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RESEARCH ARTICLE

Development and evaluation of physico-chemical quality markers of opuntia and pineapple squash.

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Abstract

Fruits and vegetables are important constituents of the diet and provide significant quantities of nutrients, especially vitamins, sugars, minerals and fiber. The fruit and cladodes of prickly pear provide interesting sources of functional compounds, such as fiber, hydrocolloids, pigments, minerals, and vitamins with antioxidant properties, such as vitamin C. Ananas comosus (pineapple) is a tropical plant with edible multiple fruit consisting of coalesced berries, also called pineapples, and the most economically significant plant in the Bromeliaceous family. The squash was developed with the optimization of the concentrations of prickly pear (5-25 %) and pineapple (0-25 %) juice. The developed fruit squash was subjected for evaluation of physico-chemical markers. Results showed significant differences ($p<0.05$) among the treatments for all the chemical components of the squash blends analyzed except for titrable acidity, TSS and SO2 which did not show significant differences between the treatments on total soluble solids (TSS) in the range of 45 - 460 brix, pH 3.8 to 4.1, titrable acidity (% citric acid) 1.45 to 1.49, total sugars 35.3 to 37%, reducing sugars 15.2 to 16.8%, ascorbic acid 6.5 to 10.5 mg/100g and SO2 348 to 350 ppm were observed in different juice blended squash treatments. The highest TSS (46oBrix), total sugars (37%), reducing sugars (16.8%) was observed in T3 prickly pear and pineapple juice blended ratio (15:10). The high acidity (1.48%) and ascorbic acid (10.9 mg/100g) were witnessed in T5 prickly pear : pineapple (5:20%) fruit juice blended squash; whereas high SO2 content was seen in pure prickly pear squash (T1) and lowest pH (3.8) was seen with the squash blended prickly pear: pineapple (15:10%) fruit juices i.e T3. The study concludes that, prickly pear and pineapple facilitates in the development of functional fruit squash with minor changes in physico-chemical markers and superior sensory attributes.

Introduction:-

Fruits and vegetables are important constituents of the diet and provide significant quantities of nutrients, especially vitamins, sugars, minerals and fiber. Daily consumption of fruits and vegetables reduce the risk of cancer, heart disease, premature aging, stress and fatigue primarily due to the integrated action of oxygen radical scavengers such as β- carotene and ascorbic acid plus calcium and dietary fiber (Sáenz, et al., 2000).Pimienta, et al., (1990) reported

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that due to the perishable nature of the fruits and vegetables they require immediate processing to avoid post-harvest losses (20-25%)

The Opuntiaficusindica (L) Mill is a xerophyte popularly known as prickly pear plant in English. Prickly pear fruit has a similar nutritional value like other fruits, although it has much higher soluble solids content than many popular fruits such as apple, apricot, cherry, melon, peach and plum (Pimienta, 1990; Sepúlveda and Sáenz, 2000). This characteristic makes prickly pear fruit suitable for processing by concentration or dehydration, taking advantage of the reduced water activity and increased sugar content as a means of preservation.

Most of the sugars present in the prickly pear fruit are reducing types, with around 53 % glucose and the remaining is fructose (Rodríguez *Et al.*,1997). The contents of protein (0.21–1.6 g [100 g]$^{-1}$), fat (0.09–0.7 g [100 g]$^{-1}$), fibre (0.02–3.15 g [100 g]$^{-1}$) and ash (0.4–1.0 g [100 g]$^{-1}$) are similar to other fruits (Pimienta, 1990; Sepúlveda and Sáenz, 2000; Rodríguez *et al.*, 1997; Muñoz de Chávez *et al.*, 1995). The calorific value of prickly pear fruit pulp varies between 31 and 50 kcal (100 g)$^{-1}$, which is comparable with other fruits such as apples, oranges, peaches and pears.

The fruit and cladodes of prickly pear provide interesting sources of functional compounds, including fiber, hydrocolloids (mucilage), pigments (betalains and carotenoids), minerals, (calcium and potassium) and vitamins with antioxidant properties, such as vitamin C. These compounds are valued for their contribution to a healthy diet and also as ingredients for designing new foods (Sáenz, 2004). These compounds can be included in a new range of foods known as functional foods, which are as foods or beverages that provide physiological benefits. They enhance health, help to prevent or treat disease and/or improve physical or mental performance with the addition of one or more functional ingredients or using appropriate biotechnologies (Sloan, 2000).

The pineapple (Ananas comosus) is a tropical plant with edible multiple fruit consisting of coalesced berries, also called pineapples, and the most economically significant plant in the Bromeliaceous family. In a 100 gram serving, raw pineapple is an excellent source of manganese (44% Daily value (DV)) and vitamin C (58% DV), but otherwise contains no essential nutrients in significant content. It is an excellent source of antioxidant, vitamin C which is required for the collagen synthesis in the body. It contains micronutrients and it protects against cancer and this micro-nutrient break up blood clots is beneficial to the heart.

There are various methods of preservation of food including thermal processing, fermentation, pickling, dehydration, freezing etc. The technology for preservation also varies with type of products and targeted market. The processing of fruit as squash enhances the raw edible quality of fruit as well as its shelf life by the selection of appropriate fruit drink processing conditions.

Squashes are sweetened juice of fruits containing minimum prescribed quantity of pulp. As per Indian Standards, squash should contain at least 25 per cent (by volume) of fruit juice. The squashes are consumed after dilution by drinking water in 1:3 ratio. These beverages contain added flavors and permitted class II preservatives. Since preservatives are added in adequate quantities, the shelf life of squashes is fairly longer at room temperature.

The present study was carried out for the development of fruit squash with prickly pear and pine apple fruits. The standardized and development of squash with different concentrations of pear and pine apple fruits and evaluation of the physico-chemical and sensory attributes.

Materials &Methods:-

Prickly pear juice:-

Mature ripe fruits were collected from the experimental plot during April-May. Spines over the surface of the fruit were picked, pealed washed cut into slices and seeds were removed. The slices are crushed with an electric blender/mixer to get pulp. The pulp was heated up to 800 C and passed through a 1/32 inch nylon sieve to remove excess fiber and coarse pulp particles. Finally obtained juice was analyzed for TSS, PH, Titrable acidity, ascorbic acid and was used for preparation of blended fruit squash.

Pineapple juice:-

Mature ripe fruits purchased from the local market were peeled, washed, cut into slices and crushed into pulp with electric blender/mixer. The crushed pulp was heated to 80^0 C and passed through a passed through a 1/32 inch nylon

sieve so as to remove excess fiber and coarse pulp particles finally obtained juice was analyzed for TSS, PH, Titrable acidity, ascorbic acid and was used for preparation of blended fruit squash.

Optimization and preparation of Squash:-
The clarified fruit juices of prickly pear and pineapple were mixed in different proportions and sample codes are represented in below Table 1.

Table:-1 Sample codes for the optimization of prickly pear and pine apple fruit squash.

Treatment	Prickly pear juice (%)	Pineapple juice (%)
T1	25	0
T2	20	5
T3	15	10
T4	10	15
T5	5	20

Fig: 1:- Flow chart for preparation of prickly pear fruit squash

Fig: 2 Images of fruit squash developed with prickly pear and pine apple

Analytical methods:-

Moisture:-

Estimation of moisture content and total solids was carried out five times. Fruit pulp (10 g) placed in an evaporating dish and dried at 105 ºC in an oven at constant weight. The moisture content was determined using following equation.(Askar 1981).

% moisture content = [(initial weight – dried weight)/initial weight] X 100.

TSS:

Total soluble solids (TSS) of different pulp, juice and products was measured with hand refractometer (ERMA, Japan) and expressed as ^{0}Brix at room temperature. Before taking the reading the refractometer was tested for error with distilled water (Ranganna**,** 1994).

pH:

P^{H} of juices and products was determined by using Digital pH meter (model-EQ-610, Equip-Tronics, Ahmedabad, India) (Anonymous, 1996).

Titrable acidity:

Titrable acidity was determined by diluting 5-10g of sample with distilled water then 10 ml of sample was taken in a 100ml volumetric flask and the volume was made up with distilled water. From this 10ml of aliquot was taken in a 100ml conical flask and titrated against 0.1N sodium Hydroxide (NaOH) solution using one (or) two drops of phenolphthalein indicator. Total titratable acidity was expressed as percent citric acid (g/100ml of sample) (AOAC 2005)

$$\text{Acidity \% (As citric acid)} = \frac{\text{Titer value} \times \text{Normally of NaOH} \times 64 \times 100}{\text{Volume of Sample taken} \times 1000}$$

Total sugars:

The total sugar content was determined by the anthrone reagent method (Plummer, 2006). The fruit juice was prepared as described in 3.3.3.2 and transferred 1.0 ml of filtered juice to the 10 ml volumetric flask, and diluted to 10.0 ml with distilled water, having strength 100µl/ml, labelled as stock solution. Stock solution (0.1 ml) was transferred into 10 ml volumetric flask, and diluted to 10 ml with distilled water, having strength 10µl/ml. The anthrone reagent was prepared right before analysis by dissolving 0.2 g of anthrone (0.2%) in 100 ml of concentrated sulfuric acid, protected from light and used within 12 h. Anthrone reagent (4.0 ml) was added

cautiously to each tube containing 1.0 ml of standard solutions of glucose (10 – 100 µg/ml) and test solution (10µl/ml).

Tubes were then placed 10 min at 5 ^{0}C. Subsequently, tubes were boiled 5 min on constant boiling water bath. After heating, allowed to cool at room temperature for 15 min. The absorbance of the colored solution was measured at 620 nm against reagent blank. Readings were taken in triplicate. Spectrophotometric response was compared to a standard calibration curve of glucose, and total sugar content was expressed as g/100 ml of glucose. (AOAC 2005).

Reducing sugars:-
Weigh accurately an amount of sample such that after dilution the solution contains about 0.6% reducing sugars. Transfer the sample quantitatively to a 500 ml volumetric flask with the aid of hot water, cool to room temperature, dilute to volume and mix thoroughly. Pipette 25.0 ml of standardized mixed Fehling's Solution into a 200 ml Erlenmeyer flask and add a few glass beads. Add the sample solution by means of the burette to within 0.5 ml of the anticipated end point (determined by preliminary titration). Immediately place the flask on the wire gauze of the titration assembly, and adjust the burner so that the boiling point will be reached in about 2 min. Bring to boil and boil gently for 2 min. As boiling continues, add 2 drops of methylene blue indicator and complete the titration within 1 min. by adding sample solution drop wise or in small increments until the blue color disappears when approaching the end point, allow about 5 sec, reaction time between additions of sample solution. (AOAC 2005).

% Reducing Sugars = (500 ml) (0.1200)(100) / (Sample Titer, ml)(Sample Wt., g)

Ascorbic acid (Vitamin C):-
Vitamin C was determined by using the procedure as outlined by Food Analysis Laboratory Manual Chapter 7 Vitamin C Determination by Indophenol Method-9 and (AOAC2005**).**

10 g of each of the samples with the exception of fruits was accurately weighed and ground using mortar and pestle with an additional of 20 ml of metaphosphoric acid and acetic acid. The mixture was further ground and strained through muslin and the extract was made up to 100 ml with the metaphosphoric-acetic acid mixture. 5 ml of the metaphosphoric acid-acetic acid solution was pipetted into three of the 50 ml Erlenmeyer flask followed by 2 ml of the samples extract. The samples were titrated separately with the indophenol dye solution until a light rose pink persisted for 5s. The amount of dye used in the titration were determined and used in the calculation of vitamin C content.

Sulphur dioxide (So_2):
Sulphur dioxide content of the sample was distilled in the presence of acid in an inert atmosphere and absorbed by iodine which converts sulphurous acid to sulphuric acid and titrated against standard thiosulfate solution. The free and combined So_2 expressed in parts per million (PPM). (Askar 1981).

Sensory evaluation:
Sensory evaluation test carried out according to Nadir et al., (2005).Taste, color, texture, odor and overall acceptability of prickly pear fruit products of squash were assessed using ten panelists of Department of Home science, S.V University, Tirupati, India.

Statistical analysis:
Obtained data was subjected for statistical analysis by Duncan multiple range test (DMRT) for testing the significance, described by Dhamu and Ramamoorthy (2012).

Results & Discussion:-

The *Opuntiaficusindica* or prickly pears are spiny and pear shaped fruits. These fruits are emerging nutraceutical fruits with high therapeutic values. These xeropyte can be an alternative crop for drought prone areas.

Formulation and development of prickly pear fruit products:
The one of the main objective of the study was development of fruit products with prickly pear (PP). The quality of fruit products depends on the pulp quality. Prickly pear pulp contains less solids and more moisture. Hence the pulp is watery which will not suitable for the quality standards of the products like squash and bar. Blending of other

fruits will be desirable, for prickly pear squash preparation. A fruit with no colour and pleasant aroma is required, so that it will not interfere into the colour of prickly pear. Pineapple was selected to blend with prickly pear, because it has no colour and have pleasant aroma.

Fresh prickly pear fruits obtained from experimental plot and fresh fruits of pineapple obtained from local markets were utilized for preparation of blended fruit products squash. These fresh fruits pulp were analyzed for physico-chemical parameters.

Table: 2 Physico-chemical parameters of prickly pear and pineapple fruit pulp.

Fruit pulp	Moisture (%)	TSS (^{0}Brix)	P^H	Acidity (% Citric acid)	Total Sugars (%)	Reducing sugars (%)	Ascorbic acid (mg/100g)
Prickly pear	86.0±1.00	13±1.00	6.2±0.10	0.12±0.01	11.7±0.10	9.2±0.12	26.0±1.18
Pineapple	87.0±1.00	15±0.95	5.0±0.15	0.40±0.01	13.5±0.15	10.1±0.06	38.0±1.00

All values means± Standard deviation of data

The mean percent of moisture content of prickly pear and pineapple pulp was 86.0 and 87.0%, the mean TSS – 13 & 15^{0}Brix, the mean P^H-6.0 and 5.0 the mean acidity (TA)-0.12 & 0.40%, the mean total sugars (TS)-11.7 & 13.5, the mean reducing sugars (RS)-9.0 & 10.1% and the mean ascorbic acid content was 26.0 & 38.0mg/100g respectively (Table 2).

Pineapple fruit contain high amount of TSS (15^0 brix), total sugars (13.5%), reducing sugars (10.1%) and acidity 0.40% while P^H being low (5.0). This is followed by prickly pear TSS (13^{0}brix), total sugars (11.7%), reducing sugars (9.2%), ascorbic acid (26.0 mg/100g). Bose et al; (1986) reported that papaya pulp contains 90.7 % moisture 9.5 % carbohydrates, 10 mg ascorbic acid per 100 g pulp and 0.5% protein, and the pineapple pulp contains 84.4% moisture, 15.7 % carbohydrates, 0.6 % protein and 63mg ascorbic acid per 100 g pulp.

Wide range of chemical constituents in prickly pear fruit pulp has been reported by several authors. Samahy et al (2007) reported the chemical characteristics of both orange yellow and red prickly pear pulp. Both have high P^H (6.2, 6.14), TSS (13.5, 11.25 ^{o}Brix), total sugars (8.5%, 8.7%) reducing sugars (8.5%, 8.3%) on fresh weight basis, crude protein (4.6%, 5.3%), crude dietary fibre (1.40%, 1.44%), pectin (2.4%, 2.44%) and ash (2.39%, 2.27%) on dry weight basis.

Similar chemical parameters of prickly pear fruit pulp were also recorded by Askar and EL-Samahy (1981). Saenz and Sepulveda (1995) reported higher TSS of 17.0% constituted 53% glucose and fructose, ascorbic acid (40mg/100g), P^H (5.3 -7.1), proteins (0.21-1.6%) fat (0.09-0.7%), fibre (0.02-3.15%) and ash (0.4-1%). Sepulveda and Saenz (1990), reported the technological characteristics of prickly pear fruit pulp for TSS (12-17%), pectin (0.17-0.19 mg/100g), Vitamin -C (4.6-41.0 mg/100g as ascorbic acid) and moderate colour values. Whereas Saenz, Sepulveda and Moreno (1995), Saenz and Sepulveda (1999) reported technological characteristics of green cactus pear (prickly pear) pulp for P^H (5.9 -6.2), acidity as % citric acid (0.03 -0.04), TSS (12.8-14.5%), Vit.C (20.0-31 mg/100g), viscosity (119.2m Pa^{o}s) and higher colour values. Sepulveda and Saenz (1999) also reported the technological characteristics of orange cactus pear fruit pulp for P^H-6.1, TSS (^{o}Brix)-14.8%, very low acidity (0.043%), reducing sugars (13.2%), total sugars (14.8%), pectin (0.04%), Vit-C (24 mg/100g) ash (0.26%, viscosity 45.0 mPa^{o}s and moderate colour value whereas orange cactus pear pulp containing comparatively high TSS and low pectin and viscosity than green cactus pear and purple cactus pear pulp. The TSS, acidity, reducing sugars of the present study is along with them. The ascorbic acid content of the three fruit pulp is also in agreement with above studies.

Physico-chemical quality characteristics of squash:-

The fruit squash is a non-alcoholic concentrated syrup used in beverage making. It is usually fruit-flavored, made from fruit juice, water, and sugar or a sugar substitute. To standardize the prickly pear and pineapple squash, five different variations of blending of prickly pear and pineapple treatments i.e T1 (25:0%), T2 (20:5%),T3 (15:10%), T4 (10:15%) and T5 (5:20%) in the ratios respectively, to standardize the best composition. The five samples were

analyzed for physico-chemical parameters and subjected to subjective evaluation to know the acceptance. The results are presented in Fig. 2, 3, 4 & 5.

The mean TSS of five treatments i.e T1, T2, T3, T4 and T5 was 45.0, 45.0, 46.0, 45.0 and 46.0^{0}Brix, the mean P^H values is 4.0, 4.1, 3.9, 3.8 and 4.0, the mean acidity is 1.49, 1.47, 1.46, 1.45 and 1.48 %, the mean total sugars values are 35.6, 36.0, 37.0, 35.3 and 36.0 %, the mean reducing sugars values are 16.3, 16.6, 16.8, 15.2 and 16.0%, the mean ascorbic acid values are 6.5, 7.6, 8.6, 9.4 and 10.5 mg/100g respectively.

Potassium metabisulphate (stock solution 200g KMS dissolved in 1 ltr of distilled water = 1 ml of KMS stock solution will give 10 ppm of sulphur dioxide (So2) to 10 ltrs of juice solution) were added as preservative to increase the shelf life of the squash. The quality parameter So2 (Sulphur dioxide) can be maintained up to 500 ppm (as per FSSAI standards). In the present samples the So2 was analyzed, the T1, T2, T3, T4 and T5 contain 350, 348, 349, 350 and 348 ppm respectively, which is within the permitted levels of the FSSAI (Food Safety Standards Authority of India).

Results showed significant differences among the treatments for all the chemical components of the squash blends analyzed except for titrable acidity, TSS and So_2 which did not show significant differences between the treatments on 'Initial' days of storage. TSS in the range of 45 to 46^0 brix, P^H 3.8 to 4.1, titrable acidity (% citric acid) 1.45 to 1.49, total sugars 35.3 to 37%, reducing sugars 15.2 to 16.8%, ascorbic acid 6.5 to 10.5 mg/100g and So2 348 to 350 ppm were observed in different juice blended squash treatments. The highest TSS (46^{o}Brix), Total sugars (37%), reducing sugars (16.8%) was observed in T3 prickly pear and pineapple juice blended ratio (15:10). The high acidity (1.48%) and ascorbic acid (10.9 mg/100g) were witnessed in T5 prickly pear : pineapple (5:20%) fruit juice blended squash; whereas high So2 content was seen in pure prickly pear squash (T1) and lowest P^H(3.8) was seen with the squash blended prickly pear: pineapple (15:10%) fruit juices i.e T3. The ascorbic acid content was however found to be high in squash blends with increase in the proportion of pineapple juice from 5 to 20% in the present study. This may be due to high ascorbic acid content of pineapple juice (38 mg/100g) comparatively than prickly pear juice (26 mg/100g).

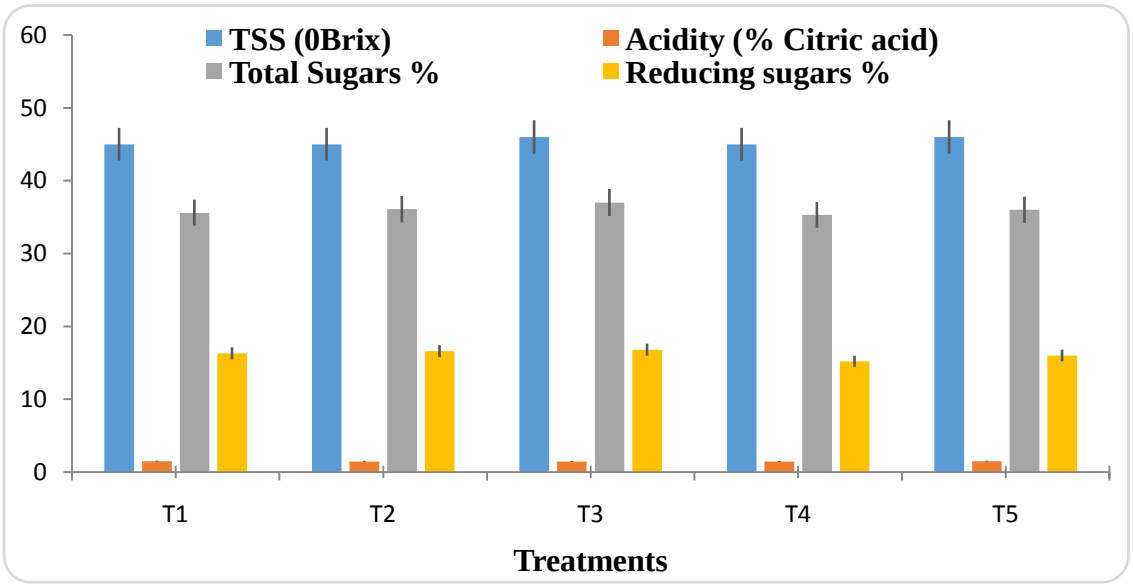

Fig:2:- Physico-chemical analyses- TSS, TS, Acidity and reducing sugars of prickly pear squash

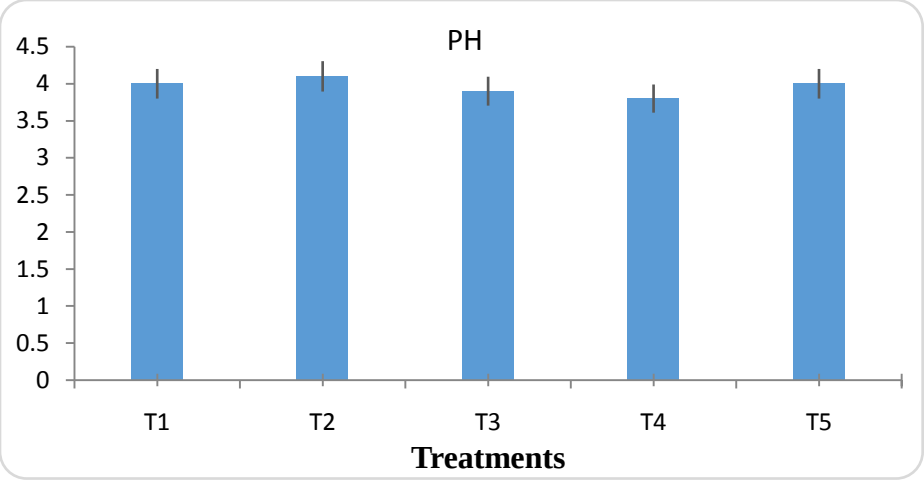

Fig:3:- Physico-chemical analyses-P^H of prickly pear squash.

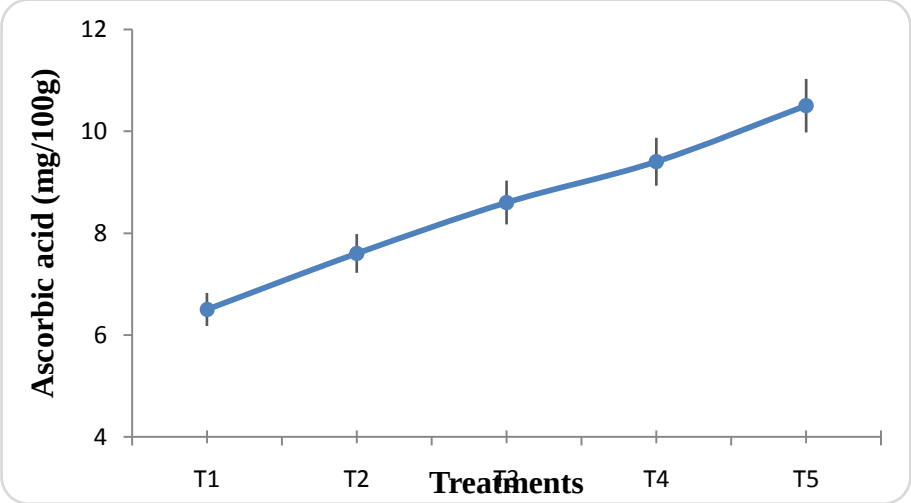

Fig:4:- Physico-chemical analyses-Ascorbic acid of prickly pear squash.

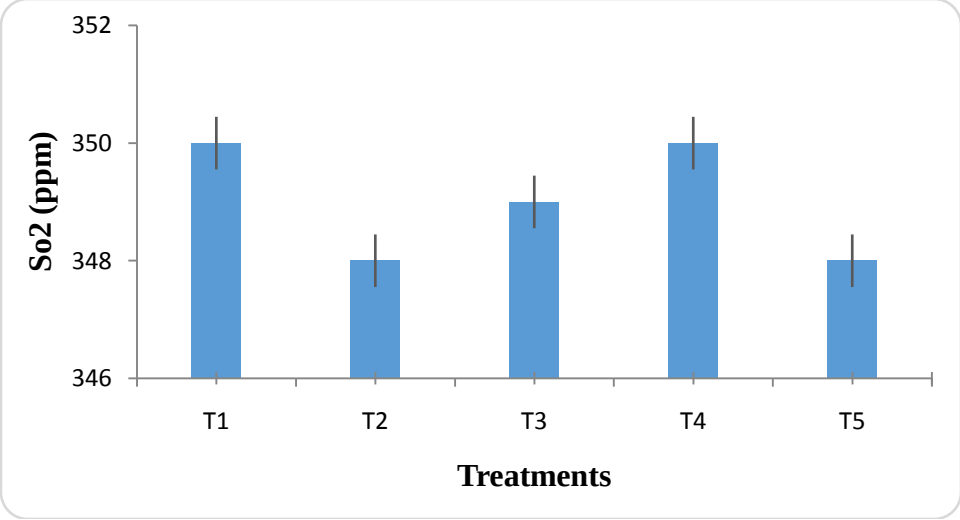

Fig:5:- Physico-chemical analyses-Sulphur dioxide (So_2) of prickly pear squash.

Sensory evaluation of prickly pear squash:
Sensory evaluation was carried out by a panel of 10 judges for appearance, taste, flavor, colour, consistency (mouth feel) and appearance on a 10 point scale where 1-2 poor, 3-4 fair, 5-6 good, 7-8 very good and 9-10 excellent (Askar 1981). The mean for each sensory attribute was computed for comparison and the overall acceptability scores were obtained by the summation individual sensory scores and means were computed for comparison.

The sensory characteristics taste, consistency (mouth feel) and appearance did not exhibit significant differences between the juice blends of the fresh squash tried, whereas the sensory parameters flavor, color and overall acceptability showed significant differences between the different juice blended fresh squash treatments (Table 3)

Table: 3:-Sensory characteristic evaluation of prickly pear squash

	% of fruit juice blends		Sensory characteristics					
	Prickly pear	Pineapple	Taste	Flavor	Colour	Mouth feel	Appearance	OAA (50)
T1	25	0	8.3±0.30^{a}	8.2±0.20^{ab}	9.2±0.10^{a}	8.2±0.40^{a}	8.0±0.30^{a}	8.36±0.08^{ab}
T2	20	5	8.3±0.10^{a}	8.6±0.30^{ab}	8.6±0.30^{ab}	8.4±0.30^{a}	8.2±0.30^{a}	8.42±0.08^{ab}
T3	15	10	8.6±0.20^{a}	8.8±0.40^{a}	8.4±0.20^{b}	8.8±0.20^{a}	8.5±0.50^{a}	8.62±0.07^{a}
T4	10	15	8.1±0.10^{a}	8.0±0.20^{b}	8.3±0.20^{b}	8.6±0.40^{a}	8.4±0.50^{a}	8.28±0.07^{b}
T5	5	20	8.0±0.20^{a}	8.0±0.30^{b}	8.1±0.20^{b}	8.5±0.30^{a}	8.3±0.20^{a}	8.11±0.01^{b}

- Each value is a mean of three replicates.
- Means were tested for significance following Duncan's multiple range test (DMRT) described by Dhamu and Ramamoorthy (2012).
- Means having same letter within the each property are not significantly different at P≤0.05 (n=3).
- Means having different letters within the each property are significantly different at P≤0.05 (n=3).

Results of the sensory characteristics evaluation of fresh prickly pear squash and its blends with pineapple juice revealed that the squash blend T3-15:10% prickly pear and pineapple juice scored high sensory values for taste (8.6), flavor (8.8), consistency (mouth feel) (8.8) and appearance (8.5) and overall acceptability score (8.62) and followed by T2-20:5% prickly pear and pineapple juice blended squash and pure prickly pear squash T1-25% juice and T2-20:5% prickly pear and pineapple juice with overall acceptability scores of 8.36 and 8.42 respectively (table-23). The other squash blends T4-10:15% and T5-5:20% prickly pear and pineapple juice blends had comparatively low scores for all the sensory characteristics including the overall acceptability 8.28 and 8.11 respectively (Table 3).

Conclusion:-

Fruits and vegetables are important constituents of the diet and provide significant quantities of nutrients, especially vitamins, sugars, minerals and fiber.Results showed significant differences ($p<0.05$) among the treatments for all the chemical components of the squash blends analyzed. The highest TSS (46^{o}Brix), Total sugars (37%), reducing sugars (16.8%) was observed in T3 prickly pear and pineapple juice blended ratio (15:10). The high acidity (1.48%) and ascorbic acid (10.9 mg/100g) were witnessed in T5 prickly pear : pineapple (5:20%) fruit juice blended squash; whereas high So2 content was seen in pure prickly pear squash (T1) and lowest P^{H}(3.8) was seen with the squash blended prickly pear: pineapple (15:10%) fruit juices i.e T3. The study concludes that, prickly pear and pineapple facilitates in the development of functional fruit squash with minor changes in physico-chemical markers and superior sensory attributes.

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