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Screening and Storage Analysis of Cider of Bael (*Aegle marmelos* (L.) Correa) Fruits

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Bael is an underutilized, indigenous fruit with excellent nutritional content. It is widely consumed as sharbat, and many of its beverages and goods are in great demand among customers during summer. Cider is one of the fermented beverages made from bael that is in high demand on the worldwide market owing to its excellent aroma, flavour, and nutritional content. The cider market has enormous potential. Consequently, an experiment was conducted in the Post-Harvest Laboratory, College of Horticulture and Forestry, Acharya Narendra Deva University of Agriculture and Technology Kumarganj Ayodhya (U.P) in the year 2020-21 to determine the stage and genotypes of bael for ideal cider, as well as the changes that occurred during the storage period of ideal cider. The study was conducted using a completely randomised design with three replications for screening bael cider in terms of organoleptic score and alcohol per cent After one month, another experiment will be conducted to assess the physicochemical changes of the ideal bael cider occurred during storage. The results of research concluded that the cider made from NB-5 in May was superior to cider made from other stages and genotypes. Alcohol, hedonic (organoleptic) score and titrable acidity exhibited a rising trend, whereas a downward trend was noted in TSS, ascorbic acid, reducing sugars, non-reducing sugars, and total sugars.

Keywords: Bael; cider; Physico-chemical; genotype; completely randomized design; alcohol; organoleptic score; fermentation.

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1. INTRODUCTION

The Bael fruit, or *Aegle marmelos* (L.) Correa has been one of the most important fruits in India since prehistoric times. It belongs to the Rutaceae family, aurantiodeae subfamily, and hard-shelled citroid fruit tree group and is thought to have its origins in the eastern ghats and central India [1]. The bael is grown in tropical and subtropical regions. [2] Bael juice and pulp make great summertime refreshers. The fruit is widely used in India as a liver and cardiac tonic and, when unripe or partially ripe, as an astringent, digestive, stomachic, useful in the treatment of diarrhoea and dysentery, as well as an efficient remedy for hi-cough, sore throat, and gum disease. The bael fruit has laxative and cooling properties that might help with constipation. *Aegle marmelos* have been utilised in Ayurvedic, Unani, and Siddha medicine as a herbal treatment for diabetes mellitus. High nutritional value can be found in marmelos' fruit. The pulp contains lignin, oil, inulin, water, sugar, protein, fibre, fat, calcium, phosphorus, potassium, iron, and vitamins (A, B, C, and riboflavin), as well as alkaloids, cardiac glycosides, terpenoids, flavonoids, and flavonoids. The fruit has a 61.5% water content, 31.8% carbohydrates, 1.8% protein, 1.75% minerals, 55mg carotene, 0.39mg fat, 0.13mg thiamine, 1.19mg riboflavin (the greatest amount among fruit crops), 1.1mg niacin, and 8mg vitamin C per 100g of edible portion [3].

Bael is not widely used as a table fruit due to its hard shell, mucilaginous texture, and abundant seeds, which make it difficult to eat by hand. A processing opportunity exists in the excellent flavour, nutritional content, and therapeutic benefits of bael fruit. Refined beverages like Bael Cider, RTS, squash, etc. can be made from ripe bael fruits. The best alcoholic sweet beverage is Bael Cider. The diluted bael pulp was improved with sugar and acid and fermented at 30 ± 2^0 C using the yeast *Saccharomyces cerevisiae* [4]. Patra et al. [5] reported fermented bael juice contains titrable acidity and lactic acid with 1.7mg tartaric acid/L and 7.2mg/L, respectively. It is rich in antioxidants and can be utilised as a medicinal drink with significant nutritional potential. The Bael cider is healthier than any other fermented beverage. have PH (4.1), total phenolics (0.93g/100 ml), beta carotene (33g/100 ml), ascorbic acid (80 mg/100 ml), lactic acid (0.64 mg/100 ml), total soluble solids (12.90^0 Brix), total sugar (2.03g/100 ml), titrable acidity (0.15g tartaric acid/100 ml), and ethanol (7.87%) [6]. This drink would be healthier than any other artificially-flavoured alcoholic beverages, which are widely available in our nation.

2. MATERIALS AND METHODOLOGY

The present investigation was carried out at Post-Harvest Laboratory, Department of PHT, College of Horticulture and Forestry, Acharya Narendra Deva University of Agriculture and Technology Kumarganj Ayodhya (U.P) in the year 2020-21 the healthy fruits of the genotype NB-4, NB-5, NB-7 and NB-9 which were free from disease, pests and bruises were randomly selected in the month of March, April and May from the main experiment station, Horticulture, Acharya Narendra Deva University of Agriculture and Technology Kumarganj Ayodhya (U.P) India.

2.1 Techniques for Preparation of Bael Cider

2.1.1 Preparation of starter

Bael fruits are picked and sliced. After retaining T.S.S. (20 per cent), these bael slices were combined with water in a ratio of 1:1, brought to a boil, and chilled to room temperature. After cooling, *Saccharomyces cerevisiae* yeast culture was inoculated under laminar airflow, and aluminium foil was put on top and secured with a rubber band so that no pathogen could infect the culture. To cr8/6/2022eate the starting culture, the whole combination was incubated for 24 hours at 30° C.

2.2 Methodology

Firm ripe fruits free from any disease were selected, thoroughly washed and broken the shell, and removed pulp with seed and fibre. The bael pulp was mixed with water in a ratio of one part pulp and one part water and heated up to 80^0C. After cooling it was massed with hands and the acidity (0.5%) and T.S.S (20%) were adjusted, then transferred to the container (at least $1/4^{th}$ part of the container should be vacant) thereafter sulphur dioxide 100 ppm was added in form of potassium metabisulphite. After half an hour, it was inoculated with the starter of *Saccharomyces cerevisiae var. ellipsoids* yeast (4%) close the container airtight and the airlock was adjusted on the top of the container for the exhaustion of carbon-dioxide gas from the container to the outside and restricts air from outside to inside the container. At the peak level of fermentation pure pectic enzyme was added

(0.5%) for getting easy clearing. After that the must be filtered through the two-layered muslin cloth discarding seeds and pomace. Filtered juice was kept again in the container for fermentation. Two- three weeks were required for the primary fermentation phase.

After the completion of primary fermentation (when the bubble does not come out in the airlock), the clear fermented juice was siphoned off and filled into the containers up to the brim and 50ppm sulphur dioxide in form of potassium metabisulphite was added, sealed, airtight and kept at room temperature for maturation. To carry out racking for six months (at an interval of two months) storage.

After the maturation of cider fermented juice was filled in 200ml glass bottles (upto drum), crown corked, pasteurized at 65^0C for 20 minutes and cooled in air and stored at ambient temperature. Ideal Cider was stored at ambient temperature for the investigation of storage stability.

2.3 Chemical Estimation of Bael Cider

Total soluble solids was estimated by using a hand refractometer (Erma) of 0 to 32% and 28-62 % range at room temperature and the reading was corrected at 20^0 C temperature. Sugars were estimated by using Fehling solution ‘A’ and ‘B’ as per the method given by Lane and Eynon [7] and Ranganna , 2010 The acidity and ascorbic acid was estimated as per the method described by [8], the alcohol estimation was done by experts of RFRAC Lucknow through the procedure mention in FSSAI Manual Fruits & Vegetable 2016.

2.4 Statistical Analysis

Statistical analyses of the data obtained in the experiments were calculated as suggested by Panse and Sukhatme [9] and results were evaluated at a 5% level of significance.

3. RESULT AND DISCUSSION

3.1 Screening of Suitable Genotype and Stage of Fruit for Bael Cider

The data arranged in Table 1 indicate that cider produced in May was noticeably superior to earlier stages. Cider made from the NB-5 genotype had a much higher organoleptic score than cider prepared from other genotypes of bael. The interaction impact between genotype and stage was found non-significant. Cider made from the NB-5 in May is of superior quality, followed by cider made from the NB-9 in May.

The alcohol produced in May has the greatest quantitative alcohol content compared to the other phases. The bael cider made from NB-5 was found to have the highest alcohol content among the genotypes. Bael's genotypes and the interaction effect were determined to be statistically non-significant. The bael cider made with NB-5 in May has the greatest alcohol content, followed by bael cider made with NB-9 in May.

3.2 Chemical Changes during the Storage Analysis of Bael Cider

The data arranged in Table 2 indicate the consistent increasing trend of the organoleptic quality of bael cider during the storage period recorded. The organoleptic score increased from 7.68 at the time of cider preparation to 8.46 in the 7^{th} month of observation. The increase in organoleptic quality may be due to increasing in the percentage of alcohol through secondary fermentation and a reduction in sulphur dioxide and yeast odour. Similar findings were also reported by Singh et al. [10]. Apple cider's organoleptic score increased with storage Tripathi et al. [11].

The alcohol content of bael cider and storage duration have a positive correlation. The trend of increasing alcohol content along with the elongation of bael cider storage. The alcohol content increased from 7.19% at the time of cider production to 7.22% during the seventh month of monitoring. The rise in alcohol (per cent) may be attributed to polysaccharide hydrolysis to fermentable sugar, secondary fermentation of fermentable sugar, and conversion to ethyl alcohol during bael cider storage. Ram [12] found that bael cider's alcohol concentration increased for five months and then stabilised. Similar results were also reported by Singh et al. [13].

Total soluble solids have been steadily decreasing while the bael cider has been stored. Up to the third month of storage, the decreasing tendency was more pronounced than the subsequent shifting pattern. At the time of preparation, the maximum amount of cider that could be stored was noted. It then steadily decreased to a level of 6.81 ^{0}Brix at the end of the seventh observational month. The decrease in TSS may be due to the hydrolysis of polysaccharides to simple sugars. Kiribhaga et al. [14] also reported a similar downward trend during the storage of banana wine.

The acidity percentage of the bael cider gradually decreases with the storage period afterwards. The acidity percentage changes from 0.764 % at the time of preparation to 0.391% at the end of the storage period. The decrease in acidity content might be due to the breakdown of citric acid in the pulp to mobilize the sugar. The results were in close agreement with Jespersen et al. [15]; Nielsen et al. [16] in cocoa beans.

Table 1. Screening of suitable genotype and stage of fruit for bael cider

Treatment	Organoleptic score	Alcohol (%)
March (S_1)		6.84
April (S_2)	7.17	7.03
May (S_3)	7.42	7.15
SEm±	**0.067**	**0.043**
C.D.(P=0.05)	**0.197**	**0.127**
NB-4 (V_1)	6.83	6.98
NB-5 (V_2)	7.3	7.12
NB-7 (V_3)	6.97	6.89
NB-9 (V_4)	7.12	7.04
SEm±	**0.077**	**0.05**
C.D.(P=0.05)	**0.227**	**0.147**
S_1V_1	6.32	6.78
S_1V_2	6.88	7.01
S_1V_3	6.46	6.64
S_1V_4	6.64	6.92
S_2V_1	6.94	7.02
S_2V_2	7.35	7.16
S_2V_3	7.12	6.91
S_2V_4	7.26	7.03
S_3V_1	7.22	7.14
S_3V_2	7.68	7.2
S_3V_3	7.34	7.11
S_3V_4	7.45	7.16
SEm±	**0.134**	**0.087**
C.D.(P=0.05)	**NS**	**NS**

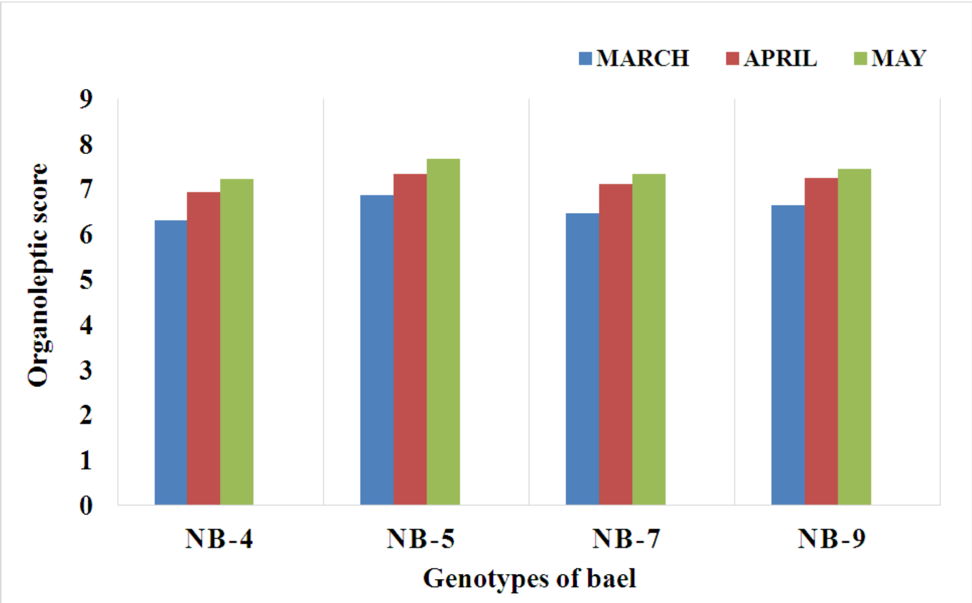

Fig. 1. Organoleptic score of the bael cider

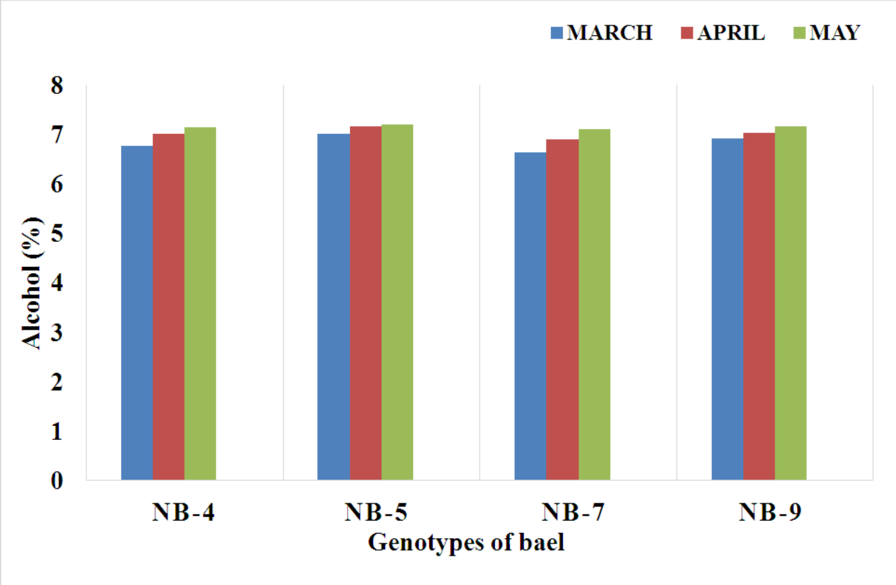

Fig. 2. Alcohol (%) of the bael cider

Table 2. Chemical changes during the storage analysis of ideal bael cider

Storage period	Organoleptic score	Alcohol content (%)	TSS (^{0}Brix)	Acidity (%)	Ascorbic acid (mg/100g pulp)	Reducing sugars (%)	Non-reducing sugar (%)	Total sugars (%)
0	7.68	7.19	11.13	0.764	82.36	4.42	5.62	10.04
1	7.87	7.20	10.04	0.715	78.6	4.16	5.34	9.5
2	7.93	7.22	8.86	0.643	71.52	3.52	4.31	7.83
3	8.06	7.23	7.98	0.61	62.13	2.48	4.18	6.66
4	8.24	7.24	7.52	0.552	54.29	2.31	3.97	6.28
5	8.31	7.28	7.15	0.501	46.35	2.11	3.81	5.92
6	8.39	7.28	6.97	0.461	41.28	1.97	3.68	5.65
7	8.46	7.31	6.81	0.391	35.23	1.94	3.64	5.58
SEm±	0.11	0.03	0.14	0.009	0.88	0.03	0.05	0.11
C. D. at 5%	0.32	0.08	0.43	0.025	2.65	0.11	0.14	0.34

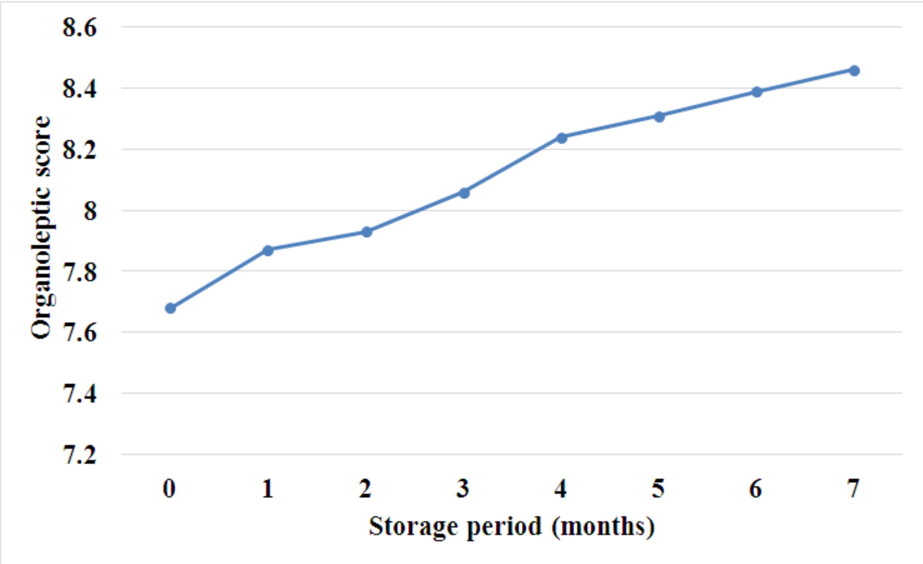

Fig. 3. Changes in organoleptic score during storage of bael cider

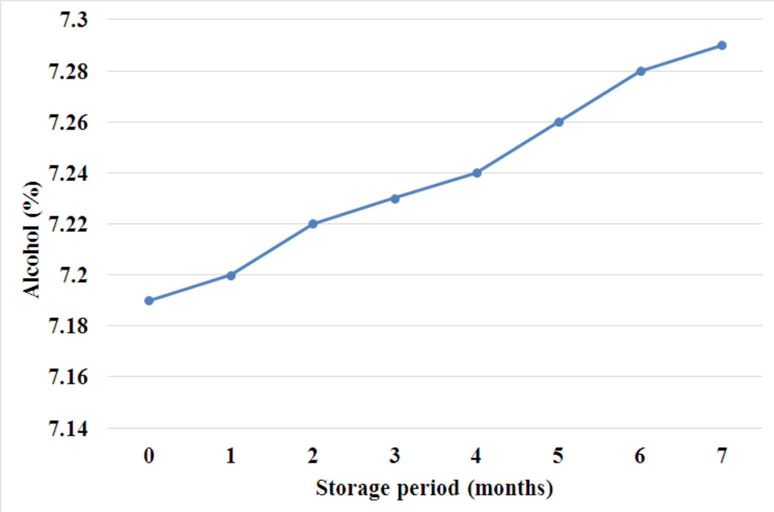

Fig. 4. Changes in alcohol (%) during storage of bael cider

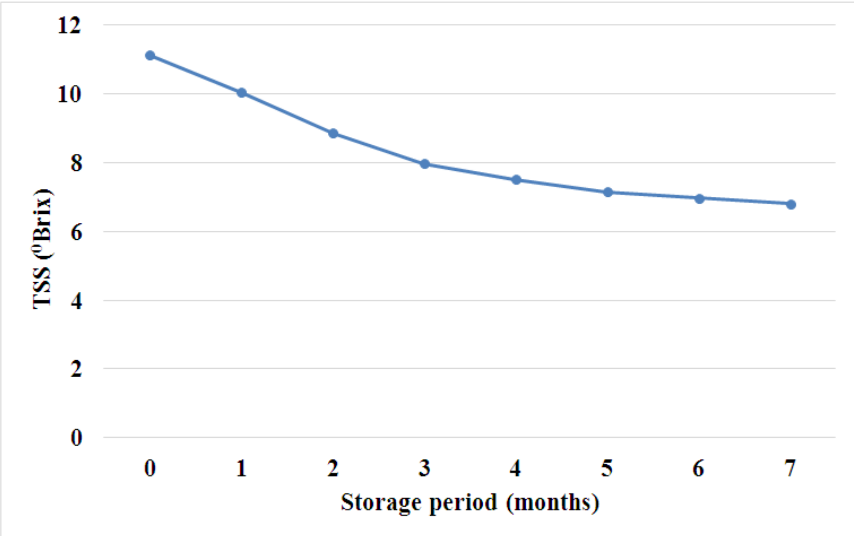

Fig. 5. Changes in TSS during storage of bael cider

Ascorbic acid levels in bael cider have been declining steadily over time. When bael cider was being prepared, ascorbic acid levels were found to be 82.36 mg/100 g of pulp, but by the seventh month of storage, it had dropped to 35.23 mg/100 g of pulp. Oxidation of ascorbic acid with trapped oxygen in the bottling ultimately leads to synthesis of dehydroascorbic acid. Kiribhaga et al. [14] also reported a similar downward trend during the storage of banana wine.

The tendency of reducing sugars to decrease as bael cider was stored. The drop started gradually during the first two months of storage, but it then became steadier up to the fifth month. After that, in the fifth month of storage, the reducing sugars almost exactly remained constant. The non-reducing sugar in bael cider was also reduced during storage [17]. For the first two months of storage, the drop was moderate. After that, it continued to decline gradually until the fifth month of storage, at which point the non-reducing sugar levels were nearly constant. The negative relationship between total sugars and bael cider storage duration was observed. Total sugars were shown to trend downward similarly to reducing and non-reducing sugar. The downward trend in the sugars might be due to the utilization of pectic substances by the yeast during fermentation in presence of pectic enzyme added during must preparation. Similar findings were also reported by Aradhna and Fleet [18]; Garg et al. [4].

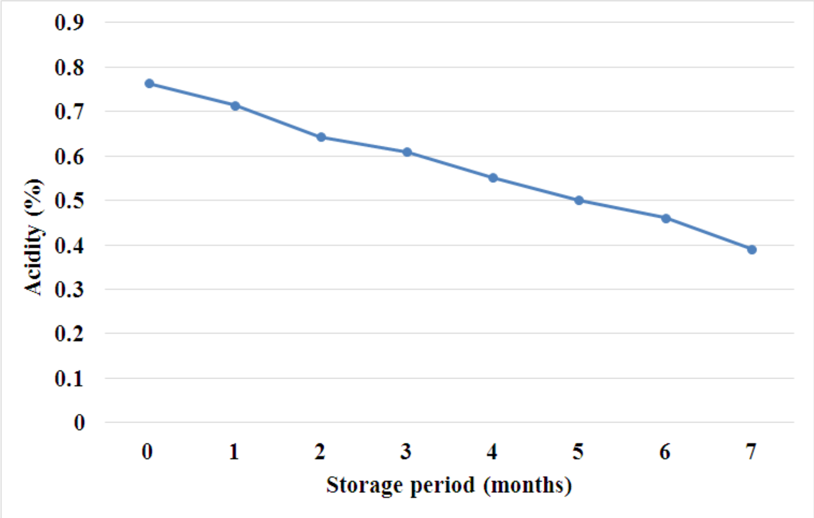

Fig. 6. Changes in acidity (%) during storage of bael cider

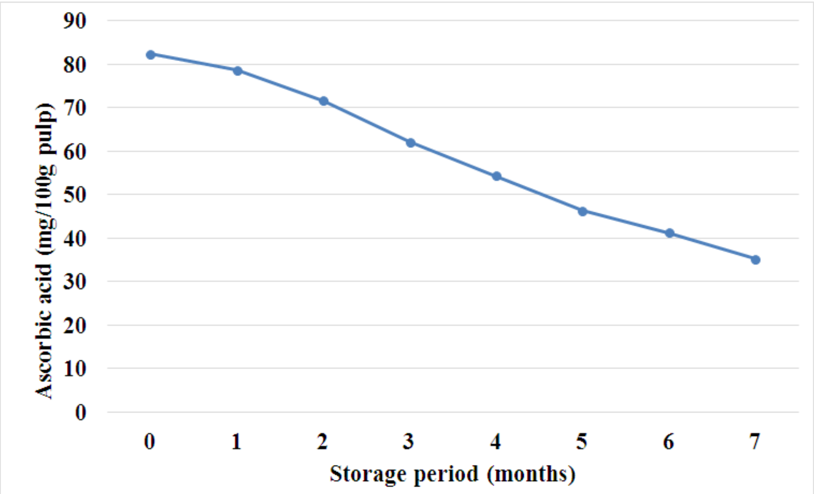

Fig. 7. Changes in ascorbic acid (mg/100g pulp) during storage of bael cider

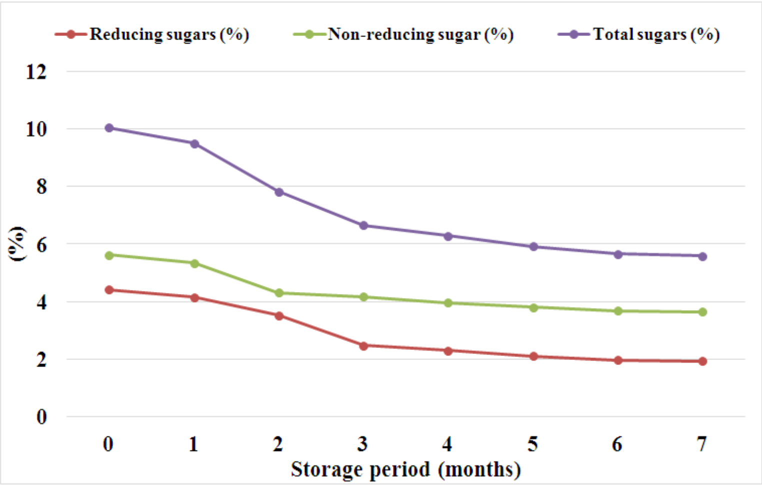

Fig. 8. Changes in sugars (%) during storage of bael cider

4. CONCLUSION

Based on the results, it can be concluded that the genotype NB-5 of bael is appropriate for cider production due to the high-quality parameters viz. average-sized fruit, higher pulp, less mucilage, seed acidity, as well as a high TSS are attributed to the selection of the NB-5 genotype. The cider produced in May is always of higher quality than cider produced in previous months due to the fact that in the month of May the bael ripened and starch was converted into glucose during ripening which is converted into alcohol during the fermentation. Bael cider prepared from NB-5 in May has the highest alcohol (%) and hedonic score. The preservation of bael cider improved its quality The alcohol (%) and acceptability of cider were increasing whereas the TSS, Sugars and ascorbic acid, acidity decreased during the storage significantly improving the quality of bael cider during the storage.

When the underutilized fruits used at commercial level in the cider industry, the bael growers can earn better margin through the processing of bael and preparation and marketing of cider.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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