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REPEATABILITY, CORRELATION AND PATH ANALYSISOF PHYSICAL AND CHEMICAL CHARACTERISTICS OF PEACH FRUITS[1]

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ABSTRACT - This study aimed to determine the number of measurements necessary to evaluate physical and chemical characteristics of peach fruits, study the relationships between them and their direct and indirect effects on the content of ascorbic acid and total carotenoids. The characteristics skin and pulp color, fruit weight, suture, equatorial and polar diameters, firmness, soluble solids (SS), titratable acidity (TA), SS/TA ratio, ascorbic acid and total carotenoids were evaluated in 39 cultivars of peach and 3 cultivars of nectarine from the orchard of the Universidade Federal de Viçosa. The repeatability coefficient was estimated by ANOVA and CPCOR. Phenotypic correlation coefficients (rf) were estimated and, after the multicollinearity diagnostics, they were unfolded to direct and indirect effects of the explanatory variables on the response variable using path analysis. There was agreement on the magnitude of repeatability coefficients obtained by the two methods; however, they varied among the 14 characteristics. The highest correlations were found between FW, SD, ED and PD. Seven fruits are sufficient to evaluate the physical and chemical characteristics of peach with a correlation coefficient of 90%. The characteristics considered in the path diagrams (b* skin, h° skin, b* pulp, h° pulp, ED, PD, FIR, SS, SS/AT and TC) are not the main determinants of the ascorbic acid. The yellow hue of the pulp (h° pulp) has the potential to be used in indirect selection for total carotenoids.

Index terms: *Prunus persica*, repeatability, fruit quality.

REPETIBILIDADE, CORRELAÇÕES E ANÁLISE DE TRILHA DE CARACTERÍSTICAS FÍSICAS E QUÍMICAS DE FRUTOS DE PESSEGUEIRO

RESUMO - Objetivou-se determinar o número necessário de medições para a avaliação de características físicas e químicas de frutos de pessegueiro e avaliar as relações entre estas, bem como seus efeitos diretos e indiretos sobre o teor de ácido ascórbico e de carotenoides totais. As características cor da casca e da polpa, peso do fruto, diâmetros sutural, equatorial e polar, firmeza da polpa, sólidos solúveis (SS), acidez titulável (AT), relação SS/AT, teor de ácido ascórbico e carotenoides totais foram avaliadas em 39 cultivares de pessegueiro e 3 cultivares de nectarineira pertencentes ao pomar da Universidade Federal de Viçosa. O coeficiente de repetibilidade foi estimado pelos métodos da ANOVA e CPCOR. Foram estimados os coeficientes de correlação fenotípica (rf) e, após o diagnóstico de multicolinearidade, foi feito seu desdobramento em efeitos diretos e indiretos das variáveis explicativas sobre a variável básica, por meio da análise de trilha. Observou-se concordância nas magnitudes dos coeficientes de repetibilidade obtidos pelos dois métodos. No entanto, estes variaram entre as 14 características. Os maiores valores de correlações observados foram entre PF, DS, ED e DP. Sete frutos são suficientes para a avaliação das características físicas e químicas de frutos de pessegueiro com coeficiente de determinação de 90%. As características consideradas nos diagramas de trilha (b* casca, h° casca, b* polpa, h° polpa, DE, DP, FIR, SS, SS/AT e CT) não são as principais determinantes do teor de ácido ascórbico. A tonalidade da cor amarela da polpa (h° polpa) apresenta potencial para ser utilizada na seleção indireta para carotenoides totais.

Termos para indexação - *Prunus persica*, repetibilidade, qualidade de fruto.

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INTRODUCTION

In conducting agricultural experiments various factors like climatic conditions, labor and financial resources, if limiting, complicate the measurement of many characters in many plants. Thus, measurement of these characters through samples is a procedure used in these experiments. However, it is common among researchers questioning about the adequate sample size for the sample that is representative of the population of plants (CARGNELUTTI FILHO et al., 2014).

Estimates of the repeatability coefficient have been used to determine the minimum number of measurements required to access the genotypic value of individuals in "açaí" (*Euterpe Oleracea*) (OLIVEIRA; FERNANDES, 2001), "bacuri" (*Platonia insignis*) (FARIAS NETO et al., 2004), "cupuaçu" (*Theobroma grandiflorum*) (ALVES and RESENDE, 2008) and passion fruit (*Passiflora* spp.) (SANTOS et al., 2010). High estimates of the repeatability coefficient of the characteristic indicate that it is possible to predict the actual value of the individual with a relatively small number of measurements (CRUZ et al., 2012), suggesting that there is little gain in accuracy by increasing the number of measurements.

Correlated responses are common in breeding programs for selection based on variables difficult to measure or when the measurement is expensive. Therefore, understanding the relationship between variables is crucial, since obtaining genetic gains and choosing the best genotypes are often directed to a set of agronomic and commercial variables. Knowledge of these relationships allows the selection of a response variable with low heritability and/or difficulty to measure on the basis of other (s) variable (s), enabling the breeder to obtain more rapid progress in relation to the use of direct selection.

The path analysis proposed by Wright (1921) allows understand better the association between variables and the study of the direct and indirect effects on one basic variable, whose estimates are obtained by regression equations in which the variables are previously standardized. In addition to understanding cause and effect relationships between variables, the unfolding of the correlations is dependent on the set of variables usually chosen by prior knowledge of the breeder, their importance and possible interrelations defined by path diagrams (CRUZ et al., 2012).

The consumption of fruits and vegetables has always been valued for the benefits that these foods can bring to health because of their large amount of vitamins, minerals and fiber that help prevent or delay diseases such as cardiovascular disease and cancer (LUTHRIA et al., 2006; LIM et al., 2007). This protective effect has been attributed to antioxidant action of phytochemicals and among the most studied non-enzymatic antioxidants for possible beneficial health effects are vitamins C and E, carotenoids and flavonoids (BARREIROS et al., 2006).

The stability of vitamin C in foods is affected by heat, light, oxygen and pH (KLEIN, 1987). Further, in the quantification of vitamin C, reagents of high risk handling are used, including sulfuric acid, and in many studies the content of ascorbic acid is determined.

The need for reliable data on food carotenoids is widely recognized in many fields of study. The factors that make this analysis difficult are the large number of naturally occurring carotenoids, their qualitative and quantitative variation in these foods, the small amount of pro-vitamin A carotenoids, their varied biopotency and the fact that carotenoids are highly unsaturated molecules, bringing about processes of isomerization, oxidation and degradation during analysis (RODRIGUEZ-AMAYA, 1999; RODRIGUEZ-AMAYA, KIMURA and AMAYA-FARFAN, 2008).

The objectives of this study were to determine the required number of measurements for the evaluation of physical and chemical characteristics of peach fruits and evaluate the relationships between these characteristics and their direct and indirect effects on the contents of ascorbic acid and carotenoids using path analysis. This information will assist selection in peach breeding programs.

MATERIAL AND METHODS

The study evaluated thirty-nine cultivars of peach and three cultivars of nectarine from the experimental orchard in Viçosa, MG (20°45'S and 42°51'O; 649 m altitude).

Thirty fruits per cultivar were randomly picked when the background color changed from green to yellow-white or cream-white and the following physical and chemical characteristics were evaluated. Fruit weight (FW) in grams (g) was determined using a digital scale accurate to 0.1 g. The skin color was measured at the equatorial region on opposite sides of the fruit and the pulp color was measured in the central part on one side of the fruit pulp. The color coordinates b* and h° were determined by a Minolta Color Reader CR-10 reflectometer, which gives readings of L*, a* and b*, C and h°. The b* readings range from blue

(-60) to yellow (+60) and the h° [h = arctan (b* / a*)] places the red at an angle of 0° and yellow, green and blue at 90°, 180° and 270°, respectively (McGUIRRE, 1992). On each fruit, suture diameter (SD) (maximum transversal distance from the suture to the opposite face), equatorial diameter (ED) (maximum transversal distance perpendicular to the suture) and polar diameter (PD) (distance from the apex to the stalk cavity) were measured (mm) using a Mitutoyo DL-10 digital caliper. Pulp firmness (N) was measured on the equatorial region of one of the faces of each fruit after skin removal, using a digital Effegi penetrometer (TF-011) with an 8 mm diameter plunger tip. Soluble solids content (SS) in °Brix of the juice manually squeezed from one equatorial face of each fruit was determined using an ATAGO digital refractometer (Palette PR-101). Titratable acidity (TA) was obtained by titrating 5 g of ground pulp plus 95 ml distilled water with NaOH solution and expressed as percentage of malic acid. The ratio soluble solids and titratable acidity (SS/TA) was calculated. The ascorbic acid content in the pulp (Vit C) was determined by titration with Tillman's reagent [2,6 dichlorophenolindophenol (sodium salt) 0.1%] according to AOAC (1997) and results expressed in mg of ascorbic acid per 100 g pulp. Carotenoids (TC) were extracted from approximately 2 g of pulp macerated with cold 80% acetone (4 °C) and absorbance was read in a spectrophotometer at 470, 646.8 and 663.2 ηm. Carotenoid contents were determined by the equations of Lichtenthaler (1987) in $\mu g.mL^{-1}$ extract. The results were multiplied by 25 and divided by the mass of pulp and expressed in mg/100g pulp.

Estimates of the repeatability coefficients ($\hat{r}$) were obtained by analysis of variance with a single factor (one-way ANOVA) and principal component analysis (PC) based on the correlation matrix (CPCOR). These methods are described in Abeywardena (1972), Rutledge (1974) and Cruz et al. (2012).

Estimates of phenotypic correlation coefficients were calculated by the Pearson's method (STEEL;TORRIE, 1960) and tested at 1 and 5% probability by the *t* test with n-2 degrees of freedom and determined for all combinations of characteristics to obtain information on the nature and intensity between them. Then, it was carried out the multicollinearity diagnostics and the unfolding of the phenotypic correlation into direct and indirect effects using path analysis, according to the methodology described by Cruz et al. (2012).

For estimation of the path coefficients were considered two diagrams showing the cause-effect relationships between the basic variable and the explanatory variables. In the first diagram was adopted ascorbic acid (Vit C) as the basic variable and in the second diagram total carotenoids (TC), and the other traits were considered the explanatory variables.

All analyses were performed using the GENES software (Cruz, 2013).

RESULTS AND DISCUSSION

Table 1 shows the estimates of the coefficient of repeatability (r), coefficient of determination (R^2) and the minimum number of measurements (η_0) for the evaluations carried out using the one-way ANOVA and principal components based on the correlation matrix (CPCOR). There was agreement on the magnitude of repeatability coefficients obtained by the two methods. When using the two methods, the estimates of the coefficient of repeatability (r) were high, as in Resende (2002), who ranked r ≥ 0.6 as high, except for fruit weight (FW) and equatorial diameter (ED).

The repeatability coefficients estimated by ANOVA were always lower or equal to those obtained by CPCOR (Table 1). However, these differences were small and, in most cases, without change in the number of measurements for the same level of accuracy. The same was true for passion fruit (SANTOS et al., 2010).

Fruit weight (FW), suture diameter (SD), equatorial diameter (ED), polar diameter (PD) and firmness (FIR) had repeatability coefficients between 0.57 and 0.70, regardless of the estimation method (Table 1). These results corroborate to those obtained by Albuquerque et al. (2004) in peach and nectarine during two years of evaluation. However, repeatability coefficients found by Danner et al. (2010a) were from 0.72 to 0.74 for FW in peach, in 30 measurements, using different methods.

The repeatability coefficients for soluble solids (SS) were 0.64 and 0.66, by ANOVA and CPCOR methods, respectively. These values are similar to those reported by Danner et al. (2010b) obtained from the measurement of 20 fruits of araçá (*Eugenia spitata*) (0.65), but are much lower than those obtained from the evaluation 2-15 fruits/matrix of bacuri (*Platonia insignis*) (0.92) by Souza et al. (2001).

TC, TA and b* of skin and pulp, regardless of the estimation method, had the most accurate assessments, with estimates of repeatability coefficients ranging from 0.79 to 0.83 and coefficients of determination (R^2) between 99.15 and 99.36%, indicating greater accuracy in predicting the actual value of these characteristics in peach. In studies with bacuri (SOUZA et al., 2001) and acerola cherry (*Malpighia emarginata*) (LOPES et al., 2001), characteristics linked to fruit morphological aspects also showed repeatability coefficients of high magnitude ($r > 0.70$).

The estimates of the coefficients of determination obtained for the 14 characteristics and by the two methods were greater than 97% (Table 1), showing that the evaluation of the characteristics can be performed with high reliability. However, within the acceptable levels of accuracy, we should seek to reduce the evaluation period and the number of measurements for saving time and resources (Chia et al., 2009).

The evaluation of 3 fruits, regardless of the estimation method, is sufficient to predict the actual value of all characteristics with 80% reliability. To select genotypes with 90% determination of the actual value, the number of measurements required ranged from 1 to 7 among the 14 characteristics (Table 1), which is a sample size smaller than the one used in this study. Higher levels of accuracy may require much larger samples and increase costs (OLIVEIRA; FERNANDES, 2001), which makes the evaluation difficult.

The highest correlations (above 0.87) were observed between the variables FW, SD, ED and PD (Table 2). The same was true for peach during two years of evaluation (ALBUQUERQUE et al., 2004). The authors discuss that the improvement of fruit physical characteristics can be done on the basis of selection for fruit diameter and low diameter (ED)/length (PD) ratio. Such correlations are important and can greatly facilitate the study of selection in passion fruit. The selection of plants with heavy fruits can be done from the measurement of the equatorial diameter in the field, not requiring to weight them (NEGREIROS et al., 2007).

Firmness (FIR) showed the highest significant correlation (0.60) with ascorbic acid (Vit C) (Table 2). The others, though some are significant, showed low correlation coefficients, such as the correlation between TA and Vit C (0.04). The same was found by Silva et al. (2013) in peach (0.07).

Pulp h° (-0.74) stands out among the characteristics associated with total carotenoids (TC), indicating that fruit pulp with lower h° have larger amounts of total carotenoids (Table 2). The concentration of total carotenoid determines the yellow color of the pulp in siriguela (*Spondias purpurea*), which was confirmed by colorimetric analysis (COSTA et al., 2010), and the variation in pulp color between varieties of orange is due to variation in the amount of the different carotenoids (GAMA; SYLOS, 2005).

The multicollinearity diagnostics between the explanatory variables and the basic variables ascorbic acid (Vit C) and total carotenoids (TC) indicated severe collinearity and variables FW, SD and TA as redundant. These variables were removed from the path analysis (Tables 3 and 4).

From the first causal diagram (Table 3), with low determination coefficient ($R^2 = 0.57$) and high residual effect (0.66), the path analysis showed that the explanatory variables (skin b*, skin h°, pulp b*, pulp h°, ED, PD, FIR, SS, SS/AT and TC) in this model are not the main determinants of ascorbic acid (Vit C). Although some correlation coefficients between explanatory variables and the basic variable were significant, their direct and indirect effects did not exceed the residual effect. Results obtained by Nunes et al., (2004) with acerola indicated the variable TA as the main determinant of vitamin C content, contradicting the results presented by Gomes et al. (2000), who recommended the selection based on SS for gains in vitamin C in acerola.

The second causal diagram had a high coefficient of determination ($R^2 = 0.85$), indicating that the explanatory variables (skin b*, skin h°, pulp b*, pulp h°, ED, PD, FIR, SS, SS/AT and Vit C) in this model are the main determinants of the basic variable total carotenoids (TC) (Table 4). Pulp h° with a correlation coefficient of -0.74 and a direct effect of -0.79 and pulp b* with a correlation coefficient of 0.47 and a direct effect of 0.45 stand out among these characteristics. This is important because the evaluation of the yellow hue (pulp b* and pulp h°) using a colorimeter is less expensive and easier to carry out. Spectrophotometric methods described in the literature for determination of carotenoids are accurate, but very laborious to evaluate numerous progenies, requiring the use of an excessive amount of reagents and time (Carvalho et al., 2005). In tomato, studies investigating the intensity of correlation between chromaticity and pigment concentrations have shown good correlation between fruit color and lycopene content, the predominant carotenoid in this fruit (D'SOUZA et al., 1992; ARIAS et al., 2000).

The remaining explanatory variables generally had significant correlation with total carotenoids, but associated with low direct effects and, in some cases, higher indirect effects were observed via pulp h°, such as for SS, SS/TA and Vit C.

TABLE 1 - Estimates of repeatability coefficients (r), coefficients of determination (R^2) and the minimum number of measurements (η0), using the method of analysis of variance (ANOVA) and principal components analysis based on the correlation matrix (CPCOR), for the characteristics of skin color (skin b* and skin hº), pulp color (pulp b* and pulp hº), fruit weight (FW), suture diameter (SD), equatorial diameter (ED), polar diameter (PD), firmness (FIR), soluble solids (SS), titratable acidity (TA), SS/TA ratio, ascorbic acid (Vit C) and carotenoid content (TC) in 30 measurements of 39 cultivars of peach and 3 cultivars of nectarine. UFV, Viçosa-MG.

	$\hat{r}$		R^2 (%)		η_0			
					ANOVA		CPCOR	
Characteristic	ANOVA	CPCOR	ANOVA	CPCOR	80%	90%	80%	90%
skin b*	0.83	0.83	99.31	99.33	1	2	1	2
skin hº	0.75	0.75	98.88	98.92	2	4	2	3
pulp b*	0.80	0.81	99.16	99.21	2	3	1	3
pulp hº	0.77	0.79	99.03	99.10	2	3	2	3
FW	0.57	0.58	97.59	97.62	3	7	3	7
SD	0.62	0.62	97.97	97.99	3	6	3	6
ED	0.59	0.59	97.72	97.77	3	7	3	7
PD	0.69	0.70	98.55	98.59	2	4	2	4
FIR	0.60	0.61	97.83	98.79	3	6	3	6
SS	0.64	0.66	98.20	98.28	3	5	3	5
TA	0.81	0.81	99.21	99.24	1	3	1	3
SS/TA	0.68	0.69	98.49	98.56	2	5	2	4
Vit C	0.72	0.74	98.75	98.83	2	4	2	4
TC	0.79	0.84	99.15	99.36	2	3	1	2

TABLE 2 - Phenotypic correlations between 14 characteristics assessed in 39 cultivars of peach and 3 cultivars of nectarine. UFV, Viçosa-MG.

Variables(1)	skin b*	skin h°	pulp b*	pulp h°	FW	SD	ED	PD	FIR	SS	TA	SS/AT	Vit C	TC
skin b*	1	0.67**	0.49**	-0.29	0.34*	0.30	0.36*	0.37*	-0.29	0.26	0.19	-0.23	-0.45**	0.48**
skin h°		1	0.09	0.05	0.27	0.22	0.30	0.37*	-0.24	0.36*	0.06	-0.05	-0.34*	0.14
pulp b*			1	0.00	0.32*	0.33*	0.36*	0.29	-0.28	-0.10	-0.06	-0.06	-0.33*	0.47**
pulp h°				1	0.00	0.08	-0.04	0.05	0.14	-0.49**	-0.56**	0.56**	0.25	-0.74**
FW					1	0.97**	0.97**	0.92**	-0.48**	-0.11	0.06	-0.20	-0.32*	0.31*
SD						1	0.92**	0.88**	-0.38*	-0.27	-0.01	-0.14	-0.24	0.23
ED							1	0.87**	-0.59**	-0.042	0.01	-0.17	-0.47**	0.39**
PD								1	-0.43**	-0.02	0.04	-0.15	-0.30	0.32*
FIR									1	0.03	0.07	0.09	0.60**	-0.37*
SS										1	0.45**	-0.27	-0.24	0.39*
TA											1	-0.94**	0.04	0.36*
SS/AT												1	0.05	-0.43**
Vit C													1	-0.50**
TC														1

(1) skin b*, skin h°, pulp b*, pulp h°: coordinates of color of skin and pulp; ED: equatorial diameter (mm); PD: polar diameter (mm); FIR: firmness (N); SS: soluble solids (°Brix); SS/TA: ratio of soluble solids and titratable acidity; TC: total carotenoids (mg/100 g pulp) * ** Significant at 5 and 1% probability level by the *t* test, respectively.

TABLE 3 - Path analysis of 39 cultivars of peach and 3 cultivars of nectarine, involving the response variable (ascorbic acid) and the explanatory variables, with unfolding of phenotypic correlations into components of direct effect (main diagonal, bold) and indirect effect (off-diagonal)

Variables(1)	skin b*	skin h°	pulp b*	pulp h°	ED	PD	FIR	SS	SS/TA	TC	Total
skin b*	**-0.20**	-0.02	0.03	0.06	-0.17	0.17	-0.10	-0.04	0.03	-0.18	-0.45**
skin h°	-0.14	**-0.04**	0.01	-0.01	-0.14	0.16	-0.09	-0.06	0.01	-0.05	-0.34
pulp b*	-0.10	0.00	**0.06**	0.00	-0.17	0.13	-0.10	0.02	0.01	-0.18	-0.33*
pulp h°	0.06	0.00	0.00	**-0.19**	0.02	0.02	0.05	0.08	-0.08	0.28	0.25
ED	-0.07	-0.01	0.02	0.01	**-0.47**	0.39	-0.21	0.01	0.02	-0.15	-0.47**
PD	-0.07	-0.01	0.02	-0.01	-0.41	**0.45**	-0.16	0.00	0.02	-0.12	-0.30
FIR	0.06	0.01	-0.02	-0.03	0.28	-0.19	**0.36**	-0.01	-0.01	0.14	0.60**
SS	-0.05	-0.01	-0.01	0.09	0.02	-0.01	0.01	**-0.17**	0.04	-0.15	-0.24
SS/TA	0.05	0.00	0.00	-0.11	0.08	-0.07	0.03	0.05	**-0.14**	0.17	0.05
TC	-0.10	0.00	0.03	0.14	-0.19	0.14	-0.13	-0.07	0.06	**-0.38**	-0.50
R^2	0.57										
Residual Effect	0.66										

(1) skin b*, skin h°, pulp b*, pulp h°: coordinates of color of skin and pulp; ED: equatorial diameter (mm); PD: polar diameter (mm); FIR: firmness (N); SS: soluble solids (°Brix); SS/TA: ratio of soluble solids and titratable acidity; TC: total carotenoids (mg/100 g pulp) ** Significant at 5 and 1% probability level by the *t* test, respectively.

TABLE 4 - Path analysis of 39 cultivars of peach and 3 cultivars of nectarine, involving the response variable (total carotenoids) and the explanatory variables, with unfolding of phenotypic correlations into components of direct effect (main diagonal, bold) and indirect effect (off-diagonal).

Variables[1]	skin b*	skin h°	pulp b*	pulp h°	ED	PD	FIR	SS	SS/TA	Vit C	Total
skin b*	**-0.19**	0.08	0.22	0.23	-0.03	0.10	0.00	0.01	-0.01	0.06	0.48**
skin h°	-0.13	**0.11**	0.04	-0.04	-0.02	0.10	0.00	0.01	0.00	0.05	0.14
pulp b*	-0.09	0.01	**0.45**	0.00	-0.03	0.08	0.00	0.00	0.00	0.05	0.47**
pulp h°	0.06	0.00	-0.00	**-0.79**	0.00	0.01	0.00	-0.02	0.03	-0.03	-0.74**
ED	-0.07	0.03	0.16	0.03	**-0.07**	0.24	0.00	0.00	-0.01	0.06	0.39*
PD	-0.07	0.04	0.13	-0.04	-0.06	**0.28**	0.01	0.00	-0.01	0.04	0.32*
FIR	0.05	-0.03	-0.12	-0.11	0.04	-0.12	**-0.01**	0.00	0.00	-0.08	-0.37*
SS	-0.05	0.04	-0.04	0.39	0.00	-0.01	0.00	**0.04**	-0.01	0.03	0.39*
SS/TA	0.04	-0.01	-0.03	-0.44	0.01	-0.04	0.00	-0.01	**0.05**	-0.01	-0.43**
Vit C	0.08	-0.04	-0.15	-0.20	0.03	-0.08	-0.01	-0.01	0.00	**-0.14**	-0.50**
R^2	0.85										
Residual	0.39										
Effect											

[1] skin b*, skin h°, pulp b*, pulp h°: coordinates of color of skin and pulp; ED: equatorial diameter (mm); PD: polar diameter (mm); FIR: firmness (N); SS: soluble solids (°Brix); SS/TA: ratio of soluble solids and titratable acidity; Vit C: ascorbic acid content (mg/100 g pulp). * ** Significant at 5 and 1% probability level by the *t* test, respectively.

CONCLUSIONS

Seven fruits are sufficient to evaluate the physical and chemical characteristics of peach with a correlation coefficient of 90%.

The yellow hue in peach is associated with total carotenoids.

The physical and chemical characteristics considered in the path diagrams (skin b*, skin h°, pulp b*, pulp h°, ED, PD, FIR, SS, SS/AT and TC) are not the main determinants of ascorbic acid.

The yellow hue of the pulp (pulp h°) has the potential to be used in indirect selection for total carotenoids.

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