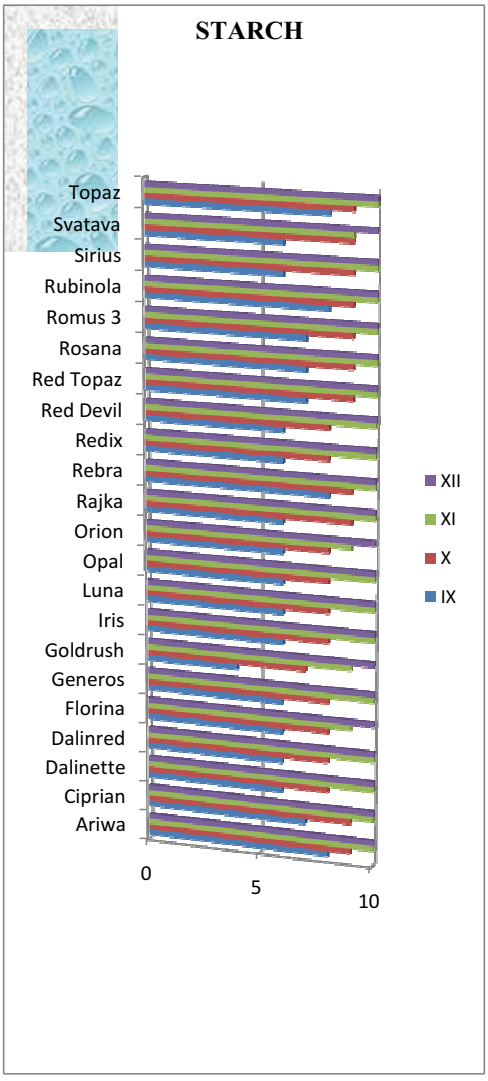

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Table 1. Fruit firmness during 3 years of study

Variety	Flesh firmness kgf/cm²																							
	2009/2010								2010/2011								2011/2012							
	IX	X	XI	XII	I	II	III	IV	IX	X	XI	XII	I	II	III	IV	IX	X	XI	XII	I	II	III	IV
Ariwa	11.0	10.2	9.4	7.1	6.4	5.3	3.2	-	11.3	10.2	8.6	6.4	5.1	3,2	-	-	11.9	10.6	9.4	8.1	6.3	4.0	-	-
Ciprian	10.4	9.1	7.3	5.8	4.0	-	-	-	11.5	8 .0	5.7	4.2	3.4	-	-	-	8.6	7.4	6.1	5.2	3.7	-	-	-
Dalinette	10.8	10.9	10.7	9.4	8.3	7.5	5.4	5.3	12.9	11.2	11.2	9.6	7.4	7.6	5.6	4.7	11.7	11.4	10.8	8.9	7.5	6.4	5.1	4.1
Dalinred	11.4	10.9	9.9	7.4	6.6	5.4	3.7	-	11.6	11.2	9.4	5.4	4.4	3.1	-	-	10.6	9.9	10.0	7.5	7.6	6,3	4.3	-
Florina	10.6	9.8	8.7	7.3	6.3	5.4	5.3	4.6	10.2	8.0	6.6	4.0	3.4	4.0	-	-	9.0	9.2	8.6	6.9	5.3	4.4	4.6	-
Generos	9.8	8.4	7.1	5.3	4.6	4.2	-	-	10.2	7.8	6.8	4.2	3.7	-	-	-	8.9	9.0	7.4	6.1	5.5	4.2	-	-
Goldrush	13.6	12.4	11.6	11.8	10.2	8.7	8.2	6.2	13.8	11.4	10.4	10.8	9.9	9.7	8.1	7.2	12.9	12.8	11.7	10.9	9.1	8.3	7.1	6.1
Iris	9.9	9.1	8.7	7.6	6.3	5.4	4.1	-	9.8	9.4	8.3	6.4	5.1	4.7	-	-	8.4	8.2	7.4	5.6	4.3	3.2	-	-
Luna	10.4	10.5	9.7	7.9	8.0	6.3	5.5	4.1	11.3	10.8	9.5	7.1	6.2	5.3	4.4	-	9.6	8.3	6.6	6.5	5.2	4.9	-	-
Opal	11.2	10.8	8.9	8.7	6.4	5.5	5.6	4.3	11.0	10,2	10.8	9.2	8.6	7.4	5.7	5.2	10.3	9.8	8.7	6.7	6.4	6.0	5.5	-
Orion	9.2	9.0	8.6	7.5	6.1	5.3	4.6	-	9.5	9.6	8.7	6.9	5.4	4.3	-	-	8.5	7.5	6.2	5.5	5.6	4.8	-	-
Rajka	4.6	4.1	4.2	3.2	-	-	-	-	7.6	6.2	4.4	4.2	-	-	-	-	7.5	6.1	5.4	4.7	4.1	-	-	-
Rebra	10.9	9.2	9.3	8.0	7.1	6.4	5.3	5.0	10.2	9.6	9.2	8.2	7.4	6.1	4.7	-	9.7	9.2	8.5	8.2	7.1	6	5.4	5.2
Redix	8.2	7.1	6.2	5.3	4.3	-	-	-	8.5	7.2	6.4	5.2	4.1	-	-	-	10.4	8.9	7.6	6.2	5.4	4.0	-	-
Red Devil	8.9	7.4	7.4	6.6	6.2	5.2	5.3	4.7	8.5	8.0	7.6	7.8	6.7	5.9	5.4	5.2	8.0	8.1	7.4	6.2	5.7	5.4	4.7	4.4
Red Topaz	9.3	8.6	7.5	6.5	6.2	5.7	4.4	-	8.2	7.0	5.8	5.2	4.7	4.3	-	-	9.7	8.8	7.2	6.1	5.4	5.6	4.7	4.3
Rosana	7.9	6.2	5.5	4.3	-	-	-	-	8,1	7.2	5.2	4.5	3.3	-	-	-	8.9	7.6	6.3	5.5	5.2	4.1	-	-
Romus 3	7.2	6.3	5.4	4.7	4.5	-	-	-	6.6	6.4	6.0	5.2	4.7	4.2	-	-	7,4	6,9	5.9	5.6	4.9	4.5	3.7	-
Rubinola	9.8	8.7	7.4	6.1	5.3	4.7	-	-	10.0	6.2	5.2	4.8	3.9	-	-	-	7.9	6.1	5.7	4.2	3.2	-	-	-
Sirius	9.3	8.6	8.0	7.1	6.5	6.1	5.4	5.2	9.8	9.4	8.2	7.1	6.5	6.0	5.1	5.2	9.5	8.3	7.0	6.5	5.2	4.2	-	-
Svatava	11.2	10.0	8.9	7.4	6.0	5.7	5.4	4,7	11.5	9.8	7.6	6.9	5.6	5.1	4.3	4.7	11.7	10.2	8.7	7.6	6.6	6.2	5.6	5.0
Topaz	12.9	11.2	11.1	10.3	9.8	8.0	6.6	5.2	13.2	10.4	9.3	7.0	6.5	5.5	5.3	4.9	10.3	9.8	8.6	7.5	7.0	6.2	5.7	5.2

Tabel 2. Total soluble solids

Variety	S.U.S %																							
	2009/2010								2010/2011								2011/2012							
	IX	X	XI	XII	I	II	III	IV	IX	X	XI	XII	I	II	III	IV	IX	X	XI	XII	I	II	III	IV
Ariwa	13.2	12.6	12.8	13.2	12.6	13.0	12.8	-	13.4	12.8	13.2	13.6	13.6	13.8	-	-	12.0	12.8	13.2	13.2	12.6		-	-
Ciprian	14.4	13.8	13.8	13.2	13.0	-	-	-	14.6	12.8	12.4	11.6	11.6	-	-	-	14.2	13.8	14.6	13.8	12.4	-	-	-
Dalinette	13.0	13.8	14.2	14.2	14.4	14.8	14.8	14.2	13.2	14.4	14.8	14.4	14.6	14.6	14.4	14.2	12.4	14.8	15.8	14.8	14.6	14.4	14.4	14.2
Dalinred	10.2	10,4	10.4	11.2	12.4	13.2	13.4	-	10.0	10.2	10.4	11.0	11.4	11.4	-	-	11.4	12.8	14.8	14.0	14.0	14.2	13.8	-
Florina	13.2	13.0	12.8	12.8	12.4	12.6	12.4	12.0	13.0	13.2	11.2	10.6	11.0	10.8	-	-	12.0	13.0	15.4	15.2	14.8	14.8		-
Generos	15.4	15.4	14.6	15.0	15.2	15.0	-	-	15.8	15.4	15.8	15.6	15.6	-	-	-	15.6	14.6	15.8	14.8	14.0	14.2	-	-
Goldrush	13.0	13.8	14.6	15.0	15.6	17.2	17.4	17.8	12.8	13.4	13.8	15.2	16.8	17.0	17.8	17.4	12.2	14.6	17.8	17.8	18.2	18.6	18.4	18.4
Iris	10.2	12.6	12.8	13.0	13,4	12.8	12.8	-	10.8	13.0	13.6	13.8	12.8	13.0	-	-	16.4	14.6	14.2	14.0	13.8	13.8	-	-
Luna	10.6	11.2	11.2	11.6	13.4	12.8	12.4	12.4	11.0	12.4	12.4	13.8	13.8	13.4	13.8	-	10.4	13.2	13.0	12.8	12.4	12.4	-	-
Opal	13.4	13.4	13.8	15.2	16.4	16.0	16.2	16.4	14.2	15.6	17.0	16 .0	16.4	17.2	16.8	16.2	12.6	14.8	15.0	16.8	16.8	16.4	16.4	-
Orion	14.2	14.2	14.8	15.2	15.2	15.8	15.8	-	13.8	14.6	14.4	15.4	15.6	15.6	-	-	14.8	14.8	14.4	14.4	14.4	14.8	-	-
Rajka	13.4	13,8	14.2	14.8	-	-	-	-	13.8	14.0	13.2	13.4	-	-	-	-	14.8	14.4	12.0	13.8	14.2	-	-	-
Rebra	12.4	12.6	12.8	12.8	14.8	13.6	13.2	13.2	13.0	12.8	13.4	13.8	13.8	14.2	14.0	-	13.8	13.4	13.4	13.0	12.8	13.2	13.2	12.8
Redix	12.2	12.8	13.4	13.6	13.6	-	-	-	13.6	13.6	13.2	12.4	13.0	-	-	-	12.2	13.6	15.0	13.8	12.0	13.2	-	-
Red Devil	14.4	15.6	15.8	14.8	15.2	15.6	14.8	14,4	15.6	15.6	15.8	16.2	15.6	15.2	15.2	15.0	16.6	15.8	14.8	14.8	14.4	14.4	14.6	14.0
Red Topaz	12.8	12.8	13.2	13.8	14.0	13.4	13.4	-	12.8	13.2	12.6	12.4	12.8	12.8	-	-	14.2	13.4	13.6	13.6	13.2	13.8	14.0	13.8
Rosana	11.0	11.2	11.2	12.8	-	-	-	-	11.2	11.4	10.6	12.6	12.8	-	-	-	15.8	14.2	13.6	13.2	11.8	12.0	-	-
Romus 3	12.0	12.2	13.6	13.4	13.8	-	-	-	12.2	13.2	12.6	11.2	12.8	12.8	-	-	12.4	12.6	12.0	12.2	11.8	12	12.8	-
Rubinola	13.2	13.8	14.0	13.2	13.2	13.0	-	-	14.0	12.4	12.0	12.2	12.8	-	-	-	13.8	16.6	14.6	15.2	16.8	-	-	-
Sirius	13.8	14.4	14.4	15.0	15.2	14.8	16.0	15.8	13.2	14.2	14.2	14.8	15.2	15.8	16.0	16.0	14.2	16.4	15.8	15.8	15.6	15.6	-	-
Svatava	13.8	14.2	14.2	13.8	14.6	14.4	14.8	14.8	14.0	14.0	13.2	13.4	13.8	13.8	14.0	14.2	14.2	14.0	14.2	14.2	13.4	13.8	14.0	13.8
Topaz	12.8	13.4	13.4	14.0	13.8	13.8	13.4	13.4	13.2	14.8	14.4	14.0	14.2	14.4	13.8	13.6	10.8	14.0	15.2	14.2	13.8	14.2	14.0	14.2

Tabel 3. Indicators of quality fruit

Variety	Average fruit weight (g)	Grading size classes (mm)	Fruit colour	Ground colour	Over colour	Type of over color	Amount of over color	Calyx end	Fruit shape	Texture	Juicyness
Ariwa	156,4	60-65	Red	Orange	Red	Stightly blushed	51-75%	Half open	Globose conical	Fine	Rather dry
Ciprian	166.5	70-75	Dark Red	Green	Dark red	Complet over colour	76-100%	Half open	Globose conical	Fine	Juicy
Dalinette	110.6	50-55	Red	Green/ Yellow	Red	Stightly blushed	76-100%	Closed	Globose	Intermediate	Juicy
Dalinred	155.4	70-75	Red	Green/ Yellow	Red	Stightly blushed	76-100%	Half open	Globose	Intermediate	Juicy
Florina	140.5	65-70	Orange/ Red	Yellow	Red	Stightly blushed	51-75%	Closed	Globose conical	Intermediate	Juicy
Generos	174.5	75-80	Orange/ Red	Green-Yellow	Orange	Stightly blushed	51-75%	Closed	Globose	Intermediate	Juicy
Gold rush	173,3	70-75	Yellow/ Orange	Green/ Yellow	Portocaliu	Stightly blushed	1-25%	Open	Conical	Intermediate	Juicy
Iris	189.5	80-85	Red	Yellow	Rosie	Striped	76-100%	Closed	Globose	Intermediate	Juicy
Luna	176.3	70-75	Yellow	Green/ Yellow	Galbena	Stightly blushed	51-75%	Closed	Globose	Intermediate	Very juicy
Opal	186.3	75-80	Yellow	Green/ Yellow	Galbena	Complet over colour	76-100%	Closed	Globose	Intermediate	Very juicy
Orion	188.4	75-80	Yellow	Green/ Yellow	Galbena	Stightly blushed	76-100%	Half open	Globose	Intermediate	Juicy
Rajka	174.2	70-75	Red	Green/ Yellow	Red	Stightly blushed	76-100%	Closed	Globose	Intermediate	Rather dry
Rebra	192.4	75-80	Orange/ Red	Green/ Yellow	Pink	Stightly blushed	51-75%	Open	Globose conical	Intermediate	Juicy
Redix	171.5	70-75	Red	Green/ Yellow	Red	Complet over colour	76-100%	Open	Long conical	Fine	Rather dry
Red Devil	89.8	50-55	Red	Orange	Red	Stightly blushed	76-100%	Closed	Globose	Intermediate	Juicy
Red Topaz	146.7	60-65	Red	Green/ Yellow	Red	Stightly blushed	76-100%	Closed	Globose	Intermediate	Very juicy
Rosana	210.5	80-85	Orange/ Red	Green/ Yellow	Red	Stightly blushed	76-100%	Half open	Globose	Intermediate	Very juicy
Romus 3	145.5	60-65	Red	Green/ Yellow	Red	Stightly blushed	76-100%	Closed	Globose conical	Intermediate	Juicy
Rubinola	181,5	80-85	Red	Orange	Dark red	Complet over colour	76-100%	Half open	Flot	Intermediate	Juicy
Sirius	180.7	75-80	Yellow	Green/ Yellow	Yellow	Complet over colour	76-100%	Closed	Globose	Intermediate	Very juicy
Topaz	232.0	80-85	Orange/ Red	Green/ Yellow	Orange	Striped	51-75%	Closed	Globose	Intermediate	Juicy

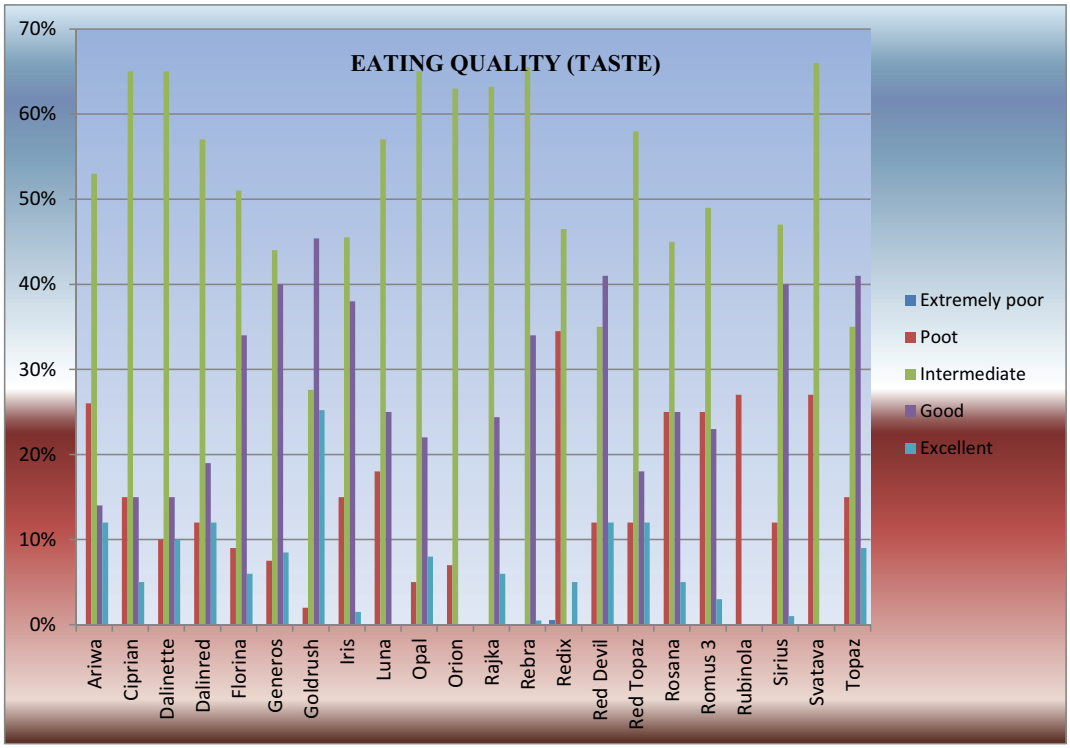

Fig. 2. Eating quality