Original Research Article

STANDARDIZATION OF RECIPES AND STORAGE BEHAVIOUR OF VALUE-ADDED PRODUCTS FROM KNOL-KHOL (*Brassica oleracea* var. *gongylodes* L.)

ABSTRACT

Knol-khol (*Brassica oleracea* var. *gongylodes* L.) is one of the most important cruciferous vegetable crops which belong to the family Brassicaceae. Knol-khol is a fast growing, cool season vegetable cultivated primarily for its enlarged stem called 'knob' which is rich in nutritional components, especially vitamin A, C, minerals and is also a good source of potassium, phosphorus, calcium, iron and sodium. To exploit its high nutritional as well as antioxidant properties and also to ensure its year around availability, it needs value addition. Therefore, in the current investigation, value added products viz., nectar and squash were prepared from Knol-khol. Four recipes of prepared nectar and squash were subjected to physico-chemical and sensory evaluation soon after preparation and at 90 days of storage. During the storage, a slight increase in pH, TSS and total sugars, a considerable rise in reducing sugars, but a slight decrease in acidity and also a considerable decrease in non-reducing sugars and ascorbic acid was recorded in various treatments of nectar and squash. The treatments K_2N_2 (15% pulp, 150B), and K_1T_2 (25% pulp, 450 among different recipes of nectar and squash respectively were found to be the best on the basis of their physico-chemical and organoleptic evaluation. These findings suggest that specific compositional parameters significantly influence the quality and acceptability of fruit-based beverages during storage.

Keywords: Nectar; Squash; TSS; Total sugars; Ascorbic acid; Overall acceptability; Knol-khol

1. INTRODUCTION

Knol-khol (*Brassica oleracea* var. *gongylodes* L. or *B. caulorapa*) belongs to family Brassicaceae, is a winter season crop originated from the coastal countries of the Mediterranean region [1]. Brassica vegetables are a potent modulator of the innate immune response system with potent antiviral, antibacterial and anticancer activity [2]. However, it was reported as an important anti-androgen [3]. Among other cole crops, it is relatively hardy and short duration crop [4]. The edible part of knol khol is knob which is harvested for human consumption as raw or cooked vegetable whereas young leaves are also utilized in some areas. It tastes like broccoli or cabbage, but it's gentler and sweeter [5]. Kohlrabi is derived from the German word Kohl, which means "cabbage," and Rube Rabi (Swiss German variant), which means "turnip," due to the swollen stem's resemblance to the latter [6]. The bulb which is swollen edible portion of the stem is referred to as the knob and it arises from the thickening of stem tissues on top of the cotyledon [7]. The temperature between 15-18˚ C has been found to be the best for the formation of knob with average yield of 200q/ha [8]. There is a tremendous scope for knol-khol production in the mid-hills of Jammu and Kashmir [6]. Besides it is additionally cultivated in some regions of southern states. The demand of Knol-khol is due to its anti-hyperglycaemia and anti-carcinogenic properties [9]. This harvested knob can be used for human consumption as raw or cooked or for creating salad and pickles. Young leaves also are cooked as vegetable.

Now a days Nectar and Squash is going global as an instant source of energy drinks and its market value is increasing day by day, and also now the nectar is available in the market in different flavours and packaging. Fruit nectar has gained a reputation of being healthier than many of the processed juices found in mainstream supermarkets [10]. So, keeping in view the nutritional and therapeutic importance of knol-khol, the efforts have been made to develop different value-added products and ensure their availability throughout the year to increase the income and economic level of the country as well the farmers. The objectives are to standardize recipes for nectar and squash derived from knol-khol, focusing on their physicochemical properties and overall sensory acceptability.

2. MATERIALS AND METHODS

2.1 Experimental site

The research has been conducted in the laboratory of Faculty of Agricultural Sciences, Jalandhar. The Knol-Khol was purchased from the temperate regions of Himachal Pradesh and Jammu. Knol-Khol of uniform size and shape, free from bruises were used for the experiment.

2.2 Extraction of juice for Nectar and Squash

The selected Knol-Khol was washed thoroughly under tap water to remove any dirt present on the fruit surface. After that the washed Knol-Khol were peeled, and then cut into small pieces using a sharp knife. The pieces were fed into a mixer grinder for mashing into fine pulp/juice. This pulp/juice was used for the preparation of value-added products viz. nectar and squash.

2.3 Preparation of Knol-Khol nectar

Extracted pulp from Knol-Khol and freshly prepared hot sugar syrup was then mixed as per the four different recipes on weight basis. Desired quantity of citric acid was added wherever necessary and finally potassium metabisulphite (70ppm) was mixed into it after dissolving in the little pulp. The prepared nectar was poured into pre-sterilized glass bottles of 200 ml capacity and sealed with crown caps. The product was then sterilized in boiling water for 25 minutes, after removing the bottles from water bath, cooled and stored at room temperature for further observations. Following was the combination of treatments of nectar: K_1N_1 = 10% pulp + 10% TSS + 0.30 % Acidity followed by K_1N_2 = 10% pulp + 15% TSS + 0.30 % Acidity, K_2N_1 = 15% pulp + 10% TSS + 0.30 % Acidity and K_2N_2 = 15% pulp + 15% TSS + 0.30 % Acidity.

2.4 Preparation of Knol-Khol squash

The procedure for knol-khol squash was same as described in nectar by following the different treatments: K_1T_1 = 25% pulp + 40% TSS + 1.00 % Acidity followed by K_1T_2 = 25% pulp + 45% TSS + 1.00 % Acidity, K_2T_1 = 30% pulp + 40% TSS + 1.00 % Acidity and K_2T_2 = 30% pulp + 45% TSS + 1.00 % Acidity

2.5 Physical parameters of Knol-khol

The observations on physical parameters of Knol-Khol such as colour, weight, length and diameter were recorded. The length and diameter of knol-khol were measured with the help of measuring scale and vernier callipers respectively. To analyze the average weight of knol-khol, randomly five fruits were selected. The weight was recorded per fruit using electronic balance. Mean weight was calculated and expressed in grams.

2.6 Physico-chemical analysis of fresh pulp and products

The fresh pulp was analyzed to determine proximate composition. The pH, total soluble solids, acidity, ascorbic acid and sugars such as total sugars, reducing sugars and non-reducing sugars were observed and recorded. Prepared products like nectar & squash were evaluated for pH, TSS, acidity, ascorbic acid and sugars during storage period of 90 days at ambient temperature.

2.7 Organoleptic evaluation of Knol-Khol products

The prepared Knol-Khol products such as nectar and squash were evaluated monthly for sensory attributes like taste, flavour, aroma & appearance, overall acceptability by the panel of five judges with the numerical method of scoring [11]. Samples were ranked for quality parameters from higher to lower in descending order of acceptability using hedonic scale.

3. RESULTS AND DISCUSSION

3.1 Physical and physico-chemical parameters

The colour of the knol-khol was light green, having the average weight, 50.10g, length, 6.22cm, and diameter, 4.03cm and contained 92% of moisture. [12] reported the similar observation for diameter in khol-khol as 5.96. In another study, the attributes of knob length and knob average weight were recorded as 3.80 cm and 60.80 respectively [13]. Extracted pulp of knol-khol contained pH of 6.33, 3.86^0 B of TSS, 0.51 per cent of acidity, 2.86 per cent of total sugars, 1.87 per cent of reducing sugars, 0.99 per cent of non-reducing sugars and the 38.45 mg per 100g of ascorbic acid.

3.2 Nectar of Knol-khol

3.2.1 pH

A rising trend of pH of nectar and squash of knol-khol was observed during the storage period which can be attributed to corresponding decrease in acidity (Table 1). The highest pH (of 4.26 which increased to 4.45) was recorded in treatment K_2N_1 (15%, 10°B) initially and also after the storage period. This increase in pH and decline in acidity in the value-added products such as nectar and squash over a storage period might be attributed to the participation of acids in hydrolytic conversion of non-reducing sugars/ polysaccharides to the hexose (reducing sugars) and also to the non-enzymatic browning reactions (Sharma et al., 2005). The similar observations were recorded for increase in pH of pomegranate juice by [14] and in bitter gourd RTS [15].

3.2.2 Acidity

A declining trend was noticed in change in acidity of nectar up to 90 days of the storage period (Table 2). Maximum reduction of (0.17%) was found in treatment K_2N_1 (15% pulp, 10ºB) during storage period, whereas the minimum reduction of about 0.10 % was found in both K_1N_1 and K_2N_2 after the storage period of 90 days. Similarly, the declining trend was also noticed in Ready-to-Serve beverage (RTS) prepared from muskmelon [16]. According to [17] decline in ascorbic acid content material could be because of thermal degradation in the course of processing

3.2.3 Total soluble solids (TSS)

An increasing trend was noticed in change in TSS of nectar up to 90 days of the storage (Table 3). The maximum increase in total soluble solids was from 10 to 11.25ºB which was found in treatment K_2N_1 (15% pulp, 10ºB) and minimum increase was recorded from (10 to 10.78ºB) which was found in treatment K_1N_1 (10% pulp, 10ºB) after a storage period of 90 days. Such increase in TSS indicates towards the change in pulp composition (in the products) during the storage. This could be due to the hydrolysis of polysaccharides such as starch, cellulose and the conversion of insoluble pectin substances into simpler soluble sugars. An increase in TSS content during storage period was also reported by [18] in cape gooseberry RTS and in guava nectar [19].

3.2.4 Ascorbic acid

A declining trend was noticed in ascorbic acid of nectar up to 90 days of the storage period (Table 4). Maximum reduction of (2.06%) was found in treatment K_2N_2 (15% pulp, 15°B) during storage period, whereas the minimum reduction of about (1.41%) was found in K_1N_1 (10% pulp, 10°B) after the storage period of 90 days. The decline in ascorbic acid content material might be because of thermal degradation in the course of processing and subsequent oxidation in storage as it is very sensitive to heat, light and oxidation [17]**.** Whereas, according to the [21] the oxidation or irreversible conversion of L-ascorbic acid into dehydro ascorbic acid in the presence of enzyme ascorbic acid oxidase caused by trapped or residual oxygen in the glass bottles might be attributed to the decrease in ascorbic acid of nectar during storage.

3.2.5 Total sugars

The slight increase was noticed in total sugars of nectar during the 90 days of the storage (Table 5). The maximum total sugars (11.85%) were recorded in K_2N_2 (15% pulp, 15°B) initially, which increased to (12.17%) after the storage period of 90 days. The minimum total sugar content of (7.77%) was noticed in K_1N_1 (10% pulp, 10°B) initially, which increased to (7.99%) during the storage. This may be due to the hydrolysis of polysaccharides during storage period which increases the amount of soluble sugars, and thus total sugars of products were dependent on the total soluble solids [20]. A similar increase in total sugars was recorded in RTS beverage made from white cabbage blended with guava nectar prepared by [21] and [22].

3.2.6 Reducing sugars

A substantial increase was noticed in reducing sugars of nectar during the storage period of 90 days (Table 6). The maximum reducing sugars content (4.05%) was recorded in treatment K_2N_2 (15% pulp, 15°B) initially, which increased to (9.42%) after the storage period of 90 days; whereas the minimum reducing sugar content of (2.08%) was noticed in K_1N_1 (10% pulp, 10°B) initially, which increased to (5.66%) after the storage of 90 days. There might be considerable amount of reducing sugar which increased with a corresponding decrease in non-reducing sugars; which could be due to the inversion of non-reducing sugars to the reducing sugars during the storage [20]. Invertases (a type of enzymes) could also be involved in sugar inversion to a little extent. In the initial stages the rate of inversion was rapid in all these products, which might be due to the availability of more substrate(s) for the inversion process. Similar observations of reducing sugars were seen in bitter gourd RTS [15] and hill lemon fruit juice [23].

3.3.6 Non reducing sugars

A continuous decreasing trend was noticed in non-reducing sugars of nectar during the storage period of 90 days (Table 7). The maximum non-reducing sugars content (8.04%) was recorded in treatment K_1N_2 (10% pulp, 15°B) initially, which decreased to (2.19%) after the storage period of 90 days. While the minimum non-reducing sugar content of (5.69%) was noticed in K_1N_1 (10% pulp, 10^oB) initially, which changed to (2.33%) after the storage of 90 days.

3.3.7 Overall acceptability

A continuous declining trend in overall acceptability was noticed over the storage (Table 8). The highest overall acceptability was found to be 4.62 in the treatment K_2N_2 (15% pulp, 15^0B) which decreased to 4.14 during the storage. Whereas the lowest overall acceptability was found to be 3.82 in the treatment K_1N_1 (10% pulp, 10^0B) which decreased to 3.52 after the storage period of 90 days. The degradation of protein and colloidal particles during storage as well as the formation of cation complexes with pectins and phenolics might be the possible causes for score decreasing [24]. The decrease in flavour score during storage could be due to the potential loss of volatile aromatic substances during storage at ambient conditions, as reported by [25].

Table 1. Changes in pH of knol-khol nectar

	Storage period (days)				
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1N_1	4.04	4.10	4.18	4.25	4.14
K_1N_2	4.06	4.13	4.17	4.28	4.16
K_2N_1	4.26	4.32	4.38	4.45	4.35
K_2N_2	4.13	4.20	4.28	4.33	4.23
Mean	4.12	4.18	4.25	4.33	
	F-test		**SE m±**		**CD at 5%**
Treatment (T)	*		0.00		0.02
Storage period (S)	*		0.00		0.02
T × S	NS		0.01		N/A

Table 2. Changes in acidity of knol-khol nectar

	Storage period (days)				
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1N_1	0.30	0.26	0.24	0.20	0.25
K_1N_2	0.30	0.24	0.22	0.19	0.23
K_2N_1	0.30	0.22	0.20	0.17	0.21
K_2N_2	0.30	0.24	0.20	0.20	0.24
Mean	0.30	0.24	0.21	0.19	
	F-test		**SE m±**		**CD at 5%**
Treatment (T)	*		0.005		0.014
Storage period (S)	*		0.005		0.014
T × S	NS		0.010		N/A

Table 3. Changes in TSS of knol-khol nectar

	Storage period (days)				
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1N_1	10	10.35	10.68	10.78	10.45
K_1N_2	15	15.30	15.84	16.00	15.53
K_2N_1	10	10.42	10.82	11.25	10.62

K_2N_2	15	15.41	15.94	16.16	16.63
Mean	12.50	12.87	13.32	13.55	
	F-test		**SEm±**		**CD at 5%**
Treatment (T)	*		0.02		0.07
Storage period (S)	*		0.02		0.07
T × S	*		0.05		0.15

Table 4. Changes in ascorbic acid of nectar

	Storage period (days)				
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1N_1	3.84	3.27	2.96	2.43	3.12
K_1N_2	3.96	3.43	2.88	2.32	3.15
K_2N_1	5.70	4.72	4.15	3.69	4.56
K_2N_2	5.76	4.70	4.02	3.70	4.54
Mean	4.81	4.03	3.50	3.03	
	F-test		**SE m±**		**CD at 5%**
Treatment (T)	*		0.00		0.02
Storage period (S)	*		0.00		0.02
T×S	*		0.01		0.04

Table 5. Changes in Total sugars of nectar

	Storage period (days)			
Treatments	**0**	**30**	**60**	**90**
K_1N_1	7.77	7.86	7.92	7.99
K_1N_2	11.13	11.26	11.40	11.54
K_2N_1	8.40	8.41	8.57	8.63
K_2N_2	11.85	11.92	12.11	12.17
Mean	9.79	9.86	10.00	10.08
	F-test		**SE m±**	
Treatment (A)	*		0.027	
Storage period (B)	*		0.027	
A ×B	NS		0.053	

Table 6. Changes in reducing sugars of nectar

	Storage period (days)				
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1N_1	2.08	3.22	4.60	5.66	3.89
K_1N_2	3.09	4.64	6.94	9.35	6.00
K_2N_1	2.25	3.41	4.73	5.81	4.05
K_2N_2	4.05	4.84	7.25	9.42	6.39
Mean	2.87	4.03	5.88	7.56	
	F-test		**SE m±**		**CD at 5%**
Treatment (A)	*		0.02		0.06
Storage period (B)	*		0.02		0.06
A ×B	*		0.04		0.12

Table 7. Changes in non-reducing sugars of nectar

	Storage period (days)

Treatments	0	30	60	90	Mean
K_1N_1	5.69	4.64	3.32	2.33	3.99
K_1N_2	8.04	6.62	4.46	2.19	5.32
K_2N_1	6.15	5.00	3.84	2.82	4.45
K_2N_2	7.80	7.08	4.86	2.75	5.62
Mean	6.92	5.83	4.12	2.52	
	F-test		**SE m±**		**CD at 5%**
Treatment (A)	*		0.00		0.01
Storage period (B)	*		0.00		0.01
A ×B	*		0.00		0.03

Table 8. Changes in overall acceptability of nectar

Treatments	Storage period (days)				
	0	**30**	**60**	**90**	**Mean**
K_1N_1	3.82	3.75	3.65	3.52	3.68
K_1N_2	3.60	3.48	3.35	3.20	3.40
K_2N_1	4.02	3.56	3.42	3.24	3.56
K_2N_2	4.62	4.52	4.42	4.14	4.42
Mean	4.01	3.83	3.71	3.52	
	F-test		**SE m±**		**CD at 5%**
Treatment (A)	*		0.00		0.01
Storage period (B)	*		0.00		0.01
A ×B	*		0.01		0.03

3.3 Squash of Knol-khol

3.3.1 pH

The pH of knol-khol squash showed an increasing trend during storage period (Table 9). The maximum pH of 3.78 was recorded in treatment K_2T_1 (30%, 40^0B), which increased to 3.95 at 90 days of storage whereas the minimum pH of 3.72 was recorded in K_1T_1 (25%, 40^0B) which increased to 3.91 in S_1T_1 (25%, 40^0B) at 90 days of storage. A similar kind of pH and decline in acidity have also been reported in other value-added preparations like karonda juice blend with beet root [26], lime blended amla squash [27] and star gooseberry squash [28].

3.3.2 Acidity

A declining trend was noticed in change in acidity of squash up to 90 days of the storage period (Table 10). The maximum reduction in acidity was recorded in both the treatments *i.e.* K_2T_1 (30%pulp, 40^oB) and K_2T_2 (30%pulp, 45^oB) which is 1.00 to 0.50 after 90 days of storage. Similarly, the minimum reduction in acidity was recorded in both the treatments *i.e.* K_1T_1 (25%pulp, 40^oB) and K_1T_2 (25%pulp, 45^oB) which is 1.00 to 0.51 after 90 days of storage. The similar observations have also been reported in amla squash by [11].

3.3.3 Total soluble solids (TSS)

An increasing trend in TSS was observed during the storage period (Table 11). The maximum increase in TSS was found in the treatment K_2T_2 (30%pulp, 45^oB) *i.e.* from 45 to 46.63 and the minimum increase in TSS was found in the treatment K_2T_1 (30%pulp, 40ºB) *i.e.* from 40 to 41.41 during storage of 90 days. This could be due to the hydrolysis of polysaccharides such as starch, cellulose *etc*, and the conversion of insoluble pectin substances into simpler soluble sugars, which resulted in an increase in total soluble sugars. An increase in TSS content during storage period was also reported by [27] in lime blended amla squash, and [29] in carrot, sugar beet and mint based RTS.

3.3.4 Ascorbic acid

A declining trend was noticed in ascorbic acid of squash up to 90 days of the storage period (Table 12). Maximum reduction of (6.28%) was found in both the treatments K_2T_1 (30% pulp, 40ºB) and K_2T_2 (30% pulp, 45ºB) during storage period, whereas the minimum reduction of about (5.77%) was found in K_1T_2 (25% pulp, 45ºB) after the storage period of 90 days. According to the [21] the oxidation or irreversible conversion of L-ascorbic acid into dehydro-ascorbic acid in the presence of enzyme ascorbic acid oxidase caused by trapped or residual oxygen in the glass bottles might be attributed to the decrease in ascorbic acid of nectar during storage. A significant decrease in ascorbic acid took place during storage in various treatments which could be due to oxidation of ascorbic acid into dehydro-ascorbic acid, furfural and hydroxyl furfural and thermal degradation [30].

3.3.5 Total sugars

A slight increase in total sugars was found during 90 days of the storage (Table 13). The maximum total sugar content was recorded in treatment K_2T_2 (30% pulp, 45ºB) of 36.60% which is increased to 37.86% after 90 days of storage. The minimum total sugars of 32.92% were found in treatment K_1T_1 (25% pulp, 40ºB) which were increased to 33.69% after 90 days of the storage period. A similar increase in total sugars was recorded in watermelon squash with xanthan gum [31] and ripe pumpkin squash by [32]. The quality evaluation of spiced squash from mulberry was also found as increasing trend of total sugars by [33].

3.3.6 Reducing sugars

Increasing trend of reducing sugars was observed during 90 days of the storage (Table 14). The maximum reducing sugar content was recorded in treatment K_2T_2 (30% pulp, 45ºB) of 14.71% which increased to 21.32% after 90 days of storage. The minimum reducing sugars of 12.36% were found in treatment K_1T_1 (25% pulp, 40ºB) which increased to 18.53% after 90 days of the storage period. The rise in reducing sugars in beverages like juices and squash during storage might be because of the conversion of non-reducing sugars. A similar increase in reducing sugars was recorded in lime blended amla squash [27], spiced mulberry squash by [33] and ripe pumpkin squash by [32].

3.3.7 Non reducing sugars

A continuous declining trend was noticed in non-reducing sugars of squash during the storage period of 90 days (Table 15). The maximum reduction of (22.56% to 15.16%) was recorded in treatment K_1N_1 (25% pulp, 40ºB), whereas the minimum reduction of (20.45% to 15.34%) was observed in treatment K_1T_2 (25% pulp, 45ºB) after 90 days of storage period. Similarly declining trend of non-reducing sugars was also found in star gooseberry squash [28], amla squash [27] and ripe pumpkin squash by [32].

3.3.8 Overall acceptability

The mean organoleptic sensory scores of the squash of knol-khol revealed that appearance, aroma, flavour, taste and overall acceptability scores decreased with the advancement of storage period (Table 16). The loss of appearance and flavour of the beverages during storage might have contributed decline in overall acceptability scores [34]. A continuous declining trend in overall acceptability of knol-khol squash was noticed over the storage period. Treatment K_1T_2 (25% pulp, 45^0B) was liked the most by the panel with the overall acceptability scores of 4.40, that decreased to 3.37 after 90 days of storage.

Table 9. Changes in pH of knol-khol squash

	Storage period (days)				
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1T_1	3.72	3.78	3.85	3.91	3.81
K_1T_2	3.74	3.80	3.85	3.92	3.83
K_2T_1	3.78	3.83	3.88	3.95	3.86
K_2T_2	3.74	3.77	3.86	3.92	3.82
Mean	3.74	3.80	3.86	3.92	
	F-test		**SE m±**		**CD at 5%**
Treatment (T)	*		0.00		0.01
Storage period (S)	*		0.00		0.01
T × S	NS		0.01		N/A

Table 10. Changes in acidity of knol-khol squash

	Storage period (days)				
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1T_1	1.00	0.93	0.74	0.51	0.80
K_1T_2	1.00	0.95	0.77	0.51	0.81
K_2T_1	1.00	0.90	0.72	0.50	0.78
K_2T_2	1.00	0.89	0.69	0.50	0.77
Mean	1.00	0.92	0.73	0.50	
	F-test		**SE m±**		**CD at 5%**
Treatment (T)	*		0.005		0.014
Storage period (S)	*		0.005		0.014
T × S	*		0.010		0.029

Table 11. Changes in TSS of knol-khol squash

	Storage period (days)				
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1T_1	40.00	40.55	40.98	41.40	40.73
K_1T_2	45.00	45.59	46.02	46.35	45.74
K_2T_1	40.00	40.69	41.11	41.41	40.80
K_2T_2	45.00	45.68	46.11	46.63	45.85
Mean	45.50	43.13	43.55	43.94	
	F-test		**SE m±**		**CD at 5%**
Treatment (T)	*		0.06		0.01
Storage period (S)	*		0.06		0.01
T × S	*		0.01		0.03

Table 12. Changes in ascorbic acid of knol-khol squash

	Storage period (days)				
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1T_1	9.71	7.77	5.38	3.85	6.68
K_1T_2	10.02	8.26	6.27	4.25	7.20
K_2T_1	11.30	9.15	6.45	5.02	7.98
K_2T_2	11.52	8.96	6.33	5.24	8.01
Mean	10.64	8.53	6.11	4.59	
	F-test		**SE m±**		**CD at 5%**
Treatment (T)	*		0.02		0.05
Storage period (S)	*		0.02		0.05
T×S	*		0.04		0.11

Table 13. Changes in total sugars of knol-khol squash

	Storage period (days)				
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1T_1	32.92	32.95	33.10	33.69	33.67
K_1T_2	34.66	34.86	35.49	35.83	35.21
K_2T_1	33.25	33.81	34.47	34.83	34.09
K_2T_2	36.60	36.98	37.27	37.86	37.18
Mean	34.85	34.65	35.08	35.55	
	F-test		**SE m±**		**CD at 5%**
Treatment (A)	*		0.18		0.52
Storage period (B)	*		0.18		0.52
A ×B	*		0.36		1.04

Table 14. Changes in reducing sugars of knol-khol squash

	Storage period (days)				
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1T_1	12.36	14.42	16.39	18.53	15.42
K_1T_2	14.21	16.66	18.49	20.49	17.46
K_2T_1	12.37	15.17	17.62	18.55	15.93
K_2T_2	14.71	17.72	19.64	21.32	18.35
Mean	13.41	15.99	18.04	19.72	
	F-test		**SE m±**		**CD at 5%**
Treatment (A)	*		0.08		0.24
Storage period (B)	*		0.08		0.24
A ×B	*		0.17		0.48

Table 15. Changes in non-reducing sugars of knol-khol squash

	Storage period (days)				
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1T_1	22.56	18.53	16.71	15.16	18.23
K_1T_2	20.45	18.20	17.00	15.34	17.74
K_2T_1	20.88	18.64	16.85	16.28	18.16

K_2T_2	21.89	19.26	17.63	16.54	18.83
Mean	21.44	18.65	17.04	15.83	
	F-test		**SE m±**		**CD at 5%**
Treatment (A)	*		0.00		0.01
Storage period (B)	*		0.00		0.01
A ×B	*		0.01		0.03

Table 16. Changes in overall acceptability knol-khol squash

Storage period (days)					
Treatments	**0**	**30**	**60**	**90**	**Mean**
K_1T_1	4.01	3.86	3.35	3.02	3.56
K_1T_2	4.40	4.10	3.70	3.37	3.89
K_2T_1	3.53	3.42	3.13	2.85	3.23
K_2T_2	3.95	3.56	3.30	2.76	3.39
Mean	3.97	3.73	3.73	3.00	
	F-test		**SE m±**		**CD at 5%**
Treatment (A)	*		0.03		0.10
Storage period (B)	*		0.03		0.10
A ×B	NS		0.07		N/A

4. CONCLUSION

The products, specifically Nectar and Squash, remained in satisfactory condition after a 90-day storage period. Notable trends observed included a slight increase in pH, total soluble solids (TSS), and total sugar content, alongside a significant rise in reducing sugars. Conversely, there was a slight decrease in acidity and a marked reduction in non-reducing sugars across the various treatments for both Nectar and Squash during storage. Organoleptic evaluations indicated that the Nectar formulation containing 15% pulp, 15°B total soluble solids, and 0.3% acidity received the highest rating for overall acceptability among the tested recipes. Similarly, the Squash prepared with 25% pulp, 45°B TSS, and 1% acidity was deemed the most favorable among all formulations. These findings suggest that specific compositional parameters significantly influence the quality and acceptability of fruit-based beverages during storage.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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