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Principal component analysis (PCA) of physio-chemical components in different pumpkin (*Cucurbita moschata* Duch.) accessions

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Abstract
Pumpkin (*Cucurbita moschata* Duch.) is an immense fruit with varied chemical composition and nutritional value. The aim of the study was to decide the major contributing physiochemical properties that explain the variations in different pumpkin accessions by applying principal component analysis. Thus the study revealed that starch, moisture, total solids, reducing sugar, total carbohydrate and TSS were the principal component of pumpkin accessions followed by flesh thickness, fruit weight and fruit equatorial diameter.

Keywords: *Cucurbita moschata*, physiochemical properties, principal component analysis

Introduction
The pumpkin (*Cucurbita moschata* Duch.) belongs to the family cucurbitaceae is native to tropical and subtropical America which is widely grown and consumed all over the world. The genus *Cucurbita* includes many species, but *Cucurbita moschata*, *Cucurbita maxima* and *Cucurbita mixta* are the three major cultivated species in India. *Cucurbita moschata* is widely cultivated in all parts of India with an area of about 78,000 ha and production of 17,14,000 MT (Anon., 2018) [1]. It is believed as healthy and functional vegetable because of its rich source of vitamins, minerals, pectin, dietary fiber and important antioxidants such as carotenoids, lutein, zeaxanthins and other abundant polyphenolic compounds (Yadav *et al*., 2010) [14]. Considering its low cost of production, it can be easily cultivated by marginal and poor farmers. It is a good and cheaper source of vitamin A to fight against malnutrition and night blindness when compared to carrot which necessitates specific climatic requirement for its production and high productivity per unit area. In recent times, pumpkin has got industrial importance with the development of pulp powder as a nutraceutical supplement to vitamin A requirement, offering consumers foods that have long shelf-life and good nutritional value. Thus knowing the chemical composition of pumpkin offers the scope for the commercialization of the crop which in turn positively reflects on the economic status of farming community. Hence this study was undertaken to decide the major contributing physiochemical properties that explain the variations in different pumpkin accessions.

Materials and Methods
The PCA model was applied to all data obtained from physiochemical properties of twenty-five different pumpkin accessions. It was to determine the major contributing physiochemical properties that explain the variations in twenty-five different pumpkin accessions.

Results and Discussion
PCA of physio-chemical components
The proportion of variation explained by each eigenvalue is given in Table 1. The first component explained 29% of variation. The second and third component explained 45% and 56% of variation respectively. Thus the first seven significant principal components explained 84% of variation in the 25 pumpkin accessions. This is an acceptably large percentage.

Table 1: Eigenvalue of principal components

Components	Eigenvalue	Percentage of variance	Cumulative percentage of variance
Component 1	6.989	29.121	29.121
Component 2	3.839	15.997	45.118
Component 3	2.778	11.574	56.692
Component 4	2.419	10.078	66.769
Component 5	1.954	8.140	74.910
Component 6	1.292	5.382	80.292
Component 7	1.023	4.263	84.555

Screeplot (Fig. 1) is an alternate method to determine the number of principal components. It plots the eigenvalues ordered from the largest to the smallest one.

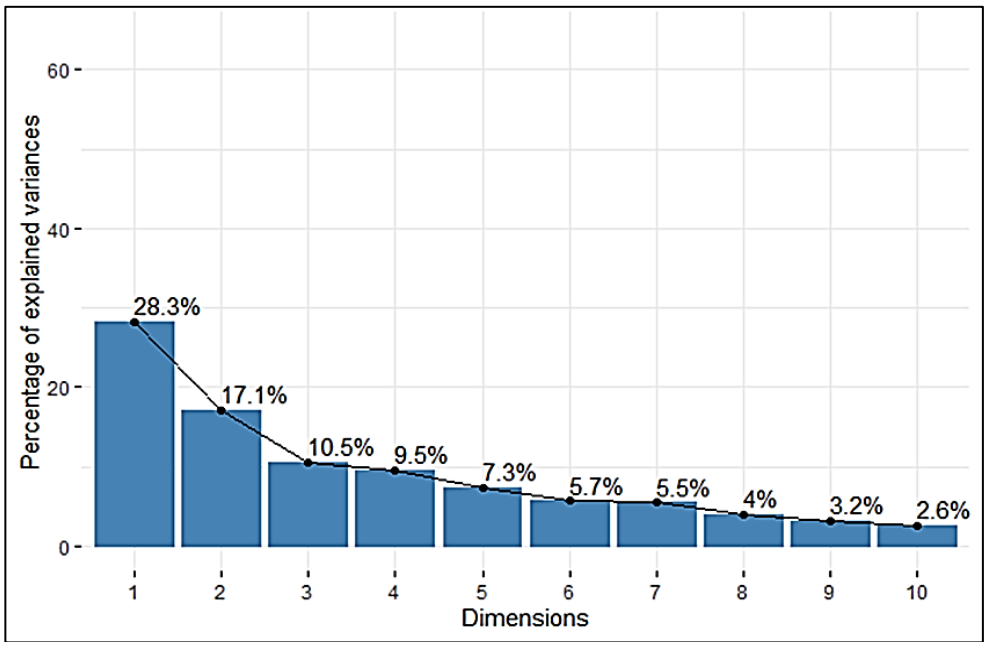

Fig 1: Percentage of variances explained in each dimension

Fig. 2 projects all the twenty-four variables onto the 2-dimension factor space of 2-dimension circle. It explains the correlation between variables as highly correlated when the two lines pointing in same direction, unrelated when they are orthogonal and negatively correlated when they are opposite in direction. Among the twenty-four variables, fruit weight and fruit polar diameter, fruit weight and fruit equatorial diameter, flesh thickness and flesh recovery, total carbohydrates and starch are positively correlated whereas, moisture and total carbohydrates, moisture and total solids, starch and reducing sugar, titrable acidity and TSS are negatively correlated. This is in line with the findings of Brothakar *et al*., (2002) [3], Mandal *et al*., (2012) [8] and Wongmetha *et* al., (2015) [13] who found that starch and reducing sugars are negatively correlated due to hydrolysis of starch to sugars during respiration. Similarly, titrable acidity and TSS are negatively correlated, which is similar to findings of Fawole and Opara (2013) [4] and Jimenez *et al*., (2011) [6] who reported that total soluble sugars increases with decrease of titrable acidity due to the advancement of maturity.

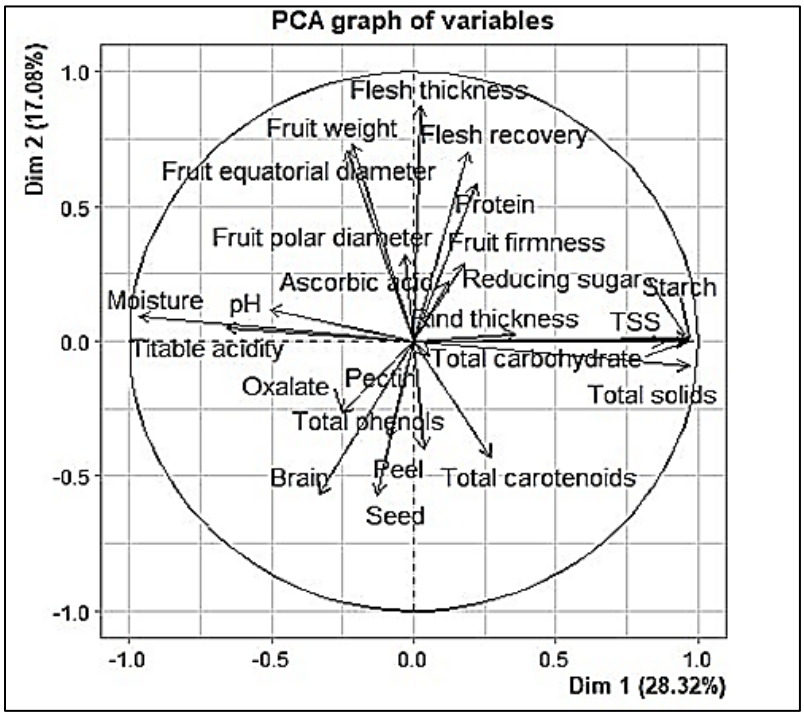

Fig 2: Correlation of variables in 2-dimension plot

Fig. 3 explains the variables contributing to each principal component. The physio-chemical components of pumpkin such as starch, moisture, total solids, reducing sugar, total carbohydrate and TSS has major contribution in first principal

component. Flesh thickness, fruit weight and fruit equatorial diameter contribute to the second component. Similarly Rosenfeld *et al*., (1998) [10] described root weight; root diameter and carotene content are the principal component of physiochemical characteristics of carrot grown at three geographical location carrot which explained 53-65% of total variation. Nowicka *et al*., (2019) [9] conducted PCA for physiochemical characteristics of different cultivar of peach fruit and determined maturity index, ash, polyphenols and organic acids as the most important variables which explained all the twenty cultivar of peach fruit.

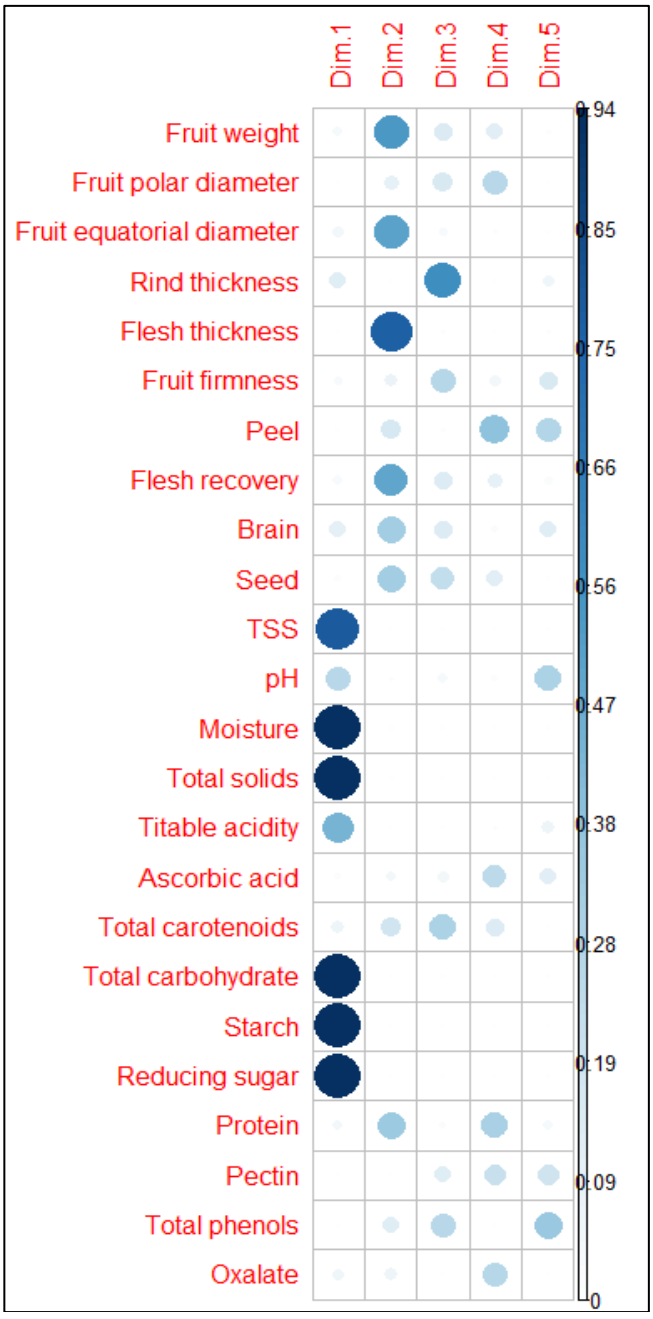

Fig 3: Correlation plot

Conclusion

Principal component analysis screens down the number of major contributing physiochemical properties in the pumpkin accessions. Thus the findings conclude that starch, moisture, total solids, reducing sugar, total carbohydrate and TSS followed by flesh thickness, fruit weight and fruit equatorial diameter are the most affecting variables of pumpkin accessions. Hence to select a pumpkin accession, taking account of these principal components are enough, since it explains 84% of the variation in the pumpkin accessions.

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