OPTIMIZATION OF ACETIFICATION PROCESS OF TOMATO CIDER VINEGAR

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ABSTRACT

Post-harvest losses of fruits and vegetables are very critical in developing countries. Processing excess fruits into vinegar, which can be used for preservation of some foods and snack is a helpful strategy in reducing these losses. The purpose of this research work was to evaluate the optimization of acetification process of tomato cider vinegar. Physiochemical analyses such as pH, Titratable Acidity, TSS & Alcohol content were evaluated at 4 days interval of storage for 40 days. Results showed that pH was decreased in all treatments (T1 Room temperature, T2 Incubator, T3 Dehydrator, T4 Open sun). Higher decrease was observed in T3 dehydrator (42.38%) while lower decrease was observed in T2 incubator (12.36%). The decrease in pH value greatly changed the percent acidity due to increase in acid content in all treatments (T1 Room temperature, T2 Incubator, T3 Dehydrator, T4 Open sun). Higher increase was observed in T3 dehydrator (93.78%) while lower increase was noted in T2 incubator (87.09%). Total soluble solids decreased both in yeast fermentation and acetic acid fermentation in all treatments. Higher decrease was observed in T3 dehydrator (83.18%) while lower decrease was observed in T2 incubator (64.09%). The results showed that alcohol content decreased continuously in all treatments. Higher decrease was observed in T3 dehydrator (95%) while lower decrease was observed in T2 incubator (8.8%). It is concluded that dehydrator treatment is the best and rapid process for acetic acid fermentation because the fresh air and constant temperature is available for the acetic acid bacterial growth.

Keywords: Tomato, Vinegar, Dehydrator, Incubator, Physiochemical, Acetic Acid Fermentation

INTRODUCTION

Tomato **(***Solanum Lycopersicum*) is botanically categorized as a fruit while a vegetable because of the way of its consumption[1]. It is economically attractive and the area under cultivation is increasing daily all over the world because of it is a relatively short duration crop and gives high yield[2]. Tomato nutritive composition is unique. It contains 11 calories, 95% of water, 4% carbohydrates.[3] They are also a good source of minerals, vitamins, essential amino acids, sugars and dietary fibers. Tomato contains vitamin (B, C), iron and phosphorus[4, 5]. The Lycopene content in tomatoes is one of the most well-known tomato eating benefits. Lycopene is an important antioxidant that helps in the prevention of cancerous cell growth [1].

Tomatoes are the sixth most popular vegetable in the world in terms of total yearly production. Every year, 162 million tons of fresh tomatoes are produced across the world. China, India, United States, Turkey, Egypt, Iran, Italy, Brazil, and Spain produce more than 74% of the world's total tomatoes. China produces roughly 50.6 million tons of tomatoes, followed by India with 18.5 million tons, and is grown in almost every country of the world [6]. Post-harvest losses particularly in fruits and vegetables are 50% which occur at different stages from harvesting to consumption. At harvesting these losses are up to 20%, followed by 8% at handling, 10% at processing and packaging, 10% at distribution and 5% at consumption or household level [7]. Postharvest losses of tomato is vary from 50-70% [8], because it is a highly perishable commodity, and its storage life is very limited due to various fungal attack, especially by *Botrytis cinerea* and *Rhizopus* species [9].

Tomato can also processed in to ketchup, paste, powder, chutney, salad, sauce and many more [10]. The easiest way to overcome the losses is to utilize low quality tomatoes, for vinegar preparation. Vinegar is divided into two categories based on the technique of production: rapid and slow method groups [11]. Vinegar is a value-added food product of different fruits. It is made from making alcohol and subsequently fermenting to acetic acid, with a carbohydrate-rich starting material [10]. Vinegar is mostly used for pickling fruits and vegetables, as well as the production of salad dressings, mustard, and other condiments. Despite the use of vinegar as a flavoring and functional ingredient its health benefits has convert the researcher's attention to its therapeutic applications [12].

Vinegar is made by two fermentation methods, one is alcoholic and second one is acetic acid fermentation. Alcoholic fermentation is a quick process that degrades complex carbohydrates into three weeks or less to simple ethanol. Yeasts, mainly Saccharomyces cerevisiae strains, are responsible for converting fermentable carbohydrates into ethanol. On the other hand in acetous fermentation, the ethanol is further oxidized into acetic acid by the acetic acid forming bacteria, known as Acetobacter. Anaerobic and aerobic conditions are used for alcoholic and acetous fermentations, respectively [13]. In the past, a large portion of the population used vinegar because it is believed to have several medicinal and antibacterial properties that improve health [14, 15]. Functional therapeutic properties of vinegar described include antibacterial activity, blood pressure reduction, antioxidant activity, reduction in the effects of diabetes, prevention of cardiovascular disease, and increased vigor after exercise [16-20].

Keeping in view the nutritional value of tomatoes and health benefits of vinegar, the present study was designed to develop a value added product from low quality tomatoes and tomatoes waste. The developed value added product will not only fetch income to the producer but will pave the way for industrial processing of tomatoes.

MATERIALS AND METHODS

Low-quality tomatoes were purchased in Peshawar's local market and brought to the quality control laboratory of Food science & Technology section in (Agriculture Research Institute Tarnab Peshawar) for experimentation.

Pre-Processing. Tomatoes were first washed with tape water to remove dust and dirt. Sorting was then carried out for whole, uniform shape, tomatoes. Juice was extracted through pulper machine. The extracted juice was filtered, and then brown sugar (Jiggery) was added to increase the total soluble solid content from 4 to 22 and then pasteurized at 80 °C for 15 to 30 min before further experimentation.

Yeast Starter. Saccharomyces cerevisiae was used for alcoholic fermentation. An inactive yeast was activated by preparing 0.1% salt solution and by adding 20 gram of yeast to the solution prepared. Then sugar solution of 20 Brix was prepared and salt solution having yeast was added to sugar solution. For activation of saccharomyces cerevisiae, the

solution was kept in incubator for 10 min at 30 °C to increase the temperature of solution to assist the activation.

Treatment preparation. Tomato juice was split into different treatment as T1 (Room temperature), T2 (**Incubator**), T3 (Dehydrator), T4 (Open sun), and placed at different environmental condition according to the plan of study mentioned below.

TABLE 1
Plan of Study

Treatment	Tomato Juice	Yeast Starter	Enviromental condition
T1	1 Lit	5 ml	Room Temperature (16.5 C°)
T2	1 Lit	5 ml	Incubator (30 C°)
T3	1 Lit	5 ml	Dehydrator (35 C°)
T4	1 Lit	5 ml	Open Sun (28 C°)

To check the status of alcoholic fermentation, all of the samples were analyzed for pH, Acidity, Alcohol content, and total soluble solid with four days interval according to standard method of AOAC [21].

After alcoholic fermentation by yeast, mother liquor of apple cider at the rate of 5 ml/liter of tomato juice was added and again samples were analyzed for pH, acidity, alcoholic fermentation, TSS.

Physiochemical analysis. The tomato cider was assessed for the physiochemical properties, such as % acidity, total soluble solid (TSS), alcohol content and pH.

Total soluble solids. A portable digital Refractometer (Atago) was used to quantify total soluble solids (TSS) in tomato juice, cider, and vinegar as % Brix. Each sample was measured three times.

pH Value. The pH of tomato cider was examined using HANNA pH meter according to standard method of AOAC [21].

Titratable Acidity. The titratable acidity of each treatment was determined using the well-known method no. 942.15 AOAC [21] with little modification. The normality of NaOH was reduced to 0.1N for accuracy.

Alcohol Content. The alcohol level of the tomato cider, was determined using an ebulliometer (Napa, CA, USA). The test is based on the fact that water and cider have different boiling points. The steps are as follows:

(1) Measure the boiling point of the water.

(2) Dilute the juice, cider or vinegar sample so that the boiling point of the diluted juice, cider or vinegar is within 4^{o}C of the boiling point of water.

(3) Calculate the concentration of the juice, cider, or vinegar using the instrument's standards value.

RESULTS

Total Soluble Solids (TSS)

The TSS content of tomato cider vinegar in different environmental condition and storage are in Figure 1. TSS content in all treatment T1, T2, T3, T4 on first day was 22% which became 5%, 7.9%, 3.7%, 6.5% on the final day. The higher decreased have been observed in T3 (Dehydrator) (83.18%) and lower in T2 (incubator) (64.09%).

Alcohol Content

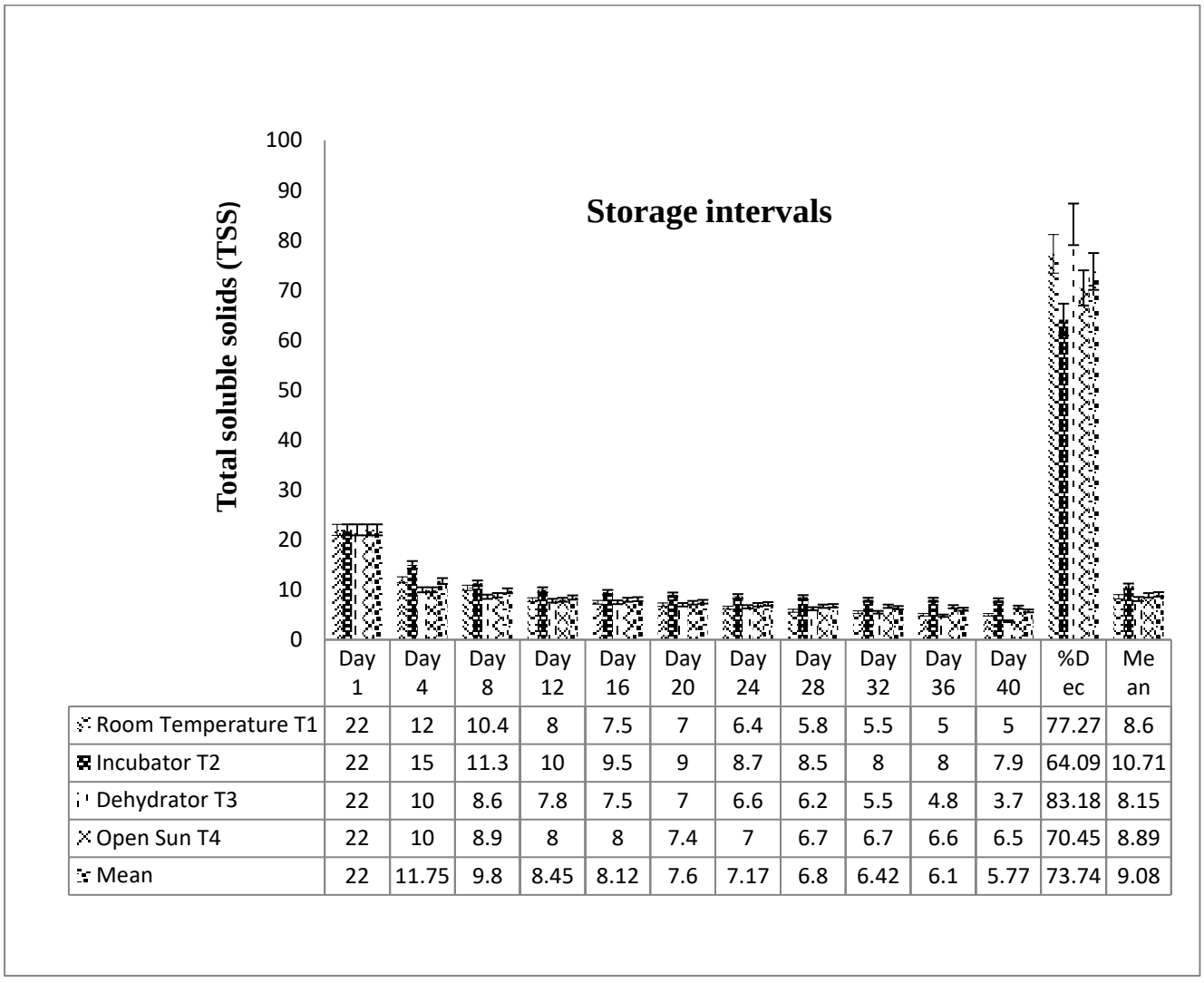
The alcohol content of tomato cider vinegar in different environmental condition and storage are in Figure 2. Alcohol content in all treatment T1, T2, T3, T4 on first day were 5.0, 4.5, 6.0, 6.0, which became 1.9, 4.1, 0.3, 3.6 on the final day. The higher decreased was observed in T3 (dehydrator) (95%) and lower in T2 (incubator) (8.8%).

pH value

The pH value of tomato cider vinegar in different environmental condition and storage are in Figure 3. pH value in all treatments T1, T2, T3, T4 on first day was 4.53 which became 3.15, 3.97, 2.61, 3.74 on the final day. In treatments the higher decrease was observed in T3 (Dehydrator) (42.38%) and lower in T2 (incubator) (12.36%).

Titratable Acidity

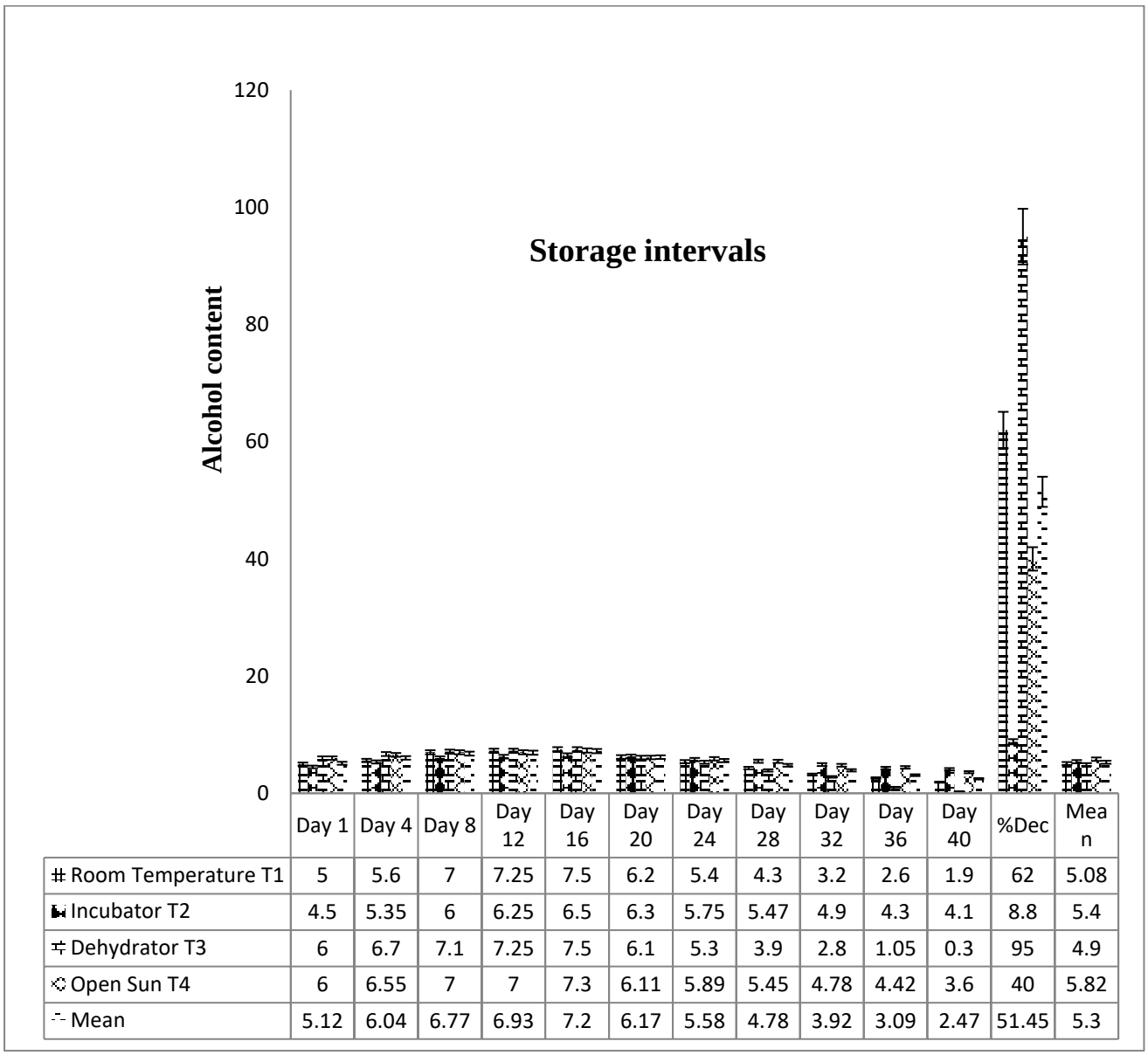
The titratable acidity of tomato cider vinegar in different environmental condition and storage are in Figure 4. Titratable acidity in all treatments T1, T2, T3, T4 on first day was 0.253 which became 3.01, 1.96, 4.07, 2.45 on the final day. In treatments higher increased was observed in T3 (Dehydrator) (93.78%) and lower in T2 (incubator) (87.09%).



	Day 1	Day 4	Day 8	Day 12	Day 16	Day 20	Day 24	Day 28	Day 32	Day 36	Day 40	%Dec	Mean
Room Temperature T1	22	12	10.4	8	7.5	7	6.4	5.8	5.5	5	5	77.27	8.6
Incubator T2	22	15	11.3	10	9.5	9	8.7	8.5	8	8	7.9	64.09	10.71
Dehydrator T3	22	10	8.6	7.8	7.5	7	6.6	6.2	5.5	4.8	3.7	83.18	8.15
Open Sun T4	22	10	8.9	8	8	7.4	7	6.7	6.7	6.6	6.5	70.45	8.89
Mean	22	11.75	9.8	8.45	8.12	7.6	7.17	6.8	6.42	6.1	5.77	73.74	9.08

FIGURE 1**: Effect of different environmental condition and storage interval on TSS of tomato cider vinegar.**

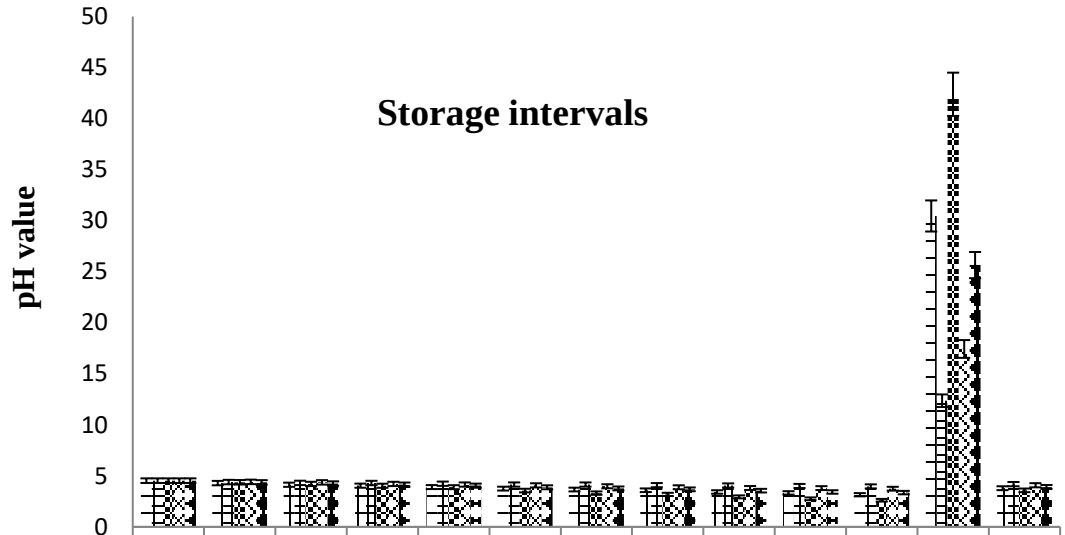
Figure 1 shows the TSS content of tomato cider vinegar during storage. The mean data showed that the total soluble content continuously decreased from 22 ^{o}Brix to 5.77^{o} Brix during total period of storage.



	Day 1	Day 4	Day 8	Day 12	Day 16	Day 20	Day 24	Day 28	Day 32	Day 36	Day 40	%Dec	Mean
Room Temperature T1	5	5.6	7	7.25	7.5	6.2	5.4	4.3	3.2	2.6	1.9	62	5.08
Incubator T2	4.5	5.35	6	6.25	6.5	6.3	5.75	5.47	4.9	4.3	4.1	8.8	5.4
Dehydrator T3	6	6.7	7.1	7.25	7.5	6.1	5.3	3.9	2.8	1.05	0.3	95	4.9
Open Sun T4	6	6.55	7	7	7.3	6.11	5.89	5.45	4.78	4.42	3.6	40	5.82
Mean	5.12	6.04	6.77	6.93	7.2	6.17	5.58	4.78	3.92	3.09	2.47	51.45	5.3

FIGURE 2**: Effect of different environmental condition and storage interval on alcohol content of tomato cider vinegar.**

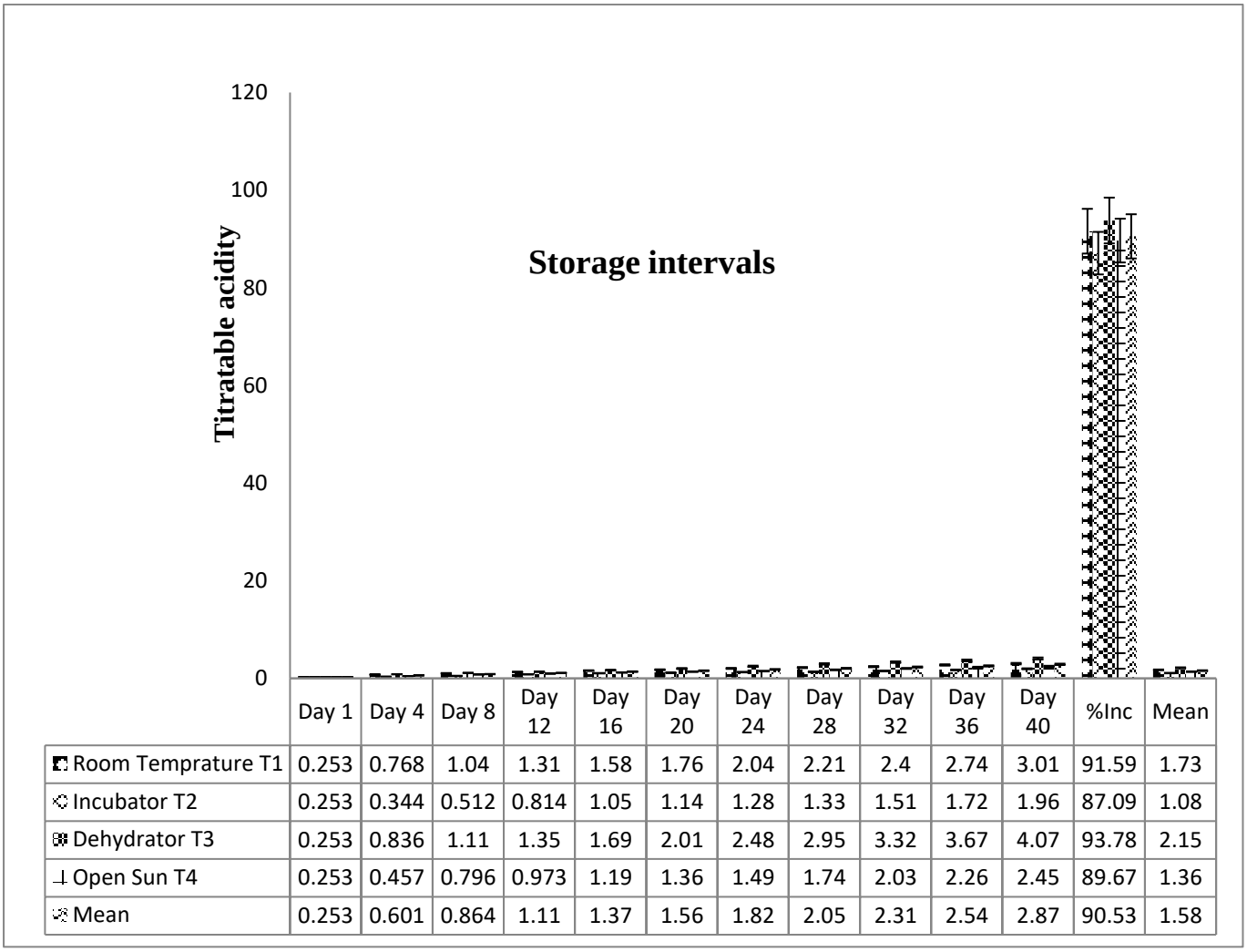
Figure 2 shows the alcohol content of tomato cider vinegar during storage.



	Day 1	Day 4	Day 8	Day 12	Day 16	Day 20	Day 24	Day 28	Day 32	Day 36	Day 40	%Dec	Mean
Room Temperature T1	4.53	4.29	4.13	4.04	3.9	3.75	3.66	3.59	3.42	3.33	3.15	30.46	3.79
Incubator T2	4.53	4.39	4.31	4.3	4.23	4.15	4.15	4.09	4.06	4.01	3.97	12.36	4.19
Dehydrator T3	4.53	4.37	4.21	4.03	3.89	3.56	3.31	3.18	2.94	2.75	2.61	42.38	3.58
Open Sun T4	4.53	4.41	4.36	4.21	4.15	4.07	3.98	3.88	3.81	3.8	3.74	17.43	4.08
Mean	4.53	4.36	4.25	4.14	4.04	3.88	3.77	3.68	3.55	3.42	3.36	25.65	3.91

FIGURE 3: **Effect of different environmental condition and storage interval on pH value of tomato cider vinegar.**

Figure 3 shows the pH value of tomato cider vinegar during storage. The results showed that the pH value decreased in all the treatments.



	Day 1	Day 4	Day 8	Day 12	Day 16	Day 20	Day 24	Day 28	Day 32	Day 36	Day 40	%Inc	Mean
Room Temprature T1	0.253	0.768	1.04	1.31	1.58	1.76	2.04	2.21	2.4	2.74	3.01	91.59	1.73
Incubator T2	0.253	0.344	0.512	0.814	1.05	1.14	1.28	1.33	1.51	1.72	1.96	87.09	1.08
Dehydrator T3	0.253	0.836	1.11	1.35	1.69	2.01	2.48	2.95	3.32	3.67	4.07	93.78	2.15
Open Sun T4	0.253	0.457	0.796	0.973	1.19	1.36	1.49	1.74	2.03	2.26	2.45	89.67	1.36
Mean	0.253	0.601	0.864	1.11	1.37	1.56	1.82	2.05	2.31	2.54	2.87	90.53	1.58

FIGURE 4: Effect of different environmental condition and storage interval on titratable acidity of tomato cider vinegar.

Figure 04 shows the titratable acidity of tomato cider vinegar during storage.

DISCUSSION

Effect of different environmental condition and storage interval decrease the TSS content of tomato cider. The initial decrease in TSS in first two week was due to the saccharification by yeast that converts the sugar to alcohol and carbon dioxide gas. The later decrease in TSS in the last two week was due to acetic fermentation. Zoecklein, Jasinski, and McMahon [22] also reported that small amounts of residual sugars can affect the microbial stability of an alcoholic beverage as fermentation progresses. The result were more robust through study of Sinclair [23] who observed the same result. At the end of the

fermentation process, 55 % of the sugars contained in grapes were changed to alcohol. Effect of different environmental condition and storage interval decrease the alcohol content of tomato cider. Initially during yeast fermentation, the alcohol content increase due the conversion of sucrose to ethyle alcohol and carbon dioxide gas. While during acetic acid fermentation. The findings support Maal, Shafiei, and Kabiri [24] observation that sugar is converted to alcohol during the first stage of fermentation, while ethanol is converted to acetic acid during the second stage. . Effect of different environmental condition and storage interval decrease the pH of tomato cider. The pH value decreased in all the treatments due to increase in the acetic acid content. The increase in the acetic acid content was due to the alcoholic fermentation by acetic acid bacteria. The results supported Raspor and Goranovi's [25] observation that as the fermentation process progresses, the formation of lactic acid during fermentation leads in a decrease in pH. Effect of different environmental condition and storage interval increase the titratable acidity of tomato cider. . The increase in the acid content was due to the alcohol fermentation by acetic acid bacteria. These findings are consistent with that of Ukwo and Ezeama [26] who studied the proliferation of acetic acid bacteria during soursop juice fermentation.

CONCLUSIONS

The purpose of this work was to assess the optimization of acetification process of tomato cider vinegar (TCV). On the basis of these results it is determined that dehydrator treatment is the best and rapid process for acetic acid fermentation in tomato cider because the fresh air and constant temperature is available for the acetic acid bacterial growth.

Data availability

The data that support the findings of this study are listed in the article and are available from the corresponding authors upon reasonable request.

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Declaration of Interest

We declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. The authors certified that there is no conflicts of interest associated with this publication, and there has been no significant financial support for publishing this work that could have influenced its outcome. As corresponding Author, I conform that the manuscript has been read and approved for submission by all the named authors. Thank you for receiving our manuscript and considering it for review.

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