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RESEARCH PAPER

Storage Study on Tomato, Pumpkin, and Ginger Composite Vegetable Squash

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دراسة التخزين لهريس الخضار المركب من الطماطم واليقطين والزنجبيل

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ABSTRACT. Sri Lanka has a vast variety of vegetables. Although the nutritional and medicinal properties of pumpkin and tomato are acknowledged, their consumption as beverage is limited due to their lack of taste. Blending these vegetables with spice extracts is considered a more nutritious alternative when added to beverages. An effort was completed to determine the storage stability of vegetable squash made using different proportion of tomato, pumpkin and ginger. Considering the findings of several preliminary studies, five formulations in various mixes of tomato and pumpkin, were chosen. The highest scores for all the sensory parameters and chemical characters were obtained by formulation (T1) 50% tomato + 50% pumpkin followed by (T2) 75% tomato +25% pumpkin. The best combination was improved using 1 % ginger to form T3 (50% tomato+ 50% pumpkin+ 1% ginger). The most three promising treatments (T1, T2 and T3) were chosen for a storage experiment at 30°C and 70-75% relative humidity. Compositional analysis and sensory assessments were done. In chemical analysis, it was found that variances in the scores of pH, ascorbic acid, titratable acidity, total sugar and reducing sugar were significant ($p< 0.05$). Squash formulations showed an increasing trend in titratable acidity (0.43 % -0.64 %), pH (3.37 – 4.08), total sugar (11.78 % - 37.04 %), reducing sugar (4.42 % -31.96 %) and a decreasing trend in ascorbic acid (308.23 mg/100 ml – 79.97 mg/100 ml) and total soluble solids (25.05 -24.3° Brix) as a function of storage time. Sensory analysis revealed significant differences ($p<0.05$) across formulations for organoleptic characteristics, such as aroma, taste and overall acceptability. The composite vegetable squash T3 was chosen as the best formulation based on the findings of physicochemical and sensory attributes. It could be stored for 12 weeks without any significant variations and prolonged shelf life.

KEYWORDS: Ginger extract, physico chemical analysis, sensory attributes, shelf life

المستخلص: سريلانكا لديها مجموعة متنوعة من الخضروات. على الرغم من الخصائص الغذائية والطبية لليقطين والطماطم، إلا أن استهلاكهما كمشروبات محدود بسبب مذاقهما. يعتبر مزج هذه الخضار مع مستخلصات التوابل بديلاً مغذيًا أكثر عند إضافته في المشروبات. تم تحديد فترة تخزين الهريس النباتي المركب من نسب مختلفة من الطماطم واليقطين والزنجبيل. بالنظر إلى نتائج العديد من الدراسات الأولية، تم اختيار خمسة تركيبات من خليط مختلف من الطماطم واليقطين. وتم الحصول على أعلى التقديرات لجميع المتغيرات الحسية والخواص الكيميائية عن طريق التركيبة (T1) ٥٠٪ طماطم + ٥٠٪ يقطين تليها التركيبة (T2) ٧٥٪ طماطم + ٢٥٪ يقطين. تم تحسين أفضل تركيبة باستخدام ١٪ زنجبيل لتشكيل T3 (٥٠٪ طماطم + ٥٠٪ قرع + ١٪ زنجبيل). تم اختيار أكثر ثلاث معالجات واعدة (T1 وT2 و T3) لتجربة التخزين عند ٣٠ درجة مئوية ورطوبة نسبية تتراوح بين ٧٠-٧٥٪. تم إجراء التحليل الكيميائي والتقييمات الحسية. في التحليل الكيميائي وجدت فروقات ملحوظة في درجات الأس الهيدروجيني وحمض الأسكوربيك وحموضة المعايرة والسكر الكلي والسكر المختزل. ($p <0.05$) أظهرت تركيبات هريس الخضار المركب اتجاهاً متزايداً في الحموضة القابلة للمعايرة (٠,٤٣٪ -٠,٦٤٪) ، ودرجة الحموضة (٣,٣٧ - ٤,٠٨) ، وإجمالي السكر (١١,٧٨٪ - ٣٧,٠٤٪) ، والسكر المختزل (٤,٤٢٪ -٣١,٩٦٪) واتجاه تنازلي في حمض الأسكوربيك (٣٠٨,٢٣ مجم / ١٠٠ مل - ٧٩,٩٧ مجم / ١٠٠ مل) والمواد الصلبة الذائبة الكلية (٢٥,٠٥ - ٢٤,٣ درجة بريكس) كدالة لوقت التخزين. كشف التحليل الحسي عن فروق ذات دلالة إحصائية ($p <0.05$) بالنسبة للخصائص الحسية، مثل الرائحة والطعم والقبول العام. تم اختيار تركيبة هريس الخضار T3 كأفضل تركيبة بناءً على نتائج الخصائص الفيزيائية والكيميائية والحسية. حيث يمكن تخزينها لمدة ١٢ أسبوعًا دون وجود أي اختلافات كبيرة وفترة صلاحية طويلة.

الكلمات المفتاحية: مستخلص الزنجبيل ، التحليل الكيميائي الفيزيائي ، الصفات الحسية ، فترة التخزين.

Introduction

Sri Lanka produces approximately 1,167,141 tons of vegetables every year over an area of 84,191 hectares (Hamangoda and Pushpakumar, 2019). Hence, postharvest loss of vegetables ranges from 16 percent to 40 percent of total production (Vidanapathirana et al., 2018) in turn creates scarcity for the vegetables at the local markets followed by cropping seasons of maha and yala. Therefore, intake of vegetables decreased, in turn increases demand for those. As vegetable prices have risen, make the people unwilling to purchase them. In Sri Lanka, per capita consumption of vegetable is 33.76 kg/person/year, meanwhile the nutritional requirement of vegetables is 75 kg/person/year. To close this gap and enhance Sri Lankans' vegetable consumption, production of vegetable-based instant foods seems to be better solution. The price of vegetables is low during the high-production season, and it can be used to manufacture value-added items, like beverages. A beverage is a food product that is made specifically for human consumption and serves to quench thirstiness. Vegetable beverages are widely available in the global market. The beverages are available under a number of names, including fruit drink, nectar, squash, spice squash, ready-to-serve (RTS) (Kumar et al., 2013). Amongst, squashes are becoming more popular than synthetic beverages,

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owing to their flavor, taste, nutritional content, and storage stability. Fruit juice, sugar, citric acid, and preservatives are common constituents in squash beverages (Maciel et al., 2013).

Tomatoes (*Solanum lycopersicum*) are one of the world's most frequently grown vegetable crops. It is a specie of the Solanaceae family of nightshades. Tomatoes contain an exceptional amount of vitamin C and beta-carotene, as well as a decent amount of the mineral manganese and a good amount of vitamin E (Aldrich et al., 2010). *Cucurbita pepo* (pumpkin) is a commercially important Cucurbitaceae family member. It is a rich source of naturally active substances and is advised to consume for diseases including arthrosclerosis and diabetes, as well as controlling cholesterol (Dhiman et al., 2017). In 2018, tomatoes were grown on 6712 hectares in Sri Lanka, with a production of 101,404 tons meanwhile pumpkins were grown in 7301 ha with the annual pumpkin output level of 81,200 tons. (Hamangoda & Pushpakumar, 2019). Ginger is the subterranean rhizome of the plant *Zingiber Officinale*, which belongs to the Zingibeaceae family. In 2018, Sri Lanka produced 14,208 tons of ginger for 1999 hectares (Hamangoda and Pushpakumar, 2019) . Ginger has been extensively used as a spice and a natural preservative.

Despite having strong nutritious properties, the use of vegetables for the preparation of various processed products is limited due to excessive acidity, astringency, bitterness, and other features in the vegetables. As a result, blending different vegetables and spices can improve the juice's storability as well as inhibit microbiological growth (Bhardwaj and Pandey, 2011). Thus, the current research was conducted to generate squash from tomato, pumpkin, and ginger, as well as to assess its quality during storage.

Materials and Methods

The experiment was conducted at the Food Science Lab of the Food Research Unit in Gannoruwa, Sri Lanka. Fresh and high-quality tomato, pumpkin, and ginger were procured from Cargills Food City in Kandy, Sri Lanka; while sugar was obtained from a nearby shop in Gannoruwa. The most preferred composite squash formulations from our previous study were selected for storage study and they are 50% tomato and 50% pumpkin (T1) and 75% tomato and 25% pumpkin (T2) (Table 1). These formulations were prepared as described in our previous study (Begum et al., 2018) and stored at an ambient temperature of 27°C and 70-75 % RH. Hence, the formulation T1 was improved with 1% ginger extract and named as T3 (50% tomato and 50% pumpkin and 1 % ginger) to investigate the potentiality of ginger extract on the improvement of storage of composite squash formulation (Table 1). The prepared blends were kept in glass bottle with three replications under ambient conditions.

Sensory evaluation

A panel of 20 un-trained panelists evaluated the formulated composite squash for organoleptic features, such as color, aroma, taste, nature, and overall acceptability at the end of storage. The panelists were chosen from different social status. Three digits numbers were selected and assigned to each treatment sample. Prepared tomato-pumpkin squashes were presented simultaneously for the panelist and serving order was randomized. The panelists were not allowed to communicate during evaluation. The hedonic rating test was used to determine the acceptability. The panelists rated their acceptability of the product on a 5-point hedonic scale. The scale was arranged liked that 5 = extreme like, 4 = like moderately, 3 = neither like nor dislike, 2 = dislike moderately and 1=extreme dislike. The sensory assessment was performed within 9.00 am and 12.00 pm. Each panelist was given a set of samples to assess at random.

Physico-chemical Analysis of Squash

The physico-chemical properties of the stored squash were assessed using AOAC-recommended standard techniques (Horwits and Latime, 2005). A hand-held refractrometer was used to measure the Total Soluble Solids (TSS) and expressed as °Brix (Model ATAGO-S-28E). A digital pH meter was used to determine the pH (Model HANNA HI 98130). 5 ml squash was homogenized with 45 ml of distilled water for 1min at 20°C to measure the pH. The titratable acidity of the juices was measured by titrating them with standard sodium hydroxide (NaOH) and expressed the results in percent citric acid. The indophenol dye method was used to determine vitamin C content, while the Lane-Eynon method was used to determine total sugar in all squash formulations. During the analysis, each parameter was replicated three times.

Statistical Analysis

To evaluate the significance at $P < 0.05$, the results of the sensory evaluation and chemical analysis were statistically evaluated using ANOVA and the computer-aided SAS statistical software was used. Standard errors were calculated using MINITAB 14 statistical package. Comparison of means of sensory evaluation and chemical analysis were done by Tukey's Standardized Range Test (TSRT) and Duncan Multiple Range Test (DMRT) respectively.

Results and Discussion

pH

Changes in pH of stored composite vegetable squashes of tomato, pumpkin and ginger are presented in the Table 2. As per the Table 2, the highest pH value (4.31) was recorded in formulation T1, while lowest (4.08) in the T3 at the end of storage. The findings of this study are

Table 1. Experimental plans

Treatments	Tomato (% w/w)	Pumpkin (% w/w)	Ginger (% w/w)
T1	50	50	00
T2	75	25	00
T3	50	50	01

expected because the phenolic components and organic acids (i.e. malic acid and oxalic acid) in ginger extract can release H^+ ions, and pH was reduced (Faiqoh et al., 2021). At room temperature, there were significant variations ($p<0.05$) in pH among squash formulations and it gradually increased during storage. This might be due to the use of acids in the presence of metal ions to produce hexose sugars from polysaccharides and non-reducing sugars during storage and the same behaviors were observed in sapota squash (Relekar et al., 2013).

Table 2. Changes in pH of Stored Composite Vegetable Squashes of Tomato, Pumpkin and Ginger

Storage Periods (weeks)	T1	T2	T3
2	4.04 ± 0.0[a]	4.02 ± 4.02[a]	3.37 ± 0.08[b]
4	4.04 ± 0.01[a]	4.03 ± 0.00[a]	3.80 ± 0.01[b]
6	4.00 ± 0.0[b]	4.17 ± 0.00[a]	3.91 ± 0.01[c]
8	4.00 ± 0.0[a]	4.16 ± 0.05[c]	3.90± 0.00[b]
10	4.32 ± 0.01[a]	4.13 ± 0.00[c]	4.07 ± 0.01[b]
12	4.31 ± 0.0[a]	4.13 ± 0.01[c]	4.08 ± 0.00[b]

T1: Treatment 1, T2: Treatment 2, T3: Treatment 3
The values are the means of three replicates ±standard error.
Values shown with different letters are different significantly ($p<0.05$)

Total Soluble Solids (TSS)

Changes of TSS in stored composite vegetable squashes of tomato, pumpkin and ginger are shown in Table 3. At the end of storage, it shows that TSS value was the highest (26.1) in T2 formulation and the lowest in the T3 formulations (24.3). It could be because the ginger juice inhibited microbial development, which could advance metabolic rates and ginger extract's phenolic compounds, such as gingerole, and shagoal. These may trap sucrose, hexoses, and other constituents, thus preventing it to contribute in the soluble components (Bhardwaj and Mukherjee, 2011; Hariharan and Mahendran, 2016).

Table 3. Experimental plans

Storage	T1	T2	T3
2	26.10 ± 0.10[a]	26.15 ± 0.45[a]	25.05 ± 0.05[a]
4	25.50 ± 0.50[a]	25.60 ± 0.00[a]	25.05 ± 0.05[a]
6	25.75 ± 0.25[a]	25.90 ± 0.10[a]	24.15 ± 0.15[b]
8	25.75 ± 0.10[a]	25.90 ± 0.20[a]	24.15 ± 0.05[b]
10	24.20 ± 0.20[b]	26.10 ± 0.10[a]	24.40 ± 0.00[b]
12	26.05 ± 0.05[a]	26.10 ± 0.10[a]	24.30 ± 0.10[b]

T1: Treatment 1, T2: Treatment 2, T3: Treatment 3
The values are the averages of three replicates ± standard error.
Means with the same letter in the column are not significantly different from each other ($P>0.05$).

TSS of all formulations was reduced as storage time increased, possibly due to chemical interactions between the squash's organic constituents (Inthuja et al., 2019). As vitamin C is water soluble and prone to oxidation, it progressively reduced; this is the fundamental reason for the decrease in acidity and TSS (Mikdat Simsek,

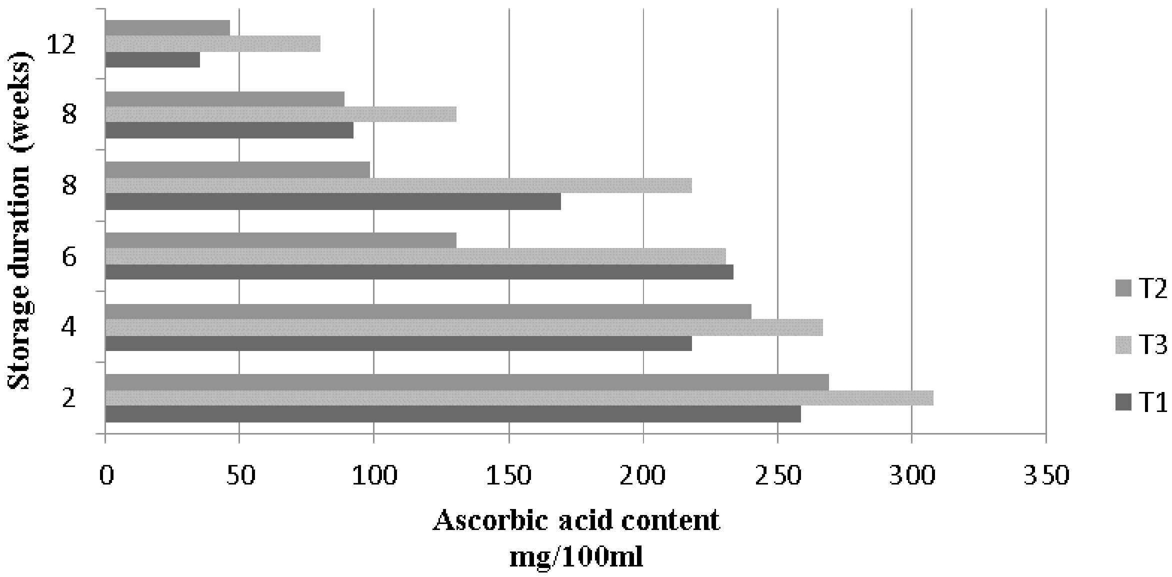

Figure 1. Changes in ascorbic acid of tomato, pumpkin, and ginger composite vegetable squashes

Table 4. Sensory evaluation of tomato, pumpkin, and ginger composite vegetable squashes at the end of 12 weeks

Formulations	Weeks	Colour	Aroma	Taste	Nature	Overall acceptability
T1	0	4.62 ± 0.18[a]	4.69 ± 0.13[a]	3.92 ± 0.24[a]	4.46 ± 0.22[a]	4.46 ± 0.24[a]
	12	2.77 ± 0.30[a]	2.93 ± 0.33[ab]	3.08 ± 0.29[a]	2.38 ± 0.14[a]	3.00 ± 0.28[ab]
T2	0	4.00 ± 0.28a[b]	3.85 ± 0.27[b]	3.31 ± 0.37[ab]	3.69 ± 0.21[b]	4.08 ± 0.21[ab]
	12	2.78 ± 0.31[b]	2.62 ± 0.21[abc]	2.08 ± 0.21[c]	2.08 ± 0.14[a]	2.00 ± 0.16[c]
T3	12	2.76 ± 0.26[a]	2.08 ± 0.27[c]	2.62 ± 0.29[abc]	2.38 ± 0.24[a]	3.46 ± 0.27[a]

T1: Treatment 1, T2: Treatment 2, T3: Treatment 3
Values are the averages of 20 replicates ± standard error
Means of the columns with the same letters are not significantly different ($p<0.05$)
Five-point hedonic scales were used to assess sensory characteristics

2011). The results are similar to the finding of a low-calorie herbal aonla-ginger beverage (Gaikwad et al., 2012).

Ascorbic acid

Figure 1 explains that the maximum average value of vitamin C was 79.97 mg/100 ml in T3 (pumpkin 50 % + tomato 50 % + ginger 1 %), while the mean minimum value was 35.35 mg/100 ml in T1 (pumpkin 50 % + tomato 50 %). During the whole storage time under ambient conditions, a gradual decline in ascorbic acid was seen in composite squash formulations. The rate of decrease was low in the case of T3 because ginger extract could reduce the oxidation process of ascorbic acid (Bhardwaj and Mukherjee, 2011). The breakdown of ascorbic acid to dehydro ascorbic acid or the unstable nature of ascorbic acid was due to the influence of heat, light, and air (Herbig and Renard, 2017). The current findings are consistent with those of squash from wild prickly pear fruits (Chauhan et al., 2019), mulberry squash (Thakur and Hamid, 2017) and sweet orange squash (Syed et al., 2012).

Titratable acidity

Figure 2 shows the changes in titratable acidity of stored composite vegetable squashes of tomato, pumpkin and ginger. At the end of storage the formulation T3 had the highest titratable acidity value (0.65 %) whereas the formulation T1 had the lowest (0.35 %) (Figure 2). During storage, titratable acidity was increased significantly in all formulations. This could be associated with the presence of microbes and the breakdown of sugar, but also might be acid production, oxidation of reducing sugars, polysaccharide degradation, or the breakdown of uronic acid and pectin components (Bhardwaj and Pandey, 2011; Kesavanath et al., 2015). Blend of pineapple, carrot and orange juices revealed a similar result (Jan and Masih, 2012).

Total sugar content

Figure 3 shows the changes in total sugar content of stored composite vegetable squashes of tomato, pumpkin and ginger. T3 (Tomato 50 % + pumpkin 50 % + ginger 1 %) had the highest mean value (37.04 %) for total sugars after the storage. Throughout twelve weeks of storage

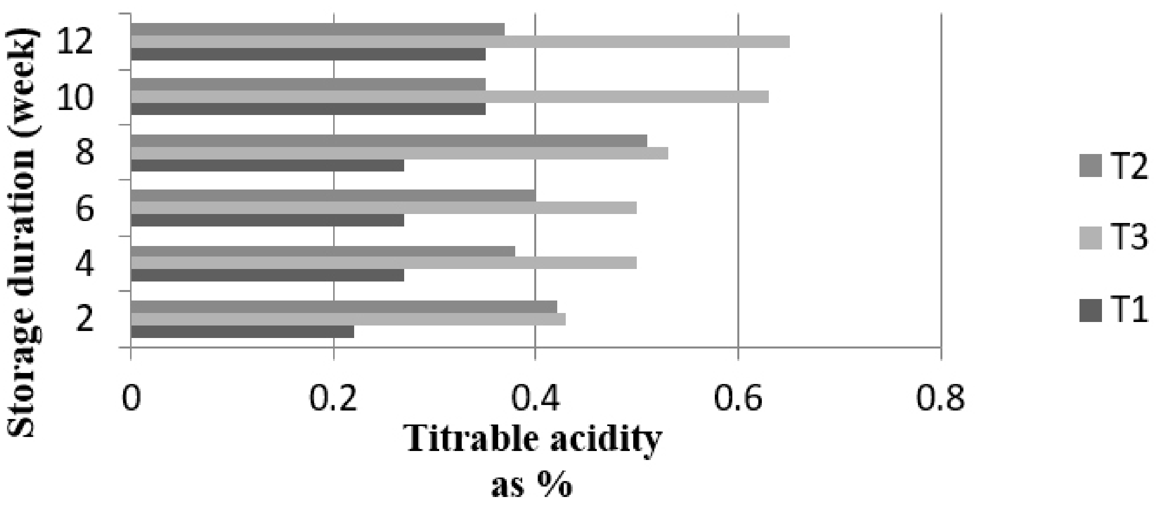

Figure 2. Changes in titratable acidity of stored composite vegetable squashes of tomato, pumpkin and ginger

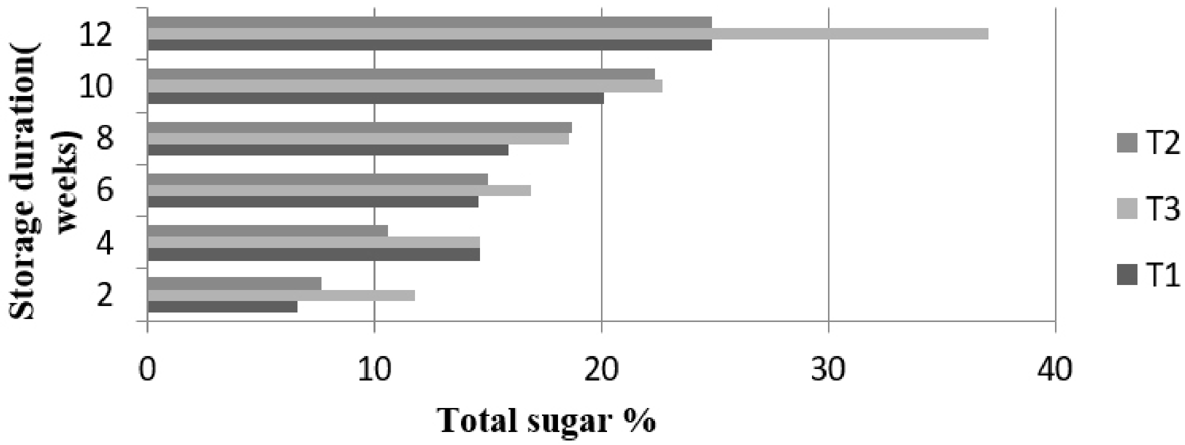

Figure 3. Changes in total sugar content of stored composite vegetable squashes of tomato, pumpkin and ginger

under ambient conditions, total sugars in squash formulations increased gradually (Figure 3). This could be due to the hydrolysis and conversion of polysaccharides from other components, such as pectin, cellulose, starch (Hariharan and Mahendran, 2016). Similar increase in the total sugars was recorded in orange-based blended RTS beverages (Malav et al., 2014), seabuckthorn squash (Ali et al., 2011) and sapota squash (Relekar et al., 2013).

Reducing sugar

Figure 4 shows the changes in reducing sugar content of stored composite vegetable squashes of tomato, pumpkin and ginger. Figure 4 displays the data reducing sugars as affected by storage of formulated squash. At the end of storage, T3 reported the mean highest value (31.96 %) for reducing sugars, while T1 showed the mean minimum value (19.97 %). During storage, the reducing sugar content of each sample increased gradually. This could also be due to starch breakdown into sugars. As well as the hydrolysis of non-reducing sugars into reducing sugars and the conversion of complex polysaccharides into simple sugars (Thakur and Hamid, 2017). In an orange-based blended RTS beverage, a similar increase in reducing sugars was shown during storage (Malav et al., 2014).

Sensory Quality

Table 4 shows sensory evaluation of tomato, pumpkin, and ginger composite vegetable squashes at the end of 12 weeks. The sensory evaluation result revealed that the color, aroma, taste, nature, and overall acceptability scores of squash gradually declined as the storage period progressed. Color is a prominent factor of visual perception. Reduced oxygen in the headspace can increase carotenoid breakdown via oxidation, thus resulted the development of off-color (Gliemmo et al., 2009). The aroma scores of various squash samples differed significantly ($p<0.05$). It was probably due to the loss of aroma (i.e. volatile aromatic components) (Thakur and Hamid, 2017). The taste of several squash samples differed significantly ($p<0.05$). The loss of the sugar-acid combination of squash after storage could be explained by the decline in taste (Chauhan et al., 2019).The drinking ability of a drink is nature. The difference in nature score between squash samples was not significant ($p>0.05$) at the end of twelve weeks. Treatment T3 had the highest mean nature (2.38) while treatment T2 had the lowest mean nature (2.08). According to statistical analysis, the overall score of various squash samples differed significantly ($p<0.05$). Squash's overall acceptability scores could be declined over storage due to the changes in appearance, flavor components, product uniformity (Ullah et al., 2015). During storage, sensory qualities in papaya blended pineapple RTS beverage (Sindhumathi and Premalatha, 2013) and box myrtle squash (Thakur et al., 2016) showed a considerable decrease. When compared with other squash samples, T3 (50 % tomato+ 50 % pumpkin+1 % ginger) was favored.

Conclusion

According to the compositional study, pH, titratable acidity, total sugar, and reducing sugar of all formulations increased with storage time (12 weeks), while total soluble solid and ascorbic acid declined marginally and the sample T3 (50 % tomato + 50 % pumpkin + 1 % ginger composite vegetable squash) obtained higher ascorbic acid, titratable acidity, total sugar and reducing sugar content. Although all the squash samples were acceptable, the formulation T3 proved to be the more superior to other when examined over a period of 12 weeks. Tomato, pumpkin, and ginger have enormous potential for creating a healthy squash. This may, if properly exploited, provide a healthier alternative to the sugar intensive drinks. This may also be a better technique to preserve the products and reduce spoilage and vegetable waste.

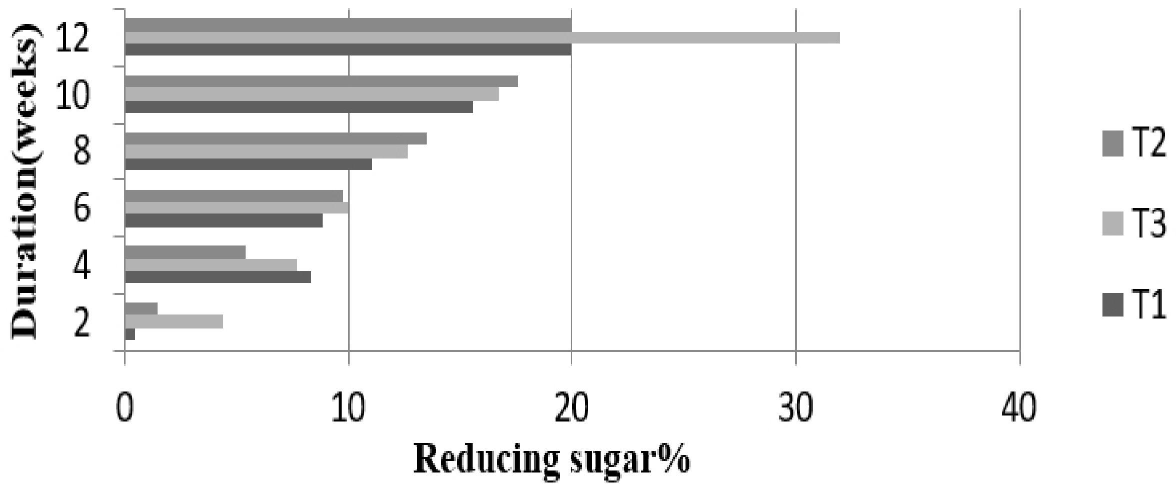

Figure 4. Changes in reducing sugar content of stored composite vegetable squashes of tomato, pumpkin and ginger

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