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# Assessing the Broccoli (*Brasicca oleracea* var. *italica*) Hybrids for Physico-Chemical Constituent and Suitability for Dehydration

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**ABSTRACT**

*Four broccoli hybrids, namely Packman, Suhani, Altar and CLX 35100 were assessed to find out suitability of their floret and stalk for dehydration and to know the variation in their physical-chemical constituents. Broccoli florets showed 1.3 times more ascorbic acid and 3 times more total chlorophyll content in comparison to the stalk portion. Florets of hybrid Suhani recorded higher content of total chlorophyll, total carotenoids, total phenols and antioxidant activity and also had better drying and rehydration ratio and less in non enzymatic browning as compared to Packman, Altar and CLX 35100. The stalk portion was found to have considerable amount of physico-chemical constituents. But, the values were manifold lesser than the respective value belonging to that of floret portion in all the hybrids of broccoli. Similarly, dehydrated florets and stalk obtained from hybrid Suhani was found to retain better nutritional quality and sensory score in comparison of dehydrated product obtained from Packman, Altar and CLX 35100, respectively.*

***Key words:*** *Broccoli, Floret, Stalk, Ascorbic acid, Chlorophyll, Antioxidants, Dehydration*

## INTRODUCTION

Broccoli (*Brassica oleraceae* var *italica*) being a gold mine of phytochemicals and natural antioxidants such as ascorbic acid, β-carotene, tocopherols, phenolics, flavonoids and glucosinolates, it helps in reducing the risk of cardio vascular diseases, diabetes and curing of cancers[31]. Consumption of 150 g of broccoli per day satisfies an adult's requirements for vitamins E, A, $B_1$ and C and boosts the immune system[4].

Broccoli hybrids have been found to vary in their content of bioactive components[23]. Among different varieties of broccoli evaluated for their antioxidant and vitamin levels, they found to vary as twofold (ascorbate) and 10-fold (carotenoids)[9]. Apart from plant genetics plant parts have also been shown to affect bioactive components in different cultivars of broccoli[7].

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As a general practice, the heads of broccoli are consumed and the stalks are thrown away. However, stalks are much delicious, healthy and rich in nutrient as much as head. Most of the β carotene is generally stored in the floret part, but stalk is also found rich in other nutrients such as calcium, iron, magnesium, thiamin, riboflavin, niacin, vitamin C and so on[21].

Broccoli is a perishable vegetable prone to rapid post harvest deterioration caused by desiccation, loss of nutrients, discoloration and development of decay. Most postharvest methodologies such as blanching, drying and have been directed to delaying the senescence and consequent degreening.

Keeping the above points in view, the present study was designed to evaluate the selected broccoli hybrids to assess their physico-chemical constituent and their suitability for dehydration.

## MATERIAL AND METHODS

The heads of broccoli in uniform size and diameter (10- 15cm) of four hybrids *viz.*, Packman, CLX-35100, Altar and Suhani grown under the field conditions of Centre for Protected Cultivation Technology, IARI were used for experiment. The heads were separated into florets and stalk. Each floret was cut into 4 equal size pieces (quarter) and the stalks were cut into 2.5 cm length and 1 cm diameter. The samples were then dried in the cabinet drier (58 ± 2°C) to final moisture content of 5 to 7 per cent. Physico-chemical parameters like Moisture content, ascorbic acid, total chlorophyll, rehydration ratio, drying ratio and NEB was determined as per procedure[24] and different methodology was used to analyze total carotenoids[30], total phenols[29] and total antioxidants[2]. For sensory evaluation a panel of 7 judges was requested to evaluate the rehydrated samples using a 9 point hedonic scale as per standard procedure[6]. The data were analysed as per procedure factorial CRD using PROC GLM of SAS. If the factorial effects are found to be significantly different through ANOVA, then these were subjected to Duncan multiple range test (DMRT) procedure using least significant difference at 5% level significance. The values for chemical parameters are expressed in dry weight basis.

## RESULTS AND DISCUSSION

### A. Physico-chemical constituents of broccoli floret.

Among the four hybrids moisture percentage was higher (89.32%) in Altar and lower in Suhani (86.80%) hybrid, whereas, the moisture content was recorded (87.83%) in Packman and (88.57%) in CLX 35100 (Table 1). The variation in moisture content may be due to variation of dry matter present in the florets of broccoli hybrids. The values for moisture content are in accordance with the findings[28].

Among the four hybrids of broccoli ascorbic acid content varied from 685.49 to 874.24 mg/100g. Suhani recorded higher value of ascorbic acid content (874.24 mg/100g), while Altar had lower level of ascorbic acid content (685.49 mg/100g). Ascorbic acid content in Packman and CLX 35100 was (857.11mg/100g) and (768.15 mg/100g) respectively (Table 1). The variation observed for ascorbic acid content was in agreement with the findings[7,12]. The huge variation in the ascorbic acid content may be due to various factors like cultivars and growing season[14].

A perusal of data in Table 1 reveals that, a significant variation in chlorophyll content was noticed among the four hybrids. Chlorophyll content (139.95 mg/100g) in the florets of Suhani was 3 fold higher than that of (47.09 mg/100g) in Packman floret. The values for chlorophyll content in Altar and CLX 35100 were (135.95 mg/100g) and (57.07 mg/100g), respectively. The variation in the total chlorophyll content among broccoli hybrids may be due to season, developmental stage of broccoli heads[14]. Similar findings have been reported in different cultivars of broccoli[32,19].

Total carotenoids were marginally higher in Suhani (31.52 mg/100g) followed by

Altar (31.14 mg/100g), CLX 35100 (24.24 mg/100g) and Packman (24.09 mg/100g) (Table 1). The high content of total carotenoids in the hybrid Suhani might be due to low moisture content[3,8]. Florets of Suhani recorded highest (361.76 mg GAE/100g) total phenolic content when compared to (314.65 mg GAE/100g) in Packman, (291.46 mg GAE/100g) in CLX 35100 and (255.69 mg GAE/100g) in Altar, respectively (boxplot 1). The variation in the total phenolic content might be due to different cultivars, growing season and dry matter content[22,26].

The values pertaining to total antioxidant activity showed a significant variation among four hybrids (box plot 2). The antioxidant activity was maximum in hybrid Suhani (569.85 µmol Trolox/100g) and minimum in Altar (448.28 µmol Trolox/100g). The antioxidant activity of Packman and CLX 35100 was (530.32 µmol Trolox/100g) and (487.02 µmol Trolox/100g), respectively. Various works are in consonance with the fact that antioxidant activity in broccoli varies not only among various genotypes[5] but also varies within parts of same plant[28]. The high antioxidant activity might be due to high content of natural antioxidants like ascorbic acid and phenols.

The low drying ratio is a beneficial criterion for suitability of cultivars because it shows the higher dry matter (yield) of broccoli after dehydration. A perusal of data in Table 1 reveals that, the broccoli hybrids did not differ significantly with respect to drying ratio. The Suhani hybrid had the least drying ratio (31.75:1) and Altar had highest drying ratio (32.43:1). However, the drying ratio for Packman and CLX 35100 was 32.22:1 and 32.30:1, respectively. This might be due to variation in the moisture and dry matter content among the broccoli hybrids. Similar results have been reported in onion[11].

The data regarding the rehydration ratio presented in the Table 1 appraises that rehydration ratio for Altar, CLX 351100, Packman and Suhani was 1:5.21, 1:5.27, 1:5.28 and 1:5.36, respectively. The values for rehydration ratio were not statistically significant. The variation in the rehydration ratio may be due to varying hydrophilic properties of the dehydrated products. Same inference has been drawn by many other workers in other crops[10,16].

NEB of florets was significantly lower in Suhani (0.622) followed by Packman (0.649), CLX 35100 (0.684) and Altar (0.706) (Table 1). In the present study, a variation in NEB was noticed among hybrids. Similar trend has been reported in onion bulbs during dehydration[27]. The chemical constituents like pectic substances, pigments and ascorbic acid, which are present in broccoli hybrids might have caused more browning[13]. The sensory score for all the attributes like odour, colour, taste, texture and overall acceptability was better in rehydrated florets of Suhani when compared to other hybrids *viz*., Packman, Altar and CLX 35100 (Figure 1). This might be due to better retention of colour, flavour and texture in the rehydrated material of Suhani. Similar results have also been reported by other workers[1,15].

**B. Physico-chemical constituents of broccoli stalk.**

A perusal of data in Table 2 reveals that, the Suhani hybrid had the least (89.90%) moisture and Altar had highest (91.24%) moisture percentage. The Packman (90.20%) and CLX 35100 (90.32%) recorded the moisture content (Table 2). Among the four hybrids, the variation in the amount of moisture content of stalks may be due to the variation of dry matter content present in the stalk of different hybrids. The values for moisture content are in accordance with the findings of Murcia *et al*[18].

Ascorbic acid content was marginally higher in Suhani (776.08 mg/100g) followed by Packman (710.67 mg/100g), CLX 35100 (584 mg/100g) and Altar (439.97 mg/100g) (Table 2). The same trend as florets was observed in stalks of broccoli with respect to the ascorbic acid content. The huge variation in the ascorbic acid content may possibly due

to cultivar variation and growing season. The variation for ascorbic acid content was in agreement with the findings[28]. The ascorbic acid content in stalk was less than the floret[17].

The total chlorophyll content recorded in the stalk of Suhani (31.78 mg/100g DW; 3.21 mg/100g FW) was twofold higher than that of Packman (16.02 mg/100g DW; 1.57 mg/100g FW). However, the chlorophyll content in Altar and CLX35100 were (26.45 mg/100g DW) and (21.00 mg/100g), respectively (Table 2). The total chlorophyll content of stalk portion was lower than the total chlorophyll content of florets. The possible reason for this might be lower distribution of chlorophyll pigments in the stalk[25].

Among the four hybrids of broccoli total carotenoids content varied significantly i.e from 4.29 to 7.82 mg/100g. Suhani recorded higher value of total carotenoids content (7.82 mg/100g), while Packman had lower level (4.29 mg/100g) of total carotenoids content. Total carotenoids content in Altar and CLX35100 were (6.40 mg/100g) and (5.23 mg/100g), respectively (Table 2). The high content of total carotenoids in the hybrid Suhani might be due to low moisture content in stalks of Suhani. Similar variations in total carotenoids have been reported[33].

The values pertaining to total phenolic content showed a significant variation among four hybrids (boxplot 3). The total phenolic content was maximum in hybrid Suhani (155.15 mg GAE/100g) and minimum in Altar (92.25 mg GAE/100g). Similarly, the values for total phenolic content (127.96 mg GAE/100g) in Packman and (103.69 mg GAE/100g) in CLX35100 were recorded. The total phenolic content of the stalk was lower than that of florets. This might be due to less distribution of phenolic compounds in the stalk portion. Similar results have been reported by other workers[28].

The data presented in the boxplot 4 indicates that the value of total antioxidant activity was significantly different among the four hybrids. Stalk of Suhani (283.75 µmol Trolox/100g) recorded highest total antioxidant activity when compared to that of Packman (276.60 µmol Trolox/100g), CLX35100 (211.61 µmol Trolox/100g) and Altar (197.85 µmol Trolox/100g). The total antioxidant activity in broccoli stalk was lower than florets. The lower antioxidant activity in the stalk portion than floret may be due to less distribution of the natural antioxidants like ascorbic acid and phenols in stalks[28,33].

Drying ratio was higher (27.63:1) in Altar and lower (27.02:1) in Suhani hybrid, whereas, the drying ratio was recorded (27.34:1) in Packman and (27.47:1) in CLX 35100 respectively. This might be due to variation in the moisture and dry matter content in the stalk of different broccoli hybrids (Table 2).

Rehydration ratio acts as a quality indicator for the dehydrated product (Femenia *et al.*, 2000). The data regarding the rehydration ratio presented in the Table 2 appraises that rehydration ratio for Altar, CLX 351100, Packman and Suhani was 1:4.82, 1:4.89, 1:4.95 and 1:5.02 respectively. This might be due to varying hydrophilic properties of the dehydrated products obtained from different broccoli stalks. Same inference has been drawn by many workers in other crops[16].

The NEB in dehydrated broccoli stalks differed significantly in all the hybrids. NEB of stalk was significantly lower in Suhani (0.683) followed by Packman (0.711), CLX35100 (0.750) and Altar (0.772) (Table 2). The chemical constituents like pectic substances, pigments and ascorbic acid, which are present in broccoli hybrids might have caused more browning[20].

The sensory score for all the attributes like odour, colour, taste, texture and overall acceptability was better for rehydrated stalks of Suhani when compared to other hybrids *viz*. Packman, Altar and CLX 35100 (Figure 2). This might be due to better retention of colour, flavour and texture in the rehydrated material obtained from the stalk of Suhani hybrid. Similar results have also been reported by other workers[10,15].

**Table 1: Physico-chemical parameters of broccoli hybrid floret**

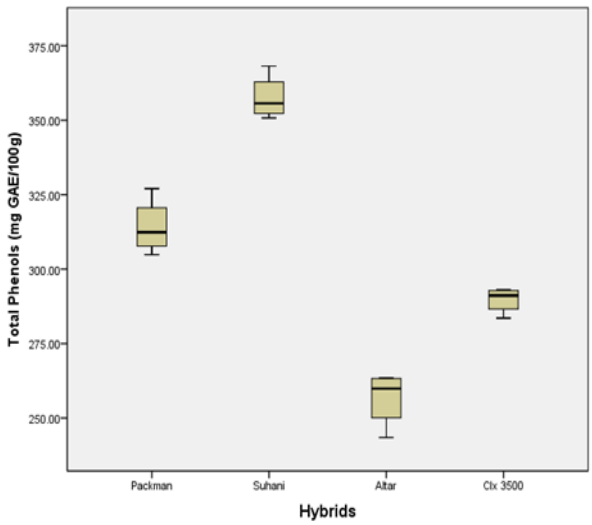
| Parameters | Hybrids | | | | S. E. | $LSD_{(0.05)}$ |
|---|---|---|---|---|---|---|
| | Packman | Suhani | Altar | Clx35100 | | |
| Moisture (%) | 87.83[a] (0.87) | 86.80[a] (0.38) | 89.32[a] (3.62) | 88.57[a] (0.69) | 1.34 | NS |
| Ascorbic acid (mg/100g) | 857.11[a] (3.04) | 874.24[a] (2.52) | 685.49[c] (2.56) | 768.15[b] (0.97) | 14.28 | 31.12 |
| Chlorophyll (mg/100g) | 47.09[d] (0.17) | 139.95[a] (0.43) | 135.03[b] (0.39) | 57.07[c] (0.09) | 1.85 | 4.04 |
| Carotenoid (mg/100g) | 24.09[b] (0.09) | 31.52[a] (0.12) | 31.14[a] (0.09) | 24.24[b] (0.05) | 0.54 | 1.18 |
| Drying ratio | 32.22[a] (0.93) | 31.75[a] (0.68) | 32.43[a] (1.22) | 32.30[a] (0.08) | 0.59 | NS |
| Rehydration ratio | 5.28[a] (0.15) | 5.36[a] (0.06) | 5.21[a] (0.22) | 5.27[a] (0.11) | 0.10 | NS |
| Non enzymatic browning | 0.649[b] (0.019) | 0.622[b] (0.013) | 0.706[a] (0.030) | 0.684[a] (0.011) | 0.014 | 0.030 |

Drying ratio= values shown against hybrids: 1; Rehydration ratio= 1: values shown against hybrids
Common letters in the superscript (row) are not significantly different ($P \geq 0.05$)
Figures in parenthesis denotes standard deviation

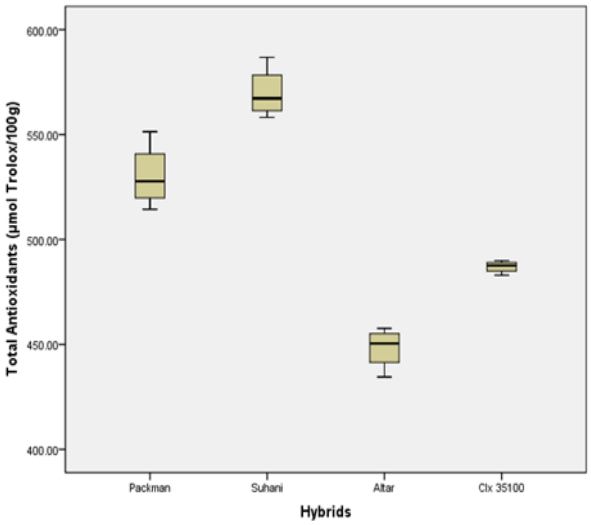
**Table 2: Physico-chemical parameters of broccoli hybrid stalk**

| Parameters | Hybrids | | | | S. E. | $LSD_{(0.05)}$ |
|---|---|---|---|---|---|---|
| | Packman | Suhani | Altar | Clx35100 | | |
| Moisture (%) | 90.20[a] (2.66) | 89.90[a] (1.94) | 91.24[a] (0.62) | 90.32[a] (1.82) | 1.35 | NS |
| Ascorbic acid (mg/100g) | 710.67[b] (2.05) | 776.08[a] (1.69) | 439.97[d] (1.46) | 584.00[c] (0.32) | 10.94 | 23.85 |
| Chlorophyll (mg/100g) | 16.02[d] (0.05) | 31.78[a] (0.07) | 26.45[b] (0.09) | 21.00[c] (0.03) | 0.45 | 0.99 |
| Carotenoid (mg/100g) | 4.29[d] (0.01) | 7.82[a] (0.02) | 6.40[b] (0.02) | 5.23[c] (0.01) | 0.12 | 0.26 |
| Drying ratio | 27.34[a] (0.80) | 27.02[a] (0.58) | 27.63[a] (0.84) | 27.47[a] (0.41) | 0.48 | NS |
| Rehydration ratio | 4.95[a] (0.15) | 5.02[a] (0.11) | 4.82[a] (0.17) | 4.89[a] (0.03) | 0.09 | NS |
| Non enzymatic browning | 0.711[bc] (0.027) | 0.683[c] (0.020) | 0.772[a] (0.017) | 0.750[ab] (0.027) | 0.016 | 0.035 |

Drying ratio= values shown against hybrids: 1; Rehydration ratio= 1: values shown against hybrids
Common letters in the superscript (row) are not significantly different ($P \geq 0.05$)
Figures in parenthesis denotes standard deviation




Boxplot 1: Total phenol content in broccoli hybrid floret




Boxplot 2: Total antioxidant capacity in broccoli hybrid floret

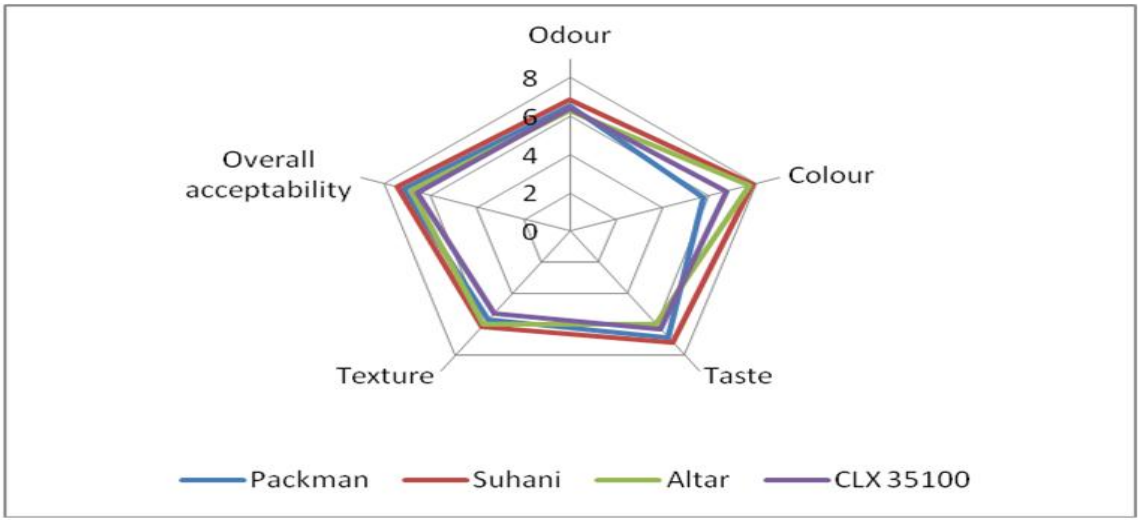
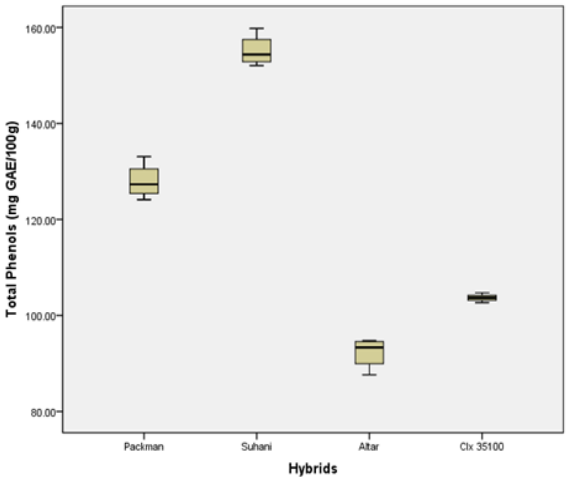
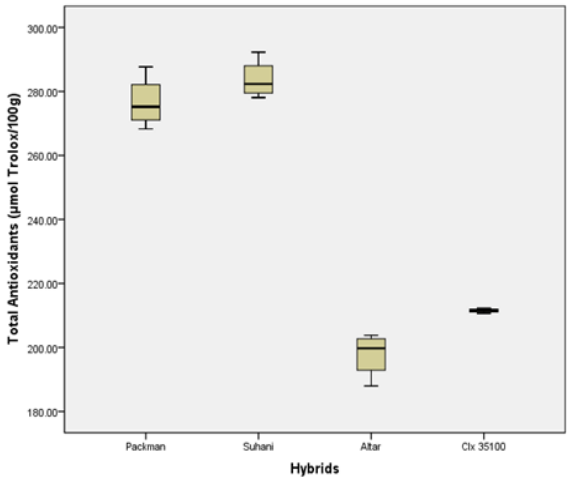



**Fig. 1: Sensory score of dehydrated broccoli hybrid floret**




Boxplot 3: Total phenol content in broccoli hybrid stalk




Boxplot 4: Total antioxidant capacity in broccoli hybrid stalk

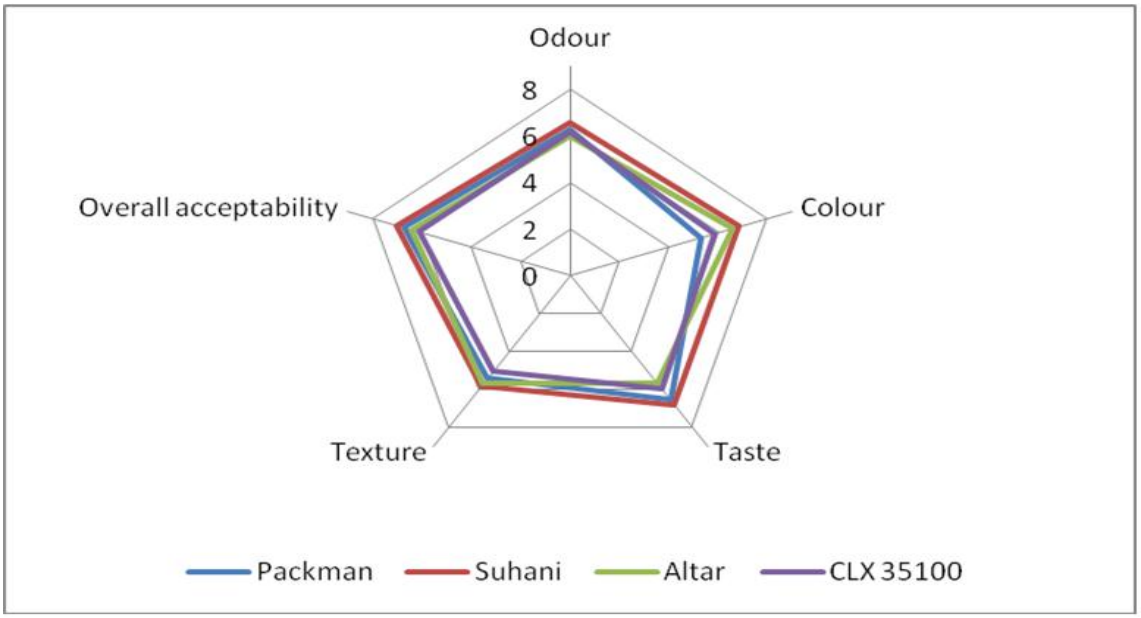



**Fig. 2: Sensory score of dehydrated broccoli hybrid stalk**

## CONCLUSION

Based on the physico-chemical constituents, dehydration characteristics and sensory score hybrid Suhani was found more suitable for dehydration, in comparison to other hybrids. In both the terms as floret and stalk it retained maximum amount of pigments, ascorbic acid, total phenols and antioxidants and thereby had high functional quality, better rehydration ratio, low drying ratio and minimum browning. However, stalk portion was found inferior to the florets of the same hybrid.

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