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CALITATEA FIZICO-CHIMICĂ A FRUCTELOR LA SOIURILE DE PIERSIC (*PRUNUS PERSICA* L.) CULTIVATE LA HOLETA, ETIOPIA
PHYSICOCHEMICAL QUALITY PROPERTIES OF PEACH (*PRUNUS PERSICA* L.) VARIETIES AT HOLETA, ETHIOPIA

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Abstract

Holeta has different peach fruit varieties that can be used for various purposes. However, their fruit quality characteristics were not fully identified. Studies have indicated that the physicochemical qualities of peach fruits are influenced by a number of factors, with the varietal factor being one of the most important. Limited information regarding the factors that affect these qualities is available in the country, specifically at Holeta. Therefore, this study was initiated to evaluate the physicochemical quality properties of peach fruit varieties. Their physical quality traits, such as fruit length, fruit diameter, fruit shape index, and average fruit weight, as well as chemical quality parameters, such as TSS, specific gravity, TA, ripening index, ascorbic acid content, and pH, were evaluated. The results revealed that both physical and chemical quality parameters were significantly affected by varietal factors. Among cultivars, 'Bonny Gold' had the longest fruit length, and 'Florida Down' had the largest fruit diameter. As far as average fruit weight is concerned, 88-18 W had the highest weight with 111.98 g, while Transvalia had the highest TSS and specific gravity. However, the 'Summer Sun' and 9A-35C varieties had the highest TA and ripening index, respectively. Thus, the physicochemical quality properties of the fruit were highly altered with peach varieties.

Cuvinte cheie: fruct, fizico-chimic, calitate, soiuri, SST, AT, index de maturare.
Key words: fruit, physicochemical, quality, varieties, TSS, TA, ripening index.

1. Introduction

Peaches [*Prunus persica* (L.) Batsch] are the world's most widely produced temperate tree fruits after apples and pears (Bassi et al., 2016). Their increased consumption can make them a significant part of the diet, economically and nutritionally significant (Remorini et al., 2008). Peach fruits are rich in carbohydrates, vitamins A and C, and minerals. Peaches can be eaten as fresh fruit and processed into canned fruit, jams, jellies, juices, pulp for yogurts, and liquors (Kelley et al., 2016). Studies have demonstrated that consuming fruits reduces the risk of developing cancer (Berrino and Villarini, 2008), diabetes, cardiovascular diseases, and obesity (Amiot and Lairon, 2008; Bazzano, 2008). In addition to improving energy balance and weight management (Arguin and Tremblay, 2008), their possible benefits have also been mentioned in studies related to neurodegenerative diseases (Singh and Ramassamy, 2008). Their flavor and aroma are produced due to the balance between sugar, phenolic compounds, organic acids, carotenoids, and volatile compounds (Toralles et al., 2008; Veerappan et al., 2021). These attributes influence consumer preference and consumption (Crisosto, 2002). Many of these traits are quantitatively inherited, but their genetic control remains unclear (Eduardo et al., 2011).

Numerous studies have reported significant variations among peach varieties that could be attributed to climatic conditions, geographical zones, crop genetics, and cultural practices (Bassi and Selli, 1990; Di Vaio et al., 2014; Veerappan et al., 2021). Organoleptic qualities such as sweetness, juiciness, and flavor vary among peach varieties (Cano-Salazar et al., 2013). Individual fruits should also be monitored for changes during ripening since the ripening pattern of one cultivar may not be applicable to other varieties within the same species (Goulao and Oliveira, 2008). Due to their possible beneficial effects on health, the biochemical constituents of peaches and other fruits have recently received increased attention (Prior and Cao, 2000). Sucrose is the most available soluble sugar in peaches, followed by glucose and fructose, with lower levels of sorbitol (Brooks et al., 1993). These sugars account for approximately 60% of the soluble sugar content (SSC) in ripe fruit (Cantin et al., 2009). The concentrations of glucose and fructose increase steadily during fruit development, but sucrose accumulates primarily during maturation (Hancock, 1999).

It is crucial to study the information on the overall fruit quality to understand the product's performance throughout the supply chain, even if climatic conditions, cultural practices, variety differences, and maturity stages at harvesting, transportation, and storage conditions influence the physicochemical characteristics of peaches. In relation to varietal diversity in Ethiopian environments, however, there is limited evidence on fruit quality. The highlands of Ethiopia now produce temperate fruits, such as peaches, and demand for them has grown over time. In the meantime, agro-processing businesses are springing throughout the nation, giving peach growers the chance to produce premium fruits that meet consumer demand.

The Holeta Agricultural Research Center has introduced various peach fruit varieties from abroad that perform better in terms of productivity and quality. Although the physicochemical properties of fruits can vary with climate, cultivation practices, and varieties, extensive information on fruit quality with various attributes of relevance is sparse. Assessing the physicochemical characteristics of peach fruits is useful to understand product behavior across the value chain and utilization for the intended purpose. Studying this high-quality information also assists breeders in setting up new breeding programs and identifying the difference between varieties in terms of their suitability for fresh or processed produce. Therefore, this study was designed to evaluate the physicochemical properties of peach fruit varieties.

2. Material and methods

Fruits with uniform maturity stages were collected from different peach varieties at the experimental fields of the Holeta Agricultural Research Center (HARC), which is located in (N9°00', E 38°30'; 2400 m elevation above sea level). The average annual rainfall in the area was 1041.4 mm, and the relative humidity was 58.7%. The average annual minimum and maximum temperatures were 6.7 and 21.7°C, respectively (EIAR, 2017). Fruits were hand-harvested and taken to the Temperate Fruits Research Laboratory at HARC. The fruits were then washed to cool down the field heat, and fifteen fruits with more or less similar maturity were selected and subjected to physicochemical quality assessment. The trial was arranged using a completely randomized design (CRD) and replicated three times. Five fruits were assigned to each plot. Physical parameters such as fruit length, fruit diameter, and fruit weight were first measured for each individual fruit and averaged thereafter. The fruit shape index was also calculated as the ratio of the fruit length to the fruit width (UPOV, 2012). The chemical quality parameters were evaluated using extracted and cleared fruit juices of five fruits per treatment. The titratable acidity was determined using the method of Garner et al. (2005), and the vitamin C content was also measured by the method of Bessy and King (1933). TSS was measured by a digital refractometer (HANNA HI96801), and juice pH was measured by a pH meter (Orion star A211). Finally, specific gravity (SG) was extrapolated from TSS value (Colin, 2017), and the TSS/TA ratio was calculated. An analysis of variance (ANOVA) was performed using SAS software version 9.3 (SAS, 2017). To identify the varieties with substantial differences, the least significant difference (LSD) was utilized.

3. Results and discussions

Physical quality traits of peach fruit varieties

The peach varieties were assessed via the fruit length, fruit diameter, fruit shape, and average fruit weight (Table 1). Peach varieties showed highly significant variation in all of the tested physical quality characteristics. Out of the thirteen tested peach varieties, 46% had fruits longer and wider in diameter than the average (5.29 and 5.31 cm, respectively), while the remaining ones had shorter and less wide fruits. The fruit lengths of these varieties were between 4.85 and 5.81 cm. The 'Bonny Gold' variety had the longest fruit, followed by 'Transvalia' and 'Early Grand', which had 9.80%, 6.77%, and 4.51% over the mean, respectively, while the '9A-35C' variety had the shortest fruits, 8.34% shorter than the grand mean. Peach varieties varied in length at both immature and mature stages since the fruits varied in the amount of accumulated assimilates throughout the growing season (Zohrabi et al., 2013). The length and breadth of the fruit were also found to be significantly influenced by variety (Singh et al., 2016). With regard to the fruit diameter, peach varieties had a fruit diameter ranging from 4.41 to 6.62 cm. The 'Florida Down' variety had the largest fruit diameter, followed by 'Florida Star' and '88-18 W', which had 24.67%, 16.01%, and 8.47% wider fruit diameters, respectively, compared to the grand mean. In comparison, the 'May Crust' variety recorded the smallest fruit diameter, 16.95% less wide than the mean diameter. El-Morshedy et al. (2016) found that the diameter of peach varieties varied from 4.81 cm to 6.40 cm.

Both the length and diameter of the fruit contribute to its shape. Over 53.85% of the varieties tested at HARC had an ovate shape (Table 1). When a fruit’s shape index value is less than one, it is more likely to have a round shape; when it is more, it will have an ovate shape. Fruit size is one potential indicator of fruit maturity; however, it can also be influenced by crop load, climatic conditions, and cultural practices. Fruit shape and/or cheek fullness indicate maturity (Kader and Mitchell, 1989). Stone fruits are considered mature when the fruits have well-developed shoulders and sutures. This criterion, however, must be combined with other indicators, such as skin color, to be reliable (Kader and Mitchell, 1989). The variation in the average fruit weight. The '88-18 W' variety had the heaviest fruit weight of 111.98 g, while the '88-22C' variety had the lowest (58.03 g). Apart from this, in several peach hybrids, fruit weight variations were observed (El-Morshedy *et al.,* 2016). Fruit weight is a significant quantitative inherited factor influencing yield, fruit quality, and consumer acceptability (Dirlewanger et al., 1999). Fruit weight varies greatly between varieties due to differences in tree production and fruit numbers per tree (Abidi et al., 2011).

Chemical quality traits

The results showed that there were statistically significant differences in all of the chemical quality traits among peach varieties (Table 2). Approximately 46.15% of the varieties were recorded to be above the mean for all chemical quality traits except ascorbic acid, which accounted for 30.77% of the varieties. The total soluble solids content (TSS) of these varieties ranged from 10.27 ('McRed') to 16.87°Brix ('Transvalia'). Such variation might be attributed to the formation of different sugars, such as sucrose, glucose, fructose, and sorbitol, and the rapid movement of these sugars from leaves to fruit, which are genetically controlled and regulated by source–sink relationships. According to Brooks et al. (1993), the sugar content varied with genotype, seasonal conditions, yield, position of the fruits in the canopy, and maturity, and similar observations in different peach varieties were reported by Singh *et al*. (1984). Soluble solids contents below 10% are generally unacceptable to consumers (Clareton, 2000). However, this standard may vary from one country to another (Farina et al., 2019).

Similarly, the variety 'Transvalia' recorded the highest specific gravity (1.067), whereas the 'McRed' variety recorded the lowest (1.041). However, ripe peaches typically have a specific gravity of 0.99 (Westwood, 1962). In accordance with these results, Wen et al. (1995) found considerable variation in the specific gravity of ripe fruit among the different peach varieties.

With regard to the titratable acidity (TA), the varieties showed a significant variation with a range of 0.74 ('88-22C') to 1.41% ('Summer Sun'). Titratable acidity in peaches is determined by several factors, among which variety is the most important one (Byrne, 2003). Peaches TA is mainly due to organic acids synthesis, with malic acid being the most abundant, followed by citric, quinic, and succinic, which is mainly governed by genetics. The TA generally ranges from 0.07 to 0.14% in low-acid varieties to 1.1 to 1.45% in acidic varieties (Bassi et al., 2016). When the TA values are lower than 0.9%, it is considered the maximum limit for low-acidity peaches (Hilaire, 2003). On the other hand, consumer satisfaction is mainly attributed to fruit firmness, soluble solid content, and TA (Crisosto et al., 2006), which mainly vary with genotype, cultural practices, climatic conditions, and ripening stages (Bassi et al., 2016).

The highest value of the ripening index, which is directly associated with total soluble solid and titratable acidity, was registered for variety '9A-35C' (16.71), and the lowest one was found for 'Summer Sun' (10.96). According to Voca et al. (2008), the relationship between total soluble solids and total acidity is a very important parameter in determining fruit quality because it provides information on the sugar/acid balance in fruits. Naturally, higher total soluble solids and lower titratable acidity of a variety in comparison with the other varieties caused the highest TSS/TA ratio (Hajilou and Fakhimrezaei, 2011). The ripening index is a major organoleptic quality trait of mature fruit and is commonly used as a quality index in peaches (Bassi and Selli 1990). The relationship between TA and TSS has an important role in consumer acceptance of some apricots, peaches, nectarines, and plum varieties. Crisosto et al. (2005) reported that consumer acceptance is controlled by the interaction between TA and TSS rather than TSS alone.

The maximum ascorbic acid content of 16.67 mg/100 gm was found in the 'Summer Sun' variety, and the minimum level of 8 mg/100 gm was determined in both, the '88-22C' and 'Florida Star' varieties. This result in general revealed that there was a considerable difference in ascorbic acid content among peach varieties (Table 2). The synthesis of ascorbic acid content in fruit depends upon a sufficient supply of hexose sugar, which declines as the ripening progresses (Kumari et al., 2020). Comparably, Gecer (2020) and, Hajilou and Fakhimrezaei (2011) reported statistically significant variations in the vitamin C content of peach varieties.

Peach varieties grown at HARC had pH values ranging from 3.41 to 4.03. Among them, the highest pH value of 4.03 was obtained from a variety of 'May Crust', and the lowest (3.41) was from 'McRed'. This indicated that most of the varieties can be grouped as high-acidity peaches. Peaches have a natural acidity of approximately 3-4 (CFSAN, 2008), and the studied varieties fall within this range. Yoshida, (1970) and Moing *et al*. (1998) reported that the pH of low-acidity peaches is greater than 4.0. Fruit pH is an important quality attribute for peaches and others in general.

Cluster analysis

Complete linkage hierarchical cluster analysis was used to measure the dissimilarity of observations using Euclidean distance measures. Hierarchical cluster analysis (HCA) of the thirteen peach varieties was performed using the ten physicochemical characteristics from the previous literature, as listed in Tables 1 and 2. The Euclidean method was used for the distance calculation for the cluster analysis. Thirteen peach varieties were grouped into four different clusters (Fig. 1). Clusters 1 and 2 were made from two varieties each. Clusters 3 and 4 consisted of six and three varieties, respectively. Most of the chemical properties of 'Florida Down' and 'Florida Star', which were in the same cluster, were not significantly different. However, the rest of the varieties in the same cluster had significantly different physicochemical properties.

Principal Component Analysis

Principal component analysis (PCA) was used to visualize the differences in physicochemical qualities among the thirteen peach varieties. The percentage of the cumulative contribution of variance of the two PCs was 63.1%; PC1 presented 41.1%, and PC2 presented 22.0% (Fig. 2). Fruit length, fruit weight, fruit width, pH, specific gravity, total soluble solids, titratable acidity, and ascorbic acid content were the main contributors to PC1 (positive side). Nevertheless, the ripening index and fruit shape index were on the negative side. On the other hand, the main contributors to PC2 (positive side) were fruit shape index, fruit length, fruit weight, and ascorbic acid content, while ripening index, titratable acidity, total soluble solids, pH, specific gravity, and fruit width were the key contributors to the negative side.

Thus, it was demonstrated that the high ascorbic acid content and heavy and long fruit were all shared by the varieties 'May Crust', 'Summer Sun', and 'Transvalia'. The physical and chemical composition of peach fruit varies significantly depending on the variety, as confirmed by the PCA conducted for this study.

Correlation among physicochemical parameters

The correlation among physicochemical quality parameters of the evaluated peach varieties is presented in Figure 3. Total soluble solids and specific gravity showed a strongly positive correlation. The fruit shape index was highly negatively correlated with fruit width. However, pH was not correlated with the fruit shape index or fruit weight. Generally, most of the parameters were correlated with each other even if the correlation coefficient varied considerably.

4. Conclusions

In general, peach fruit physicochemical quality characteristics were highly influenced by varieties. Hence, this study indicated that these varieties can be considered for various purposes and uses of interest according to their quality profile. However, other factors, such as preharvest management practices, environment, and climatic conditions, may need to be assessed to understand their contribution to physicochemical quality characteristics.

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Tables and figures

Table 1. Fruit length, fruit diameter, fruit shape index, and average fruit weight of peach fruit varieties at Holeta

Variety	Fruit length (cm)	Fruit diameter (cm)	Fruit shape index	Average fruit weight (g)
McRed	5.11 fg	4.62gh	1.11b	71.70 fgh
88-18 W	5.33de	5.76c	0.92e	111.98a
90-19H	5.18def	5.19def	1.00d	63.00hi
9A-35C	4.85 h	4.87 fg	1.00d	75.37efg
Tropic Beauty	5.36cd	5.46cd	0.98de	68.57gh
88-22C	5.15ef	4.98ef	1.04bcd	58.03i
Early Grand	5.53bc	5.16def	1.07bc	88.41c
Florida Down	5.33de	6.62a	0.81f	76.07efg
Florida Star	4.95gh	6.16b	0.81f	63.32hi
May Crust	5.29def	4.41 h	1.20a	78.96def
Summer Sun	5.25def	5.03ef	1.04bcd	85.50cd
Transvalia	5.65ab	5.32de	1.07bc	81.90cde
Bonny Gold	5.81a	5.45cd	1.07bc	97.74b
Mean	**5.29**	**5.31**	**1.01**	**78.50**
LSD (5%)	**0.18**	**0.32**	**0.06**	**8.53**
CV (%)	**1.98**	**3.56**	**3.56**	**6.48**

Means indicated by the same letters within the column have no statistically significant differences (P ≤ 0.05).

Table 2. TSS, SG, TA, TSS/TA, ascorbic acid, and pH of peach fruit varieties at HARC during the 2021 cropping season

Variety	Total soluble solid (°Brix)	Specific gravity (SG)	Titratable acidity (%)	Ripening index (TSS/TA)	Ascorbic acid (mg/100gm)	pH
McRed	10.27 h	1.041 h	0.80 g	12.87def	9.11ef	3.41e
88-18 W	12.33ef	1.049ef	1.03cd	11.98efg	8.89f	3.42e
90-19H	11.40 g	1.045 g	0.94def	12.21efg	10.67c	3.44de
9A-35C	13.67c	1.055c	0.82 fg	16.71a	10.22cd	3.57cd
Tropic Beauty	11.87 fg	1.047 fg	0.95de	12.46defg	9.78de	3.48de
88-22C	11.13 g	1.045 g	0.74 g	15.11b	8.00f	3.49de
Early Grand	12.80de	1.051de	0.85efg	14.98bc	9.33ef	3.46de
Florida Down	14.73b	1.059b	1.21b	12.24efg	8.89f	3.91ab
Florida Star	14.67b	1.059b	1.09bc	13.49cde	8.00f	3.80b
May Crust	13.50cd	1.054cd	1.19b	11.42 fg	9.33ef	4.03a
Summer Sun	15.43b	1.062b	1.41a	10.96 g	16.67a	3.82b
Transvalia	16.87a	1.067a	1.17b	14.45bc	14.22b	3.82b
Bonny Gold	13.10cd	1.052cde	0.96de	13.84bcd	14.67b	3.66c
Mean	**13.21**	**1.053**	**1.03**	**13.29**	**10.60**	**3.64**
LSD (5%)	**0.74**	**0.003**	**0.12**	**1.42**	**0.74**	**0.13**
CV (%)	**3.32**	**0.171**	**7.22**	**6.36**	**4.17**	**2.13**

Means indicated by the same letters within the column have no statistically significant differences (P ≤ 0.05).

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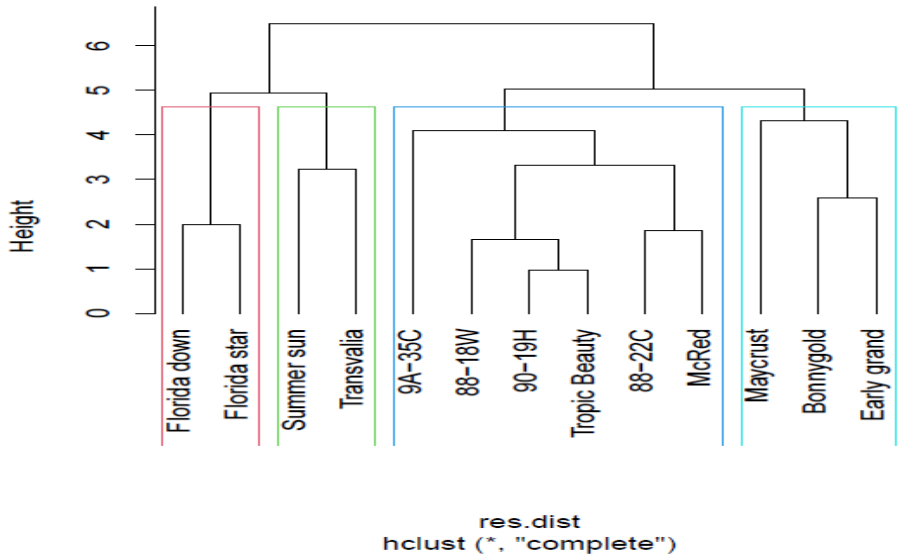

Fig. 1. Complete hierarchical cluster analysis based on a similarity matrix using the Euclidean method of thirteen peach varieties

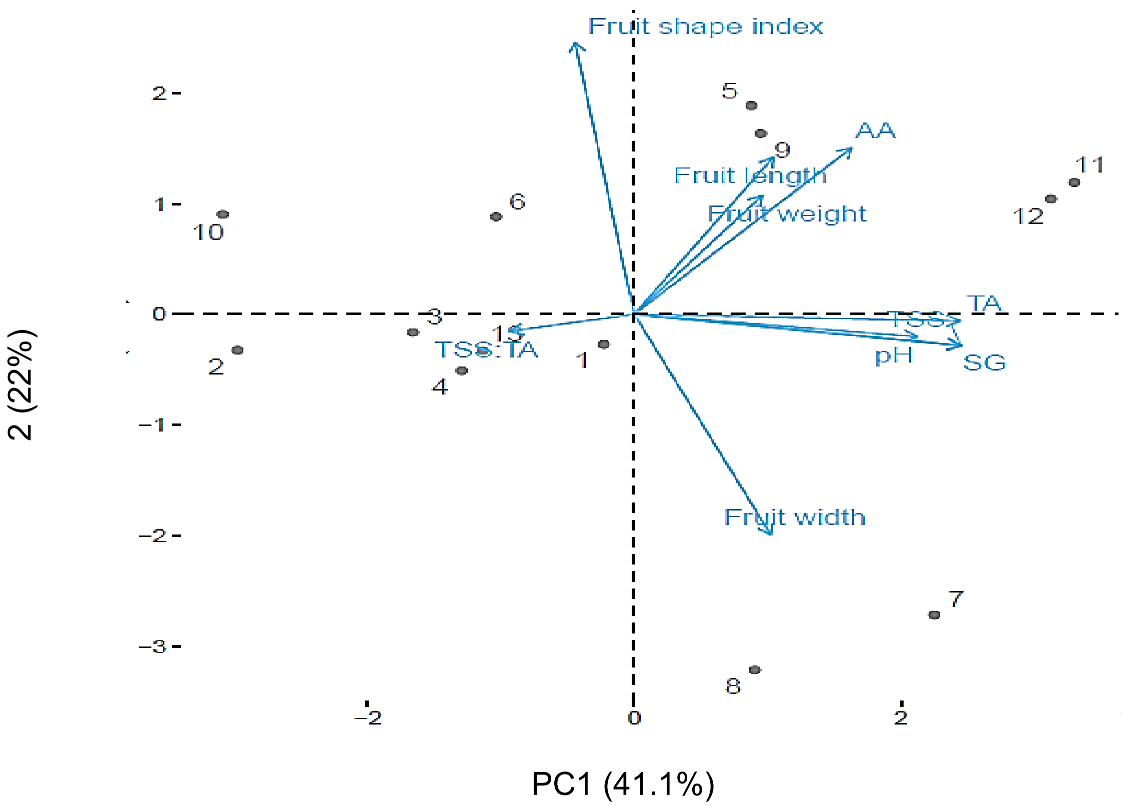

Fig. 2. PCA biplot map illustrating the relationship among the physicochemical properties of thirteen peach fruit varieties; Note: 1=88-18 W, 2=88-22C, 19-90H, 4=9A-35C, 5=Bonny Gold, 6=Early Grand, 7=Florida Down, 8=Florida Star, 9=May Crust, 10=McRed, 11=Summer Sun, 12=Transvalia, 13=Tropic Beauty

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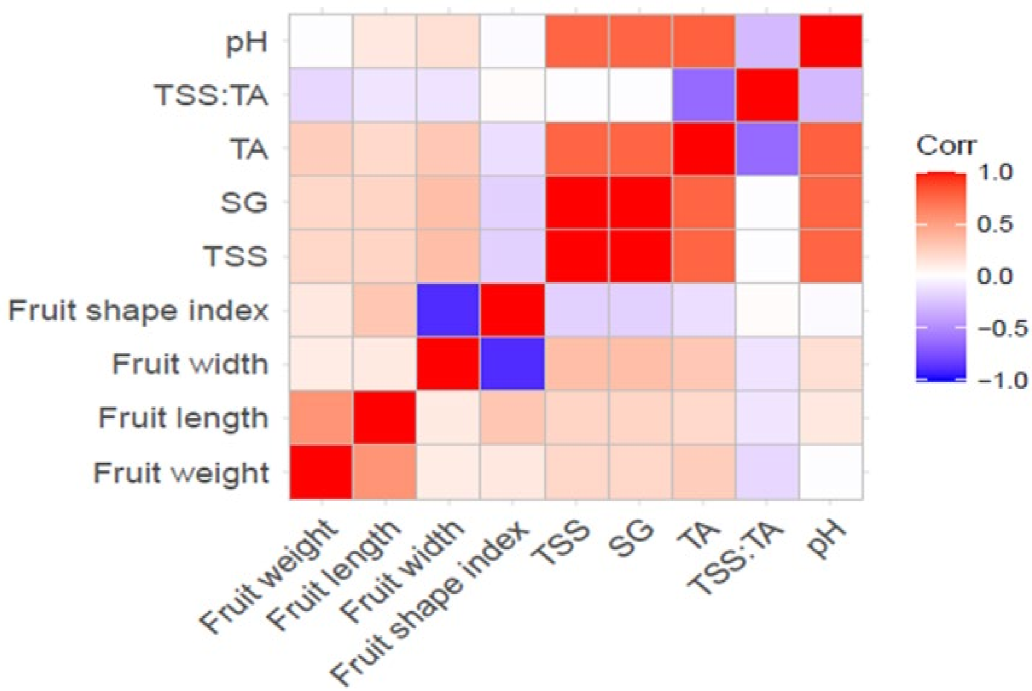

Fig. 3. Correlation among physicochemical properties