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Performance of different levels of yeast and sugar on production and quality of Apple cider

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Abstract
The most significant temperate fruit crop, apples (*Malus x domestica* Borkh), are grown extensively in both the north-eastern part of India and the north-western Himalayan region. It is incredibly high in dietary fibers, flavanoids, and vital antioxidants. The goal of the current study was to make apple cider using fresh apple juice, yeast and sugar. Different concentrations of yeast and sugar were mixed with fresh apple juice. Apple juice was treated with yeast and sugar to create apple cider. The apple must was then fermented using a strain of *Saccharomyces cerevisiae*.
The titratable acidity of apple cider declined as the percentage of added juice, whereas TSS, pH, and ascorbic acid increased. The apple cider made with T_4 (apple juice (500ml) + yeast (0.5g) + sugar (150 g) received the highest rating in the chemical and sensory quality parameters study, followed by T_2 and T_4, was deemed the best cider to drink.

Keywords: Apple juice, ascorbic acid, yeast, antioxidants, cider, fermentation

Introduction
The most significant temperate fruit is the apple *(Malus x domestica* Borkh). Additionally noteworthy is Apple's ability to treat a variety of chronic ailments. In the Eastern Mediterranean region, apple juice has been fermented for over 2000 years to produce a tasty alcoholic beverage (Laplace *et al*., 2001) [10]. In addition to wine and brandy, apple juice is currently fermented to create cider, a sparkling, fruit-flavored beverage that is enjoyed in many nations worldwide (Alberti *et al*., 2011) [1].
Apples naturally contain a balanced amount of nutritional salts that allow yeast to produce a stable and palatable beverage. According to Lea and Drilleau (2003) [11], tannins are a group of poly phenols that give cider its astringency and bitterness and are crucial to its outstanding organoleptic qualities. Even more popular than beer in the eleventh and twelfth centuries, it was a prevalent beverage during the Roman invasion of England in 55 BC (Jarvis *et al*., 1995) [7]. Cider may be soft or firm compared to other comparable beverages, the scientific features of its manufacture are less well documented, despite the fact that it has been produced for more than two millennia (Joshi and Sharma, 2011) [9].
India produces a lot of apples, and its cider production has the potential to be a valuable tool for diversification and post-harvest loss prevention. In a previous published work, apple juice and apple base wine were blended in varying quantities to create apple cider (Banjare and Patel, 2020) [2]. However, there is no information on how apple cider is made or how different apple juice percentages affect the physical-chemical makeup and flavor of apple cider. Consequently, an attempt was made to make apple cider by mixing apple juice, yeast and sugar in varying amounts, and the outcome is shown in this message (Beech and Carr, 1977) [3].

Materials and Methods
The present experiment entitled "Performance of Different Levels of Yeast and Sugar on Production and Quality of Apple Cider" was carried out in the Laboratory, CHRS, Saja, Bemetara (C.G.) during the year 2024-2025.

Experimental Details

Fruit	Apple
Botanical Name	*Malus x domestica* Borkh
Family	Rosaceae
Chromosome Number	2n=34
Fruits	From local market
Year of experiment	2024-25
Design	CRD
Number of Treatments	10
Number of Replications	3
Experiment site	CHRS, Saja, Bemetara (C.G.)

Table 1: The details of treatment

Treatment	Treatment Details
T_0	Control
T_1	Apple juice (500ml) + yeast (0.5g) + sugar (100 g)
T_2	Apple juice (500ml) + yeast (1.0 g) + sugar (100 g)
T_3	Apple juice (500ml) + yeast (1.5g) + sugar (100 g)
T_4	Apple juice (500ml) + yeast (0.5g) + sugar (150 g)
T_5	Apple juice (500ml) + yeast (1.0 g) + sugar (150 g)
T_6	Apple juice (500ml) + yeast (1.5g) + sugar (150 g)
T_7	Apple juice (500ml) + yeast (0.5g) + sugar (200 g)
T_8	Apple juice (500ml) + yeast (1.0 g) + sugar (200 g)
T_9	Apple juice (500ml) + yeast (1.5g) + sugar (200 g)

Methods of Preparation of Apple Cider

1. Selection of fruits
The apple fruit was purchased from local market Raipur (C.G.) for making the cider.

2. Apple juice extraction
Apple fruits' juice was extracted. Fruits were peeled, cleaned, and sliced into little pieces. The apple juice was recovered by filtering the grated apple through a muslin cloth after the apples were grated using a home mixer grinder.

3. Quantity of sugar taken
According to the treatments, 4.5 kg of sugar were utilized in total during the study. The quantity of sugar is measured by using the weighing machine available in the laboratory.

4. Yeast inoculums
Using a wooden spoon, carefully swirl 0.5 g, 1.0 g, and 1.5 g of yeast powder (*Saccharomyces cerevisiae*) were introduced separate beakers based on the treatments. The pulp was supplemented with activated yeast based on the different treatments.

5. Heating of juice
To dissolve the sugar and keep the juice at the right temperature for the inoculum, it was heated for five minutes.

6. Preparation of must
To obtain the filtrate "must," the extracted juice (pulp) was sieved using a muslin cloth with a pore size of 0.8 mm. Since the juice had a relatively thick consistency, the slurry was further diluted in a 1:1 water to pulp ratio.

7. Preparation of bottles
After properly cleaning and sterilizing the bottles with hot water, they were left to dry in the sun. The procedure is carried out to lessen the possibility of microbiological contamination of the final cider.

8. Bottling
Sterilized bottles were filled with the prepared blended product, and the bottles were sealed with balloons. In order to release the gas during the fermentation process and to lessen the possibility of bottles exploding, tiny holes were cut on the balloons using a needle.

9. Fermentation
Saccharomyces cerevisiae activated media was made and used to incubate the apple must. At room temperature, the fermentation process was conducted in bottles. The content was shaken two to three times on a regular basis, and the ° Brix drop was noted. When a steady TSS was achieved, the fermentation was deemed to be finished. Airlocks were installed at the conclusion of fermentation. Apple must was tested for pH, TSS, acidity, specific gravity, and alcohol level during the fermentation process.

10. Clarification of Cider
After the fermentation process was finished, the resulting cider was syphoned off and filtered using syphon tubes and a sterile, clean muslin cloth. For three weeks, the cider was racked in order to clarify it.

11. Aging
The most crucial stage following cider preparation is cider aging, which may enhance the quality of the final product for consumption.

Observation to be recorded

1. Sensory Parameters
1. Colour and Appearance
2. Taste
3. Aroma
4. Overall acceptability

2. Chemical Parameters
1. TSS (°Brix))
2. Titratable acidity (%)
3. Ascorbic acid (mg/100 g of pulp)
4. pH

Fig 1: Apple cider bottles in storage under ambient temperature.

Results and Discussion
The current study's findings about the effects of varying yeast and sugar concentrations on the yield and caliber of apple cider (*Malus x domestica* Borkh) have been examined and analyzed.

Ten treatments and three replications were used in the Completely Randomized Design (CRD) of the experiment. The following headings include the findings of a statistical analysis of the data. T_4 ((apple juice (500 ml) + yeast (0.5 g) + sugar (150 g)) was determined to be the best cider among the treatments based on both the sensory and chemical aspects (Peng *et al.*, 2020) [15]. Because treatment T_4

produced apple cider with optimal acidity, TSS, pH, ascorbic acid, color and appearance, taste, aroma and overall acceptability up to 30 days of storage, it was clearly superior based on physio-chemical and sensory quality characteristics. Up to 30 days of storage, the color and appearance, taste, aroma and overall acceptability all were steadily improved (Jensen *et al*., 2009) [8].

A statistical analysis was conducted on the preserved apple cider's color and appearance, taste, aroma and overall acceptability. The table and figure show that there were notable differences between the different treatments at 0, 15 and 30 days of storage (Jalali *et al*., 2013) [6]

Sensory Parameters

It is clear from table 2 that various treatments were used at successive stages over the course of 30 days of storage. The treatments differed significantly from one another.

Color and Appearance

T_4 ((Apple juice (500ml) + yeast (0.5g) + sugar (150 g)) had the highest color score among the treatments used, with scores of 7.20, 7.50, and 7.60. T_2 ((apple juice (500ml) + yeast (1.0 g) + sugar (100 g)) had the second-highest color score, with scores of 7.10, 7.30 and 7.40 and minimum score had the T_0 ((apple juice (500 ml)) with scores of 6.0, 5.7 and 5.5 (Jarvis *et al*., 1955) [7].

Aroma

The highest flavor and fragrance scores are obtained by T_4 ((apple juice (500ml) + yeast (0.5g) + sugar (150 g)) with 7.50, 7.70and 7.9. T_2 ((apple juice (500ml) + yeast (1.0 g) + sugar (100 g)) with 7.10, 7.30 and 7.60 and minimum score had the T_0 ((apple juice (500 ml)) with scores of 5.4, 5.1 and 4.9. It could be partially caused by the flavor of apple juice and partially by the masking effect of sugar. Apple juice became more palatable and less bitter as the concentration of sugar. It's possible that the high juice content enhanced the apple flavor and reduced the cider flavor, leaning more toward soft than hard cider (Jarvis *et al*., 1995) [7]. The main characteristic of cider is its spicy, aromatic apple flavor, which is present in all of the cider to varying degrees. It sets the ciders apart from other fermented drinks as a result.

Taste

The highest taste scores are obtained by T_4 ((apple juice (500ml) + yeast (0.5g) + sugar (150 g)) with 7.30, 7.50 and 7.70 and T_2 ((apple juice (500ml) + yeast (1.0 g) + sugar (100 g)) with 7.10, 7.30 and 7.60 and minimum score had the T_0 ((apple juice (500 ml)) with scores of 5.3, 4.9 and 4.7.According to (Mangas *et al*., 1993) [13] it could be partially caused by the apple juice's flavor and partially by the masking effect of sugar. The apple's composition determines the cider's flavor and taste. An increase in the amount of sugar in apple juice made it more palatable and less tough.

Overall acceptability

It is clear that various treatments at each subsequent step of storage had an impact on the overall quality. At 0, 15 and 30 days, there were notable differences between the treatments. Of the treatments used, T_4 ((apple juice (500ml) + yeast (0.5g) + sugar (150 g)) with (7.20, 7.50, and 7.80) had the highest overall quality score, followed by T_2 ((apple juice (500ml) + yeast (1.0 g) + sugar (100 g)) with (7.0, 7.30 and 7.60) that were significantly better than T_0 ((apple juice (500 ml)) with (5.40, 5.10 and 4.80) respectively. Apple juice became more palatable and less bitter as the concentration of sugar (Mangas *et al*., 1993) [13].

It's possible that the high juice content enhanced the apple flavor and reduced the cider flavor, leaning more toward soft than hard cider. The main characteristic of cider is that it is spicy and astringent, which is true of all of the cider to a greater or lesser extent. It sets the cider apart from other fermented drinks as a result (Yadav *et al*., 2012) [18].

Chemical Parameters

It is clear that various treatments at each point of the 30 days storage period had an impact on Table 3. The treatments differed significantly from one another.

TSS

T_4 ((apple juice (500ml) + yeast (0.5g) + sugar (150 g)) had the highest TSS (°Brix) with 7.49, 7.35 and 7.16. T_2 ((apple juice (500ml) + yeast (1.0 g) + sugar (100 g)) had the next-highest TSS (7.17, 7.05 and 6.93) and minimum score had the T_0 ((apple juice (500 ml)) with scores of 5.68, 5.44 and 5.27. The reduction in TSS over the storage period may be due to the full use of sugar (Beera *et al*. (2013) [4].

Acidity

T_4 ((apple juice (500ml) + yeast (0.5g) + sugar (150 g)) has the greatest acidity (%) with 0.53, 0.55 and 0.56. T_2 ((apple juice (500ml) + yeast (1.0 g) + sugar (100 g)) has the next highest acidity (%) with 0.49, 0.53 and 0.55 and minimum score had the T_0 ((apple juice (500 ml)) with scores of 0.31, 0.34 and 0.37 (Sahu *et al*., 2012) [16]. The production of specific organic acid by yeast during storage may be the cause of the apple cider's rising acidity.

pH

The pH of T_4 ((apple juice (500ml) + yeast (0.5g) + sugar (150 g)) is the highest at 2.99, 2.96 and 2.92. T_2 ((apple juice (500 ml) + yeast (1.0 g) + sugar (100 g)) comes in second with 02.95, 2.93 and 2.89 and minimum score had the T_0 ((apple juice (500 ml)) with scores of 2.72, 2.68 and 2.66 (Liu *et al*., 2016) [12]. A rise in acidity causes the pH of many cider to drop.

Ascorbic acid

Ascorbic acid (mg/100 g) is highest in T_4 ((apple juice (500ml) + yeast (0.5g) + sugar (150 g)) with (0.53, 0.54 and 0.57), followed by T_2 ((apple juice (500 ml) + yeast (1.0 g) + sugar (100 g)) with (0.49, 0.52 and 0.55) and minimum score had the T_0 ((apple juice (500 ml)) with scores of 0.21, 0.23 and 0.26 (Sousa *et al*., 2020) [17]. The decrease in ascorbic acid throughout the storage period may have been caused by heat oxidation and degradation (Patras *et al*., 2009) [14]. These acids might have acted as an oxygen scavenger to shield the wine from oxidative alterations. Other apple products, such pro-biotic fermented apple juices and cider, or fermented products made from apple produced as industrial by-products, are also produced via fermentation techniques (Chen *et al*., 2019) [5].

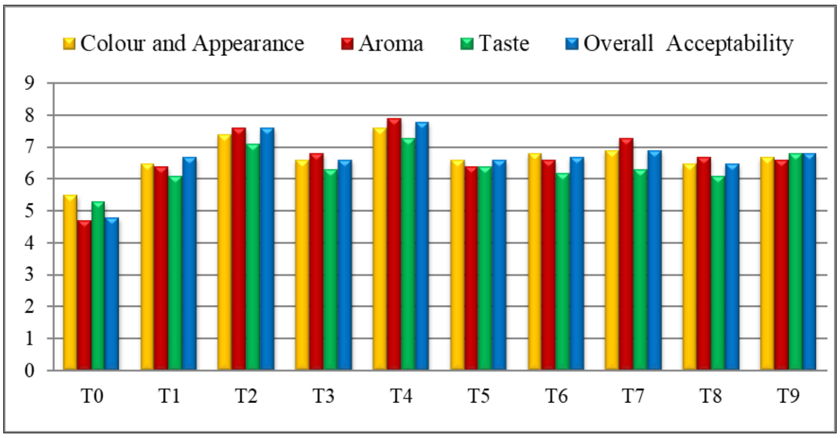

Fig 2: Effect of different treatments on sensory evaluation of stored apple cider

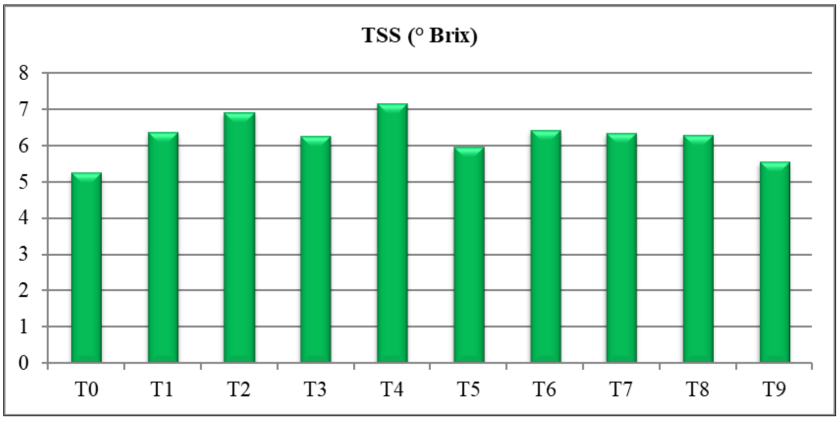

Fig 3: Effect of different treatments on TSS (° Brix) of stored apple cider

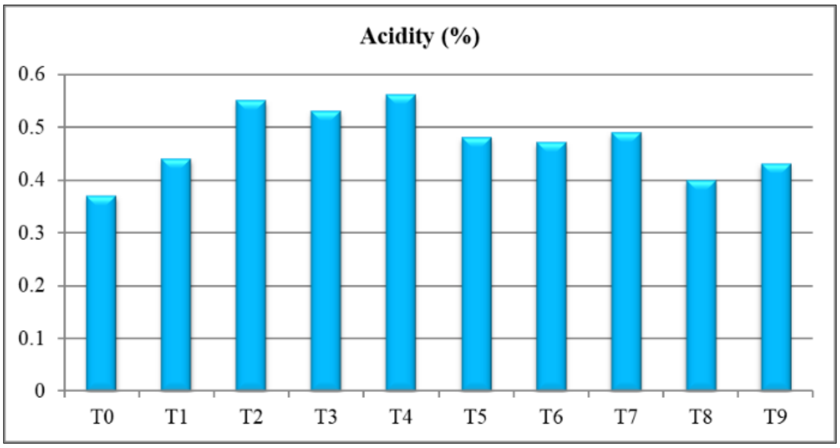

Fig 4: Effect of different treatments on Acidity (%) of stored apple cider

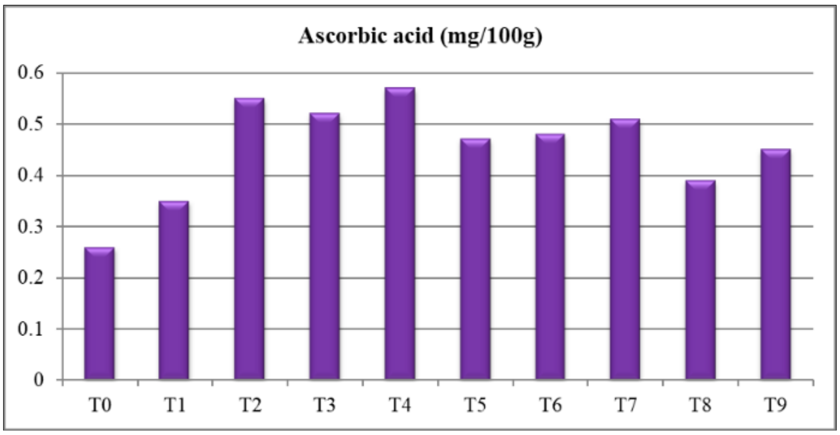

Fig 5: Effect of different treatments on Ascorbic acid (mg/100 g) of stored apple cider

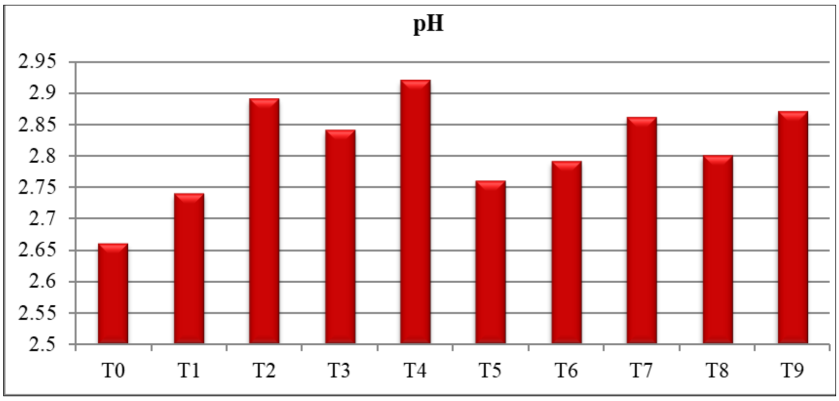

Fig 6: Effect of different treatments on pH of stored apple cider

Table 2: Effect of different treatments on sensory parameters of stored apple cider

Treatments		Colour and Appearance	Aroma	Taste	Overall acceptability
T_0	Control	5.5	4.7	5.3	4.8
T_1	Apple juice (500ml) + yeast (0.5g) + sugar (100 g)	6.5	6.4	6.1	6.7
T_2	Apple juice (500ml) + yeast (1.0 g) + sugar (100 g)	7.4	7.6	7.1	7.6
T_3	Apple juice (500ml) + yeast (1.5g) + sugar (100 g)	6.6	6.8	6.3	6.6
T_4	Apple juice (500ml) + yeast (0.5g) + sugar (150 g)	7.6	7.9	7.3	7.8
T_5	Apple juice (500ml) + yeast (1.0 g) + sugar (150 g)	6.6	6.4	6.4	6.6
T_6	Apple juice (500ml) + yeast (1.5g) + sugar (150 g)	6.8	6.6	6.2	6.7
T_7	Apple juice (500ml) + yeast (0.5g) + sugar (200 g)	6.9	7.3	6.3	6.9
T_8	Apple juice (500ml) + yeast (1.0 g) + sugar(200 g)	6.5	6.7	6.1	6.5
T_9	Apple juice (500ml) + yeast (1.5g) + sugar (200 g)	6.7	6.6	6.8	6.8
CD at 5%		0.078	0.075	0.065	0.071
S.Em(±)		0.026	0.025	0.022	0.024

Table 3: Effect of different treatments on chemical parameters of stored apple cider

Treatments		TSS (^{0} Brix)	Acidity (%)	Ascorbic acid (mg/ 100 g)	pH
T_0	Control	5.27	0.37	0.26	2.66
T_1	Apple juice (500ml) + yeast (0.5g) + sugar (100 g)	6.39	0.44	0.35	2.74
T_2	Apple juice (500ml) + yeast (1.0 g) + sugar (100 g)	6.93	0.55	0.55	2.89
T_3	Apple juice (500ml) + yeast (1.5g) + sugar (100 g)	6.26	0.53	0.52	2.84
T_4	Apple juice (500ml) + yeast (0.5g) + sugar (150 g)	7.16	0.56	0.57	2.92
T_5	Apple juice (500ml) + yeast (1.0 g) + sugar (150 g)	5.98	0.48	0.47	2.76
T_6	Apple juice (500ml) + yeast (1.5g) + sugar (150 g)	6.43	0.47	0.48	2.79
T_7	Apple juice (500ml) + yeast (0.5g) + sugar (200 g)	6.34	0.49	0.51	2.86
T_8	Apple juice (500ml) + yeast (1.0 g) + sugar(200 g)	6.29	0.40	0.39	2.80
T_9	Apple juice (500ml) + yeast (1.5g) + sugar (200 g)	5.57	0.43	0.45	2.87
CD at 5%		0.057	0.051	0.052	0.061
S.Em(±)		0.019	0.017	0.018	0.020

Conclusion

T_4 (apple juice (500 ml) + yeast (0.5 g) + sugar (150 g)) was determined to be the best cider among the treatments based on both the sensory and chemical aspects. Due to optimal acidity, TSS, pH, ascorbic acid, color and appearance, taste, aroma, and overall quality of apple cider up to 30 days of storage, treatment T_4 was noticeably better on the basis of physio-chemical and sensory quality characteristics. Up to 30 days of storage, the color and appearance, taste, aroma and overall acceptability were steadily improved.

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