

UDC 664.85:634.13:663.5:005.336.3:001.891

STUDY OF QUALITY AND SENSORY CHARACTERISTICS OF ALCOHOLIC PEAR SLICES

<https://doi.org/10.15673/fst.v18i2.2900>

Correspondence:

Kishor Rai
E-mail: kishorchamling1989@gmail.com

Cite as Vancouver style citation

Himalaya Ghimire, Basanta Kumar Rai, Kishor Rai, Ramila Dahal et al. Study of quality and sensory characteristics of alcoholic pear slices. Food science and technology. 2024;18(2):75-84.

<https://doi.org/10.15673/fst.v18i2.2900>

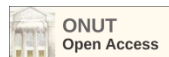
Цитування згідно ДСТУ 8302:2015

Study of quality and sensory characteristics of alcoholic pear slices / Himalaya Ghimire et al. // Food science and technology. 2024. Vol. 18, Issue 1. P.75-84.

<https://doi.org/10.15673/fst.v18i2.2900>

Copyright © 2015 by author and the journal "Food Science and Technology".

This work is licensed under the Creative Commons Attribution International License (CC BY). <http://creativecommons.org/licenses/by/4.0>



Himalaya Ghimire¹, Student of bachelor degree (Food technology)

Basanta Kumar Rai², Professor (Food technology)

Kishor Rai^{3,*}, Student of master degree (Management)

Ramila Dahal⁴, Student of bachelor degree (Food technology)

Girija Sherma², Student of master degree (Food technology)

Saru Giri¹, Student of bachelor degree (Food technology)

Sanjay Chaudhary², Student of master degree (Food technology)

Priti Acharya⁴, Student of bachelor degree (Food technology)

¹ Department of Food Technology, Dharan Multiple Campus, Tribhuvan University, Dharan, Nepal, 56700

² Department of Food Technology, Central Department of Food Technology, Tribhuvan University, Dharan, Nepal, 56700

³ Department of Management, Mahendra Multiple Campus, Tribhuvan University, Dharan, Nepal, 56700

⁴ Department of Food Technology, Nilgiri College, Tribhuvan University, Itahari, Nepal, 56705

Abstract. Pear fruit (*Pyrus pyrifolia*) is known for its distinctive chemical composition, making it a promising substrate for wine fermentation. However, a significant challenge in the fermentation process is the wastage of pear slices once fermentation is complete. Therefore, this study aimed to address this issue by optimizing the process of producing alcoholic pear slices, analyzing fermentation kinetics, and refining the product through sensory evaluation. The research involved fermenting locally sourced *Pyrus pyrifolia* for different durations: A (0 days), B (2 days), C (4 days), D (6 days), E (8 days), F (10 days), G (12 days), H (14 days), I (16 days), and J (18 days). The fermented pear slices were then assessed and optimized based on key sensory attributes such as color, taste, texture, and overall acceptance. Additionally, the slices were stored at different sugar concentrations (X = 15°Bx, Y = 20°Bx, and Z = 20°Bx) to evaluate the impact of sugar levels on their sensory properties. Sensory evaluations identified sample E, fermented for 8 days, and sample Y, with a sugar concentration of 20°Bx, as the most preferred. The findings revealed that extended fermentation durations resulted in a decrease in pH and total soluble solids, while acidity and alcohol content increased. Statistical analysis showed a significant ($p \leq 0.05$) effect of both fermentation duration and sugar concentration on the sensory qualities of the alcoholic pear slices. The study concludes that controlled fermentation, coupled with the right sugar concentration, can significantly enhance the quality of alcoholic pear slices, providing a valuable use for byproducts in pear wine production. This novel product offers the combined benefits of alcohol content and fruit flavor, making it a unique addition to the market.

Key words: Pear, Alcoholic pear slices, Fermentation kinetics, Proximate analysis and Sensory analysis.

Introduction. Formulation of the problem

In Nepal, pears rank as the second preferred type of deciduous fruit. Across the nation, it is grown in both mid- and high-hill areas (800–2100 masl). Two varieties of pears are farmed in Nepal. *Pyrus communis*, the European pear, and *Pyrus pyrifolia* or *P. serotina*, the Asian or "sand" pear [1]. Pears are cherished as both table and dessert fruits for their sensory qualities and nutritional benefits. It has a considerable amount of fiber, proteins, fats, vitamins, minerals, and saccharides [2]. In addition to its micro- and macronutrients, the pear also contains various secondary metabolites such as phenolic acids,

flavanols, anthocyanins, and the glycosylated hydroquinone arbutin [3]. The antioxidant properties of these non-nutritive compounds help the body to scavenge harmful free radicals, potentially protecting tissues from oxidative damage, reducing cancer risk, and enhancing immune function [4]. In the food industry, pears are considered valuable for their high functional benefits and health-related properties. They are either eaten fresh or used to make a variety of products, such as juices, jams, ice creams, cakes, pies, and risottos. However, pear processing generates large amounts of waste, including peels, cores, seeds, pulp residue, and pomace, which are often discarded, leading to significant environmental concerns [5].

There is evidence that these pear wastes and by-products contain various phytoconstituents, including phenolic acids, flavonoids, sterols, alkaloids, triterpenoids, and carotenoids [6].

Looking back at human history, it is evident that making wine has been a way to preserve perishable goods like grape juice and grapes [7]. This practice has evolved into a significant technique for preserving and preparing products with desirable qualities even today [8]. Fermentation helps maintain the safety, nutrition, and shelf life of fruit while facilitating the development of new products [9]. While wine is traditionally made from completely or partially fermented grape juice, other fruits such as apples, plums, peaches, pears, berries, strawberries, cherries, currants, apricots, and bananas have also been utilized in winemaking [10,11]. Perry, an alcoholic beverage made from fermented pears, is one of the most widely accepted fermented alcoholic drinks globally, except where restricted by religious beliefs [12,13].

The production of pear wine offers a promising alternative for the utilization of sand pear fruit, which has a very limited use for the pear for its direct consumption due to its gritty texture [12]. Transforming these pears into pear wines or other fermented beverages, whether alcoholic or nonalcoholic, can help minimize fruit loss and offer innovative value-added pear products [14]. However, it's important to note that the wine-making industry generates millions of tons of residues post-fermentation, posing challenges in terms of waste management, both ecologically and economically [15]. In a similar vein, the byproduct of pear wine production, in the form of fruit residue, poses a waste management challenge. This fruit residue, comprising pear slices, can be repurposed for consumption alongside the produced pear alcohol, contributing to the reduction of waste in alcoholic fermentation. Notably, there is currently a lack of comprehensive reports on the utilization and quality evaluation of alcoholic pear slices.

Analysis of recent research and publications

Fresh fruits are rich in essential nutrients such as vitamins, sugars, organic acids, fibers, antioxidants, and minerals, all of which are vital for human health [16]. Nepal is blessed with a variety of climatic and agroecological conditions ideal for the production of high-quality horticulture products [17]. In developing countries, the lack of advanced postharvest technologies poses a significant challenge to extending the shelf life of fruits. These challenges have a negative effect on fruit farm sales, national income, consumer pricing, and the nutritional value of the product [18]. The food industry employs various preservation and processing methods to extend the shelf life of fruits, allowing them to be consumed year-round and safely transported to consumers worldwide, not just those near the growing regions [19]. To overcome these losses, researchers have been

exploring ways to convert high-moisture fruits into various products to enhance their shelf life [20-23].

Many fruits are eaten fresh, however during peak harvest seasons, a significant amount of harvested fruit is lost because of factors including excessive temperatures and humidity, improper handling, inadequate storage facilities, and microbial diseases. As a solution, winemaking from these ripe or surplus fruits offers an alternative way to utilize excess and overripe produce, providing additional revenue for fruit growers [24]. In Nepal, some wine, like toddy, is consumed as a traditional beverage [25]. Traditional foods and beverages have been passed down through generations and consumed by multiple generations (26). According to Rolle and Satin [27], fermentation methods are believed to have developed to minimize toxicity, give desired flavor and texture to meals, preserve fruits and vegetables during periods of scarcity, and shorten cooking times. Alcoholic beverages such as wine and beer are examples of fermented products that fall under the category of alcoholic fermentation [28].

Winemaking is one of humanity's oldest technologies and has evolved into a highly profitable biotechnological process [29]. Fruit wine can be produced from a variety of fruits other than grapes, including cherries, kiwifruit, apples, peaches, berries, pears, muskmelon, and jamun [7,8]. The production of grape wine generates significant amounts of solid waste, specifically grape pomace or grape marc, and lees. These solids, which include skins, seeds, and stems, account for about 20% of the total processed grapes [30-32]. In white wine production, these solids are produced after pressing and before fermentation, whereas in red wine production, they are generated after fermentation [33, 34].

The shelf life of pear fruits is quite short, ranging from 7 to 10 days at room temperature (25 to 30°C) without packaging. Pear fruit has a relatively limited shelf life and is prone to deterioration, mechanical harm, moisture, and nutritional losses while stored [35]. The processing of pears to produce juice and other value-added goods like makjeilli, pear wine (perry), and paste results in a significant quantity of waste [36]. To extend the shelf life of pears, they are often processed into pear wine, commonly known as perry. Similar to grape wine production, the process of making pear wine also produces byproducts such as pear pomace [37]. To reduce pear pomace waste, pear slices are used in winemaking, and these slices are also being studied for their quality and sensory attributes.

The primary **purpose** of this study was to study the prepared alcoholic pear slices. The study was effective because of the **objectives** listed below:

- 1) Physico – chemical analysis of pear.
- 2) Process optimization of alcoholic pear slices.
- 3) Analyze fermentation kinetics.
- 4) To carry out the sensory of alcoholic pear slices
- 5) To determine the acceptability of the product.

Research materials and methods

Raw materials

Fresh, mature and ripe pears (*Pyrus Pyrifolia*) from Pakhribas, Hile, a hilly region north of Dharan. The pears were harvested during the month of August, with sizes ranging from 3 cm to 6.5 cm. Carefully collected samples were transported fresh to the college for detailed studies. Essential materials, including pure, clean, white granular cane sugar, wine yeast (*Saccharomyces cerevisiae* [ex bayanus], Lalvin EC-1118, Canada), citric acid and yeast food $[(NH_4)_2SO_4]$, were supplied by Dharan Multiple Campus.

Chemical reagents and equipments

Materials for the analysis of nutrient content include a cupric sulphate ($CuSO_4 \cdot 5H_2O$), potassium sulphate (K_2SO_4), Sodium hydroxide pellets (NaOH), Hydrochloric acid (HCL), concentrated sulfuric acid solution (H_2SO_4) from Thermo fisher scientific India Pvt. Ltd., Boric acid solution (H_3BO_3) (Merck specialties Pvt. Ltd, India), Petroleum ether (Boiling point: 60–80°C, Specific Density: 0.68, Himedia laboratories Pvt. Ltd, India), Indicator methyl red /bromocresol green solution and Phenolphthalein indicator from Oxford lab fine chem LLP, India and distilled water.

Stainless steel basins, knives, cutting boards, spoons and plastic jar. While the equipment used for the analysis of nutrient content includes petri plate, burette, pipette, test tube, volumetric flask, hot air oven (Navyug Udyog, Haryana, India), calibrated analytical balances (Model: PH3203CH No: 13020123, Capacity: 320g, Precision: $\pm 0.001g$ and Model: HZT-A500, Max. Capacity: 500g, Min. Capacity: 10g, India), desiccators containing desiccant, muffle furnace (Relitech, Model-MF-1, Wattage-2KW, India), electric heaters, electronic Grinder (Yasoda, India), multi-Thermometer (KT 201270865, Mextech), water bath, porcelain cups, Kjeldahl digestion (Jain Laboratory Glassware co., India, Power-50HZ), alcoholmeter (Range= 0-100, Sainco, India), complete Soxhlet apparatus (Religlass, Model-SEU-6M, Wattage-1200W, Jain Laboratory Glassware co., India), Suction pump (Indian Company), kjeldahl distillation apparatus, Buchner filter assembly.

Methods

Process followed for alcoholic pear slices

The outline of the process of alcoholic pear slices is given in Fig. 1, followed by necessary explanations as follows:

Slicing: The preparation of alcoholic pear slices involves specific considerations for the slicing process. For firm fruits, thin slices are recommended, while softer fruits should be sliced into thicker pieces to maintain their shape during fermentation. Additionally, thicker slices may result in incomplete penetration of yeast for fermentation. In this particular case, slices of 5 mm were chosen as they yielded the best texture

during test fermentation. Manual slicing was performed with regular measurements to achieve consistency in size. Furthermore, the slices were immersed in acidic water to slow down the activity of Polyphenol oxidase [38].

Blanching: Blanching was carried out in acidic medium (pH~3.5) to inactivate natural enzymes in pear [38] and thus oxidative reaction is inhibited which, otherwise, may affect color, and texture of final product.

Addition of Ammonium sulfate $[(NH_4)_2SO_4]$: The addition of yeast food serves to fulfill the nitrogen requirements in the fermentation process. Nitrogen is an essential nutrient for yeast, and providing it in the form of yeast food helps support a healthy and efficient fermentation [39].

Fermentation: In the fermentation process, the starter culture (yeast) transforms the sugar present in the medium into alcohol, and carbon dioxide gas is produced as a by-product, forming bubbles at the top of the jar. For each plastic jar (250 ml), 200 ml of sugar syrup and 200 g of uniformly sliced pear were added for fermentation. A total of 10 jars were utilized, allowing for separate analysis based on the schedule. Fermentation was conducted over a period of 18 days at room temperature (30°C). The temperature range of supplied yeast (Lalvin EC-1118) was 10-30°C [40].

Steam pasteurization of slice: The process of passing steam through the slices for about 2 min was performed to inactivate the yeast and halt the alcoholic fermentation. This step effectively kills the fermenting yeast, ensuring that the desired fermentation is stopped at a specific point in the production process [41].

In the proximate analysis, a fresh pear sample was employed. To assess changes in alcohol content, total Soluble Solids (TSS), pH, acidity, and reducing sugar during the alcoholic fermentation of pear slices, extracts were prepared. The fermentation process was carried out in a plastic jar. To facilitate analysis at scheduled time intervals, the fermentation was halted through steam sterilization. The resulting broth contains the fermented fruit slices along with the medium, which includes sugar syrup. This approach allows for a detailed examination of the fermentation progress and the associated changes in the composition of the pear slices.

The schedule for analysis was as follows:

1. TSS of the product (every 48 h): 0, 48, 96, 144, 192, 240, 288, 366, and 384.
2. pH of product (every 48 h): 0, 48, 96, 144, 192, 240, 288, 366, and 384.
3. Acidity of product (every 48 h): 0, 48, 96, 144, 192, 240, 288, 366, and 384.

Alcohol content of product (every 48 h): 0, 48, 96, 144, 192, 240, 288, 366, and 384.

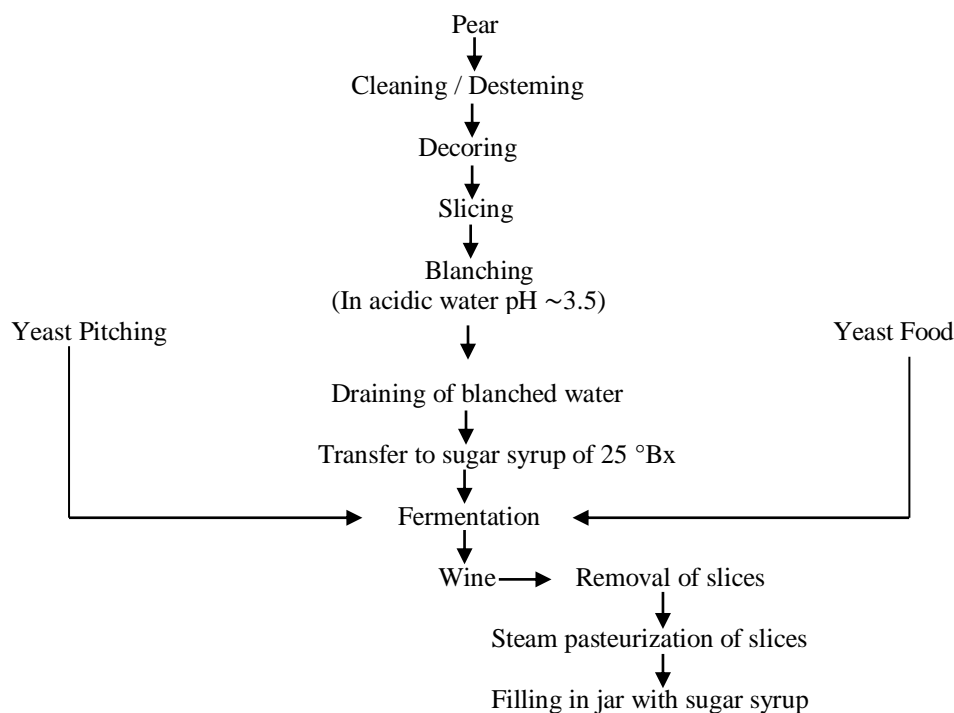


Fig. 1 Process followed for alcoholic pear slices

Analytical procedure

Determination of moisture content

The moisture content was determined using the hot-air oven method [42]. A 20 g sample was taken from a Petri dish of known weight. It was then placed in a hot air oven set to $100 \pm 5^\circ\text{C}$ and dried until a constant weight was observed. The difference in the sample weight was interpreted as the presence of water in the sample.

Determination of crude fat content

The crude fat content of the samples was determined by the solvent extraction method using a Soxhlet apparatus and petroleum ether solvent [42].

Determination of crude protein content

The protein content was determined using a 2 g bone-dry sample, which had been dried in a hot air oven. The total nitrogen content was measured employing the micro-Kjeldahl method Rangana [43]. To convert the nitrogen content to crude protein, a conversion factor of 6.25 was applied.

Determination of crude fiber content

The crude fiber content of the samples was determined using the Chemical digestion method described by Rai and KC [42]. Crude fiber was determined on defatted dried sample. Digestion was carried out by refluxing the sample for 30 min each in 1.25% H_2SO_4 and 1.25% NaOH.

Determination of total ash

The total ash content of the 5 g sample was determined following the method described by Rangana [43] using a muffle furnace.

Determination of carbohydrates

Total carbohydrate was determined by difference method.

$$\text{Total Carbohydrate (\%)} = 100 - (\text{fat \%} + \text{protein \%} + \text{ash \%} + \text{moisture \%} + \text{crude fiber \%})$$

Determination of Total Soluble solids (TSS)

TSS of both the fresh pulp pear and fermented broth of pear were measured using a portable refractometer (Hanna® make) with a range of 0–32°Bx. The values are reported in °Brix. In the procedure, 2 g of the samples were crushed, and the solution was dissolved in 10 ml of water. After calibrating the refractometer with water, TSS content was measured. The observed value was then multiplied by five to calculate the final TSS, as per the method outlined by Rangana [43].

Determination of pH

In the analysis, 10 g of the fermented pear broth were dissolved in 10 ml of distilled water and swirled for three to four minutes. Subsequently, the pH of the fermented broth was measured using a calibrated portable pH meter with a sensitivity of ± 0.1 units. Prior to use, the pH meter was calibrated using buffer solutions of pH 4.0 and 7.0, as procedure outlined by Rangana [43].

Determination of Acidity

The acidity of the fermentation broth was determined through titration with standard NaOH using the phenolphthalein indicator, following the method described by Rai and KC [42]. A 10 g sample was taken and made up to a final volume of 100 ml with distilled water. 10 ml of the prepared sample were then placed in a conical flask for acidity determination, and a 0.1N NaOH solution was used as a titer in a burette. Phenolphthalein served as the indicator. The volume of NaOH solution used for neutralization was recorded, and the acidity was calculated using a specific formula.

$$\frac{\text{Titer} \times \text{N of NaOH} \times \text{volume made up in ml} \times 64}{\text{Aliquot} \times \text{wt. of sample taken} \times 1000} \times 100$$

Where, 64= equivalent weight of citric acid anhydrous

N = Normality

1000 is the factor relating mg to grams (mg/g)

Determination of Alcohol content

Alcohol content of the fermentation broth was determined by using alcoholmeter after distillation of sample.

Sensory evaluation

Composite scoring test was adopted for rating the samples [43]. For this study, 10 panelists were provided with a tray containing the samples at room temperature (randomly coded using three-digit number), a glass of water, and an evaluation sheet. Participants were instructed and trained to evaluate the dimensions of the individual quality characteristics critically, and in the use of the weighted scale and were not required to expectorate or consume the entire volume served. There was an inter stimulus interval of 30 s imposed between the samples, to allow time to recover from adaptation. Separate plate was used for serving different samples. Enough space was given to handle the samples and questionnaire, and evaluation time was not constrained.

Statistical analysis

Data on sensory analysis were tabulated for comparison and were graphically represented using Microsoft Excel-2013. Data were also statistically processed by GenStat 12.0.1 (Copyright 2009, VSN International Ltd) for Analysis of Variance (ANOVA). Means of the data were differentiated using LSD (least significance difference) at 5% level if significance.

Results of the research and their discussion

The fresh pear fruit was analyzed, and the results are displayed in Table 1 and 2 respectively. The key qualities responsible to appearance of pears are their color and glow [44]. The indication of maturity in Asian pears is prominently conveyed through the transformation in their fruit color. When Asian fruits attain full maturity, their initial vibrant green shade evolves into a brown-yellow hue [1]. When pears reach full ripeness, the color can vary across cultivars, ranging from dark green to light yellow. Typically, a preference exists for yellow pears, as this color is widely associated with ripeness [45]. Fruit texture encompasses various attributes dictating the mouthfeel of a fruit. The firmness of the flesh is intricately tied to ripeness, exhibiting variations from soft and buttery to crisp and breaking, depending on the specific cultivar, even at optimum ripeness. Desirable textural qualities in European-type pears include a delicately breaking skin, a soft buttery flesh, and the absence of fibers and grit (stone cells). Grittiness, a distinctive trait of *P. pyrifolia* and other Oriental species, is inherited by

hybrids with *P. communis*, exemplified by the Kieffer pear, as documented by Quamme and Gray [45]. Drawing a comparison between Asian pears, specifically *P. pyrifolia*, characterized by a round form, crisp flesh, gritty texture, high sugar levels (especially fructose), low acidity, subtle aroma, and a mild flavor, and their Western or European counterparts, represented by *P. communis*, exhibiting a gourd-like shape, soft and smooth flesh, few stone cells, and a more pronounced aroma and flavor [46,47]. Additionally, Quamme and Gray [45] highlight that while the flesh color of pears is generally creamy white to white, variations such as green, yellow, pink, and brown can also be observed.

Table 1 – Organoleptic evaluation of pear fruit (*P. pyrifolia*)

Parameters	Results
Shape	Round
Fruit skin color	Greenish yellow with prominent dots
Flesh color	Creamy white
Taste	Sweet
Texture	Crisp and gritty

The chemical composition of pear fruit is presented in the Table 2.

Table 2 – Chemical composition of pear (*P. pyrifolia*)

Parameters	*Values (%)
Moisture	84.53 ± 0.58
Crude protein	0.31 ± 0.03
Crude fiber	2.79 ± 0.04
Crude fat	0.10 ± 0.03
Total ash	1.92±0.04
Total carbohydrate	10.35± 0.53
TSS (°Bx) [#]	11 ± 0.02
pH [#]	4 ± 0.20

[#]Data were not in %.

*The values in the table are the mean of the triplicate ± standard deviation

The chemical composition analysis of *Pyrus pyrifolia* [48] fruit yielded the following results: moisture 84.53%, crude protein 0.31%, crude fiber 2.79%, crude fat 0.10%, and total ash 1.92%. These findings closely align with the results reported by Baniwal and Hathan [49] for *Pyrus pyrifolia* L., which recorded moisture, crude protein, crude fiber, crude fat, and total ash as 88.23%, 0.61%, 7.32%, 0.24%, and 1.86%, respectively. However, the carbohydrate content in *Pyrus pyrifolia* was determined to be 10.35%, higher than the 1.79% reported by Baniwal and Hathan [49] for sand pear fruit (*Pyrus pyrifolia* L.). Additionally, Verma and Kushwaha [50] reported moisture content (84.84–86.59%), ash content (0.28–0.33%), and crude fiber (2.87–2.98%) in mature and ripe stages of 'Gola' Pear (*Pyrus pyrifolia*) fruit. In comparison, Hwang, Woo [51], presented values for water content, carbohydrate, protein, and lipid in Asian pear or Korean pear (*Pyrus pyrifolia* Nakai) as 85–88%, 10–13%, 0.3%, and 0.2%, respectively. These

values differ slightly from those in Table 2, possibly due to variations in pear variety and the time of collection. For this research, pears were collected in August when they were ripened.

TSS measured for the pear fruit were found to be $11 \pm 0.02^\circ\text{Bx}$, slightly lower than the value reported by Baniwal and Hathan [49] who observed $13.2 \pm 0.05^\circ\text{Bx}$ for pear (*Pyrus pyrifolia* L.) fruit. Likewise, Verma and Kushwaha [50] reported TSS values of $12.33\text{--}14^\circ\text{Bx}$ for the mature and ripe stage of 'Gola' Pear (*Pyrus pyrifolia*).

The acidity levels in pears can range from pH 2.6 to 5.4 [52]. The observed pH of the pear fruit in this study was acidic, measuring 4 ± 0.20 . This pH value is somewhat similar to the acidity level reported for pear fruit (*Pyrus pyrifolia* L.) by Baniwal and Hathan [49], which was 3.8 ± 0.15 . Additionally, Verma and Kushwaha [50] reported pH values of 4.10–4.45 for the mature and ripe stage of 'Gola' Pear fruit (*Pyrus pyrifolia*).

Interpretation of fermentation kinetic. The progress of fermentation was viewed during the fermentation by monitoring the parameters like TSS, pH, acidity and alcohol content. The result of kinetics is described under the following headings:

The change in pH of medium was observed and the graph for change in pH according to fermentation time (days) is shown in Fig. 2

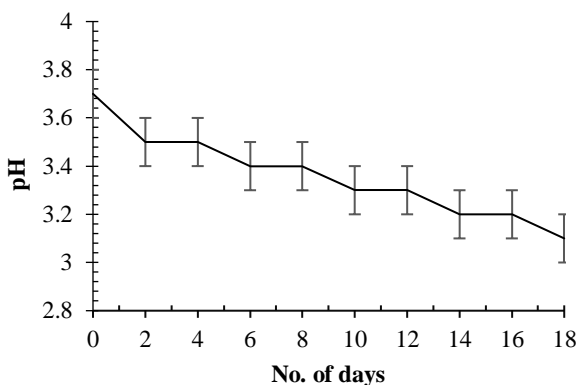


Fig. 2 Change in pH according to fermentation time (days)

It was observed that pH of the medium decreases as the fermentation days increases. This aligns with the well-known phenomenon that the pH of the medium tends to drop early in the fermentation process and undergoes slower changes in the later stages. As noted by Amerine, Berg [53], the ongoing fermentation process leads to a reduction in pH, and at very low pH levels, the lag phase is extended, resulting in decreased fermentation activity. These findings are consistent with prior studies, such as the work conducted by Subba, Rai [54], which also reported a decrease in pH as fermentation progresses.

The alteration in acidity during fermentation was specifically monitored in terms of citric acid. The

graph depicting the changes in acidity over the course of fermentation time (days) is illustrated in Fig. 3. The data presented in Fig. 3 illustrates that as the days of fermentation increase, the acidity level also increases. Acidity and pH typically have an inverse relationship. From both Fig. 3 and Fig. 4, it is evident that as the pH decreases, the acidity increases. This inverse correlation between pH and acidity is a common phenomenon in fermentation processes.

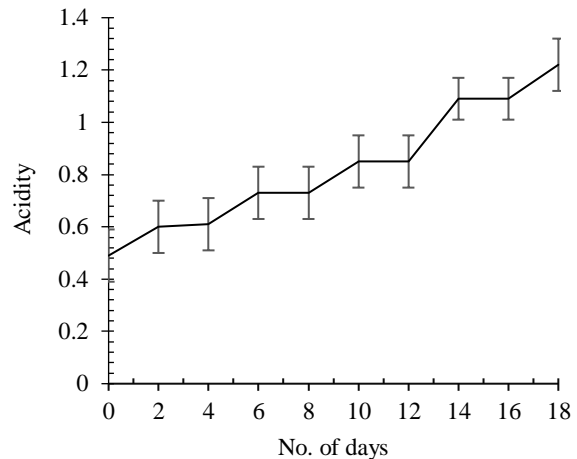


Fig.3 Change in acidity (% as citric acid) with respect to fermentation time (days)

During the course of fermentation, the change in TSS according to fermentation time (days) was observed. The graph for changes in TSS according to fermentation days is shown in Fig.4. The diminishing trend in the TSS of the medium over the progression of fermentation days, as illustrated in Fig. 4, corresponds with the findings of Muzaifa, Rohaya [55]. Their investigation focused on the alcohol content and total soluble solids of kombucha produced from cascara, incorporating dragon fruit, and undergoing various fermentation durations. According to their observations, there is a consistent decline in total soluble solids as fermentation time increases. The graphical representation in Fig. 4 indicates a rapid decrease in TSS during the initial 2 days of fermentation, attributed to the uneven distribution of TSS between the pear and the medium. Consistent with this pattern, the highest concentration of TSS in kombucha, made from cascara with the addition of dragon fruit and subjected to various fermentation times, was achieved during the second fermentation period of 2 days, measuring at 10.97°Brix , as reported by Muzaifa, Rohaya [55].

The TSS curves appear to stabilize after about 16–18 days of fermentation, under the fermentation conditions applied. As the fermentation continues, yeast utilizes the carbon source available to produce alcohol. From the graph, at 16–18 days the depletion is almost constant as the amount of sugar available is almost depleted and the alcohol content has increased

(Fig.5). According to Berry and Brown [56], increase in alcohol content restrict the yeast activity.

The fermentation process commences with yeast breaking down sugar, leading to the production of alcohol [55]. The longer the fermentation resulted the greater opportunity for the yeast to break down the existing sugars so that the alcohol produced increases. This observation aligns with findings reported by Muzaifa, Rohaya [55], who noted a direct correlation between the length of fermentation and the conversion of sugar into alcohol. Their study highlights that a prolonged fermentation period results in higher alcohol content due to increased sugar conversion.

The graphical representation illustrating the alteration in alcohol content over the fermentation period is depicted in Fig. 5. Muzaifa, Rohaya [55] reported similar findings in their study, which investigated the alcohol content and TSS of kombucha produced from casacara.

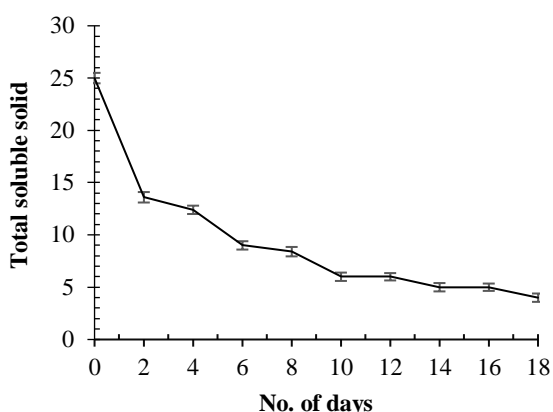


Fig. 4 Effect of number of days of fermentation on the change in TSS

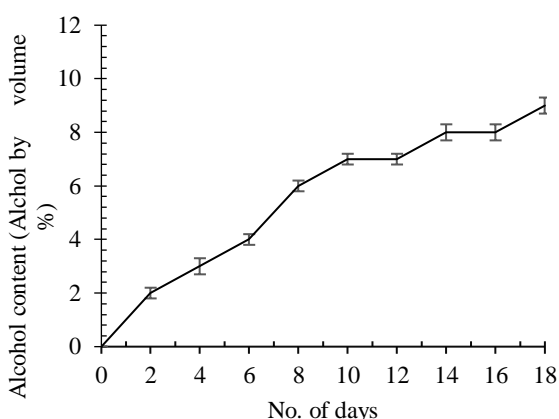


Fig.5 Change in alcohol content according to fermentation time (days)

The experiment involved introducing dragon fruit into the mix with varying fermentation durations ranging from 2 to 8 days and observed a rise in alcohol content with the prolongation of the second fermentation

period, utilizing dragon fruit pieces measuring 1 cm x 1 cm. Yeast utilizes sucrose to produce alcohol. As the number of days of fermentation increases, the alcohol content increase. Yeast increases in number and depletion of TSS increases. From the Fig 5, the increase in alcohol content at 16-18 days is almost constant as the TSS available is almost depleted and the yeast activity is restricted by increased alcohol content.

Sensory analysis of alcoholic pear slices

Pear slices underwent fermentation for various durations, and the corresponding samples are coded as follows: A (0 days), B (2 days), C (4 days), D (6 days), E (8 days), F (10 days), G (12 days), H (14 days), I (16 days), and J (18 days). Results from the sensory evaluation studies are summarized in Table 3. The results generally show significant variations in the sensory attributes for the various fermentation times.

Based on the information presented in Table 3, it is evident that fermentation does not have a significant effect on the color of the produced. The mean sensory scores for the color of the alcoholic pear slices ranged from 16.30 to 18.60. Notably, the control sample A (non-fermented) attained the second-highest average color score at 18.00. The color scores ascend significantly up to sample E (fermentation duration: 8 days) with a peak at 18.60, signifying it as the most favored sample. Subsequently, a gradual decline is observed until sample J (fermentation duration: 18 days), which registers the lowest mean color score of 16.30, marking it as the least preferred sample. Color is a pivotal factor that governs food acceptance as a major response variable [57].

The data presented in Table 3 indicates a clear preference among the panelists for the taste of fermented pear slices over the non-fermented Sample A. Sample E, fermented for 8 days, secured the top ranking with a taste score of 27.6, showing a significant difference ($p > 0.05$) compared to other samples. Conversely, Sample A, the non-fermented one, received the lowest taste score at 15.7, demonstrating a significant distinction from the rest of the samples. Samples I and J showed no significant difference ($p < 0.05$) in taste, and similarly, there was no notable distinction between D and G, although both were significantly different from the other samples.

The recorded values for the texture of the prepared alcoholic pear slices, outlined in Table 3, varied from 16.3 to 43.6. A noticeable trend is observed: as the fermentation days increase, the texture of the samples degrades. Specifically, the control sample (Sample A) exhibited the highest texture value and was significantly different ($p < 0.05$) from the other samples, while Sample J displayed the lowest mean texture value at 16.3. Notably, all samples showed significant differences from each other in terms of texture.

Based on the data provided in Table 3, it is apparent that fermentation has a significant effect on the overall acceptance of alcoholic pear slices. Sample

E, subjected to an eight-day fermentation, achieved the highest score (86.1) across all assessed attributes. However, following the eight-day fermentation period (Sample E), the overall acceptances for alcoholic pear slices gradually diminished, reaching the lowest overall score of 52.6 at 18 days (Sample J).

Sample E, treated with an 8-day fermentation, was deemed the most preferred in terms of sensory attributes. Subsequently, for further exploration, sugar variations were introduced and coded as Sample X (treatment: sugar 15°Bx), Sample Y (treatment: sugar 20°Bx), and Sample Z (treatment: sugar 25°Bx).

The mean sensory score for the different amount of sugar variations in sample E is presented in Table 4.

Sample Y (treatment: sugar 20°Bx) had the highest score (93.40) for overall acceptability while sample X (81.80) has the lowest. All the samples contained trace alcohol of the product. Sample X (15°Bx) had alcoholic taste only. In Sample Z, alcoholic taste of the product was suppressed by higher concentration of sugar, 25°Bx. Sample Y (20°Bx), was alcoholic as well as sweet which increases the overall acceptability of product.

Table 3 – Mean sensory score for alcoholic pear slices

Alcoholic Pear slices Sample	Parameters*			
	Texture	Taste	Color	Overall Acceptance
A	43.6 ^e ± 3.13	15.7 ^a ± 0.67	18.0 ^{cd} ± 1.42	77.3 ^d ± 2.75
B	42.3 ^e ± 4.64	16.1 ^a ± 0.79	17.9 ^{cd} ± 1.42	76.3 ^d ± 4.55
C	41.8 ^e ± 3.49	18.2 ^b ± 1.15	17.9 ^{cd} ± 1.48	78.0 ^d ± 4.06
D	40.0 ^{de} ± 5.68	22.0 ^{ef} ± 1.26	17.9 ^{cd} ± 0.99	79.8 ^d ± 5.51
E	39.9 ^{de} ± 5.53	27.6 ^h ± 1.19	18.6 ^d ± 0.42	86.1 ^e ± 5.63
F	33.8 ^{cd} ± 6.99	23.6 ^g ± 1.33	17.5 ^{bc} ± 1.34	74.9 ^d ± 7.13
G	27.3 ^{bc} ± 10.09	22.3 ^f ± 0.53	16.9 ^{ab} ± 1.15	66.5 ^c ± 9.62
H	22.6 ^{ab} ± 11.35	21.2 ^{de} ± 0.42	16.8 ^{ab} ± 1.14	60.6 ^{bc} ± 11.06
I	18.3 ^a ± 11.50	20.4 ^{cd} ± 0.53	16.4 ^a ± 1.26	55.1 ^{ab} ± 11.49
J	16.3 ^a ± 11.46	20.0 ^c ± 0.00	16.3 ^a ± 1.26	52.6 ^a ± 11.24

*The values in the table are the mean of the triplicate ± standard deviation. Means with different superscripts within the same column are significantly different ($P < 0.05$).

Table – 4 Mean sensory score for variation of sugar

Sample	Parameters*			
	Texture	Taste	Color	Overall Acceptance
X (15°Bx)	24.10 ^a ± 1.37	44.00 ^a ± 2.31	13.70 ^a ± 2.06	81.80 ^a ± 2.82
Y (20°Bx)	27.90 ^c ± 0.88	48.30 ^c ± 0.67	17.20 ^c ± 1.87	93.40 ^c ± 2.07
Z (25°Bx)	26.50 ^b ± 1.08	46.10 ^b ± 1.89	15.60 ^b ± 2.07	88.20 ^b ± 2.69

*The values in the table are the mean of the triplicate ± standard deviation. Means with different superscripts within the same column are significantly different ($P < 0.05$).

Conclusion

Sample E, pear slices fermented for 8 days, produces alcoholic pear slices of acceptable quality. When these slices, also known as Sample Y, are treated with a sugar concentration of 20°Bx, they are considered the best product. Thus, the optimized alcoholic pear slices offer a well-balanced alcoholic profile with added sweetness, which enhances the overall flavor profile during storage. Notably, the duration of fermentation significantly affects the texture of the pear slices, while its impact on color is relatively minimal. Consequently, alcoholic pear slices

can be effectively utilized as a desirable product after fermentation. This information could be valuable for winemaking industries and individuals seeking to reduce waste by effectively utilizing byproducts. For further studies, it is not recommended to use sugar syrup concentrations higher than 20°Bx, as this can mask the alcoholic taste. Instead, research could focus on varying fruit types, slice thickness, and packaging materials to achieve better results and extend the product's shelf life.

Conflicts of interests. None

Funding. No funding was raised.

References

1. Gotame TP, Subedi GD, Dhakal M, Khatiwada PP. Postharvest handling of asian pear in Nepal. Tasikhel, Lalitpur, Nepal: Nepal Agricultural Research Council 2015.
2. Silva GJ, Souza TM, Barbieri RL, Costa de Oliveira A. Origin, domestication, and dispersing of pear (*Pyrus* spp.). Adv Agric. 2014;2014:1-8. <https://doi.org/10.1155/2014/541097>
3. Liaudanskas M, Zymonė K, Viškelis J, Kleivinskas A, Janulis V. Determination of the phenolic composition and antioxidant activity of pear extracts. J Chem. 2017;2017(1):1-9. <https://doi.org/10.1155/2017/7856521>
4. Hameed F, Gupta N, Rahman R, Anjum N, Nayik GA. Jamun. In: Nayik GA, editor. Antioxidants in fruits: properties and health benefits. Singapore: Springer; 2020. https://doi.org/10.1007/978-981-15-7285-2_32

5. Hameed F, Gupta N, Rehman R. Pear wastes and by-products: Chemistry, processing, and utilization. In: Muzaffar K, Sof SA, Mir SA, editors. Handbook of fruit wastes and by-products: chemistry, processing technology, and utilization. Boca Raton, London, New York: CRC Press; 2023. p. 305-13. <https://doi.org/10.1201/9781003164463-20>
6. Sahiba MA, Divya J. A review on pharmacognostical and phytochemical evaluation of *Pyrus pashia* Buch-Ham ex D. Don. *The Pharm Innov J*. 2018;7(5):186-9.
7. Joshi VK, Thakur NS, Bhat A, Garg C. Wine and brandy: a perspective. In: Joshi VK, editor. Handbook of enology: Principles, practices and recent innovations. 1. New Delhi: Asia Tech Publisher; 2011. p. 3-45.
8. Joshi VK, Panesar PS, Rana VS, Kaur S. Science and technology of fruit wines: An overview. In: Kossovea M, Joshi VK, Panesar PS, editors. Science and technology of fruit wines. UK: Elsevier; 2017. p. 1-72. <https://doi.org/10.1016/B978-0-12-800850-8.00001-6>
9. Pinto T, Vilela A, Cosme F. Chemical and sensory characteristics of fruit juice and fruit fermented beverages and their consumer acceptance. *Beverages*. 2022;8:1-22. <https://doi.org/10.3390/beverages8020033>
10. Mohanty S, Ray P, Swain M, Ray R. Fermentation of cashew (*Anacardium occidentale* L.) "apple" into wine. *J Food Process Preserv*. 2006;30(3):314-22. <https://doi.org/10.1111/j.1745-4549.2006.00067.x>
11. Joshi V, Sharma R, Girdher A, Abrol GS. Effect of dilution and maturation on physico-chemical and sensory quality of jamun (Black plum) wine. *Indian J Nat Prod Res*. 2012;3(2):222-7.
12. Bhat A, Joshi VK. Processing. In: Sharma RM, Pandey, S.N., Pandey, editor. The Pear: Production, post-harvest management and protection. Lucknow: IBDC; 2010. p. 699.
13. Joshi VK, Ray RC. Wine and winemaking: An introduction. In: Joshi VK, Ray RC, editors. Winemaking basics and applied aspects. Boca Raton: CRC press; 2021. p. 3-36. <https://doi.org/10.1201/9781351034265-2>
14. He W, Tian Y, Liu S, Vaateri L, Ma X, Haikonen T, et al. Comparison of phenolic composition and sensory quality among pear beverages made using *Saccharomyces cerevisiae* and *Torulaspora delbrueckii*. *Food Chem*. 2023;422:136184. <https://doi.org/10.1016/j.foodchem.2023.136184>
15. Fontana AR, Antonioli A, Bottini R. Grape pomace as a sustainable source of bioactive compounds: Extraction, characterization, and biotechnological applications of phenolics. *J Agric Food Chem*. 2013;61(38):8987-9003. <https://doi.org/10.1021/jf402586f>
16. Kusumaningrum D, Lee S-H, Lee W-H, Mo C, Cho B-K. A review of technologies to prolong the shelf life of fresh tropical fruits in Southeast Asia. *J Biosystems Eng* 2015;40(4):345-58. <https://doi.org/10.5307/JBE.2015.40.4.345>
17. Parajuli A, Katuwal N, Dangal A. Optimization and shelf-life evaluation of mayonnaise like paste prepared using avocado pulp. *Acta Agric Serb*. 2022;27(54):149-56. <https://doi.org/10.5937/AASer2254149P>
18. Wu C-T, editor An overview of postharvest biology and technology of fruits and vegetables. Technology on reducing post-harvest losses and maintaining quality of fruits and vegetables proceedings of 2010 AARDO Workshop; 2010.
19. Barrett DM, Lloyd B. Advanced preservation methods and nutrient retention in fruits and vegetables. *J Sci Food Agric*. 2012;92(1):7-22. <https://doi.org/10.1002/jsfa.4718>
20. KC Y, Rayamajhi S, Dangal A, Shiwakoti LD. Phytochemical, nutritional, antioxidant activity and sensorial characteristics of amala (*Phyllanthus emblica* L.) chutney. *Asian Food Sci J*. 18 (1). 2020:43-52. <https://doi.org/10.9734/afsj/2020/v18i130209>
21. C Y, Dangal A, Thapa S, Rayamajhi S, Chalise K, Shiwakoti LD, et al. Nutritional, phytochemicals, and sensory analysis of Lapsi (*Choerospondias axillaris*) fruit leather. *Int J Food Prop*. 2022;25(1):960-75. <https://doi.org/10.1080/10942912.2022.2070203>
22. Chhetri AJ, Dangal A, Shah R, Timsina P, Bohara E. Nutritional and sensory quality of prepared tomato (*Solanum lycopersicum*) Leather. *Anal Sci Technol*. 2022;35(4):169-80.
23. Dangal A, Timsina P, Dahal S. A comprehensive review on study of physical, nutritional, and phytochemical characteristics as well as therapeutic activities of *Choerospondias axillaris* (lapsi). *Food Biosci*. 2023;53:102713. <https://doi.org/10.1016/j.fbio.2023.102713>
24. Jagtap UB, Bapat VA. Wines from fruits other than grapes: Current status and future prospectus. *Food Biosci*. 2015;9:80-96. <https://doi.org/10.1016/j.fbio.2014.12.002>
25. Khadka N, Acharya DR, Dangal A, Rai K, Gurung G, Sherma G, et al. Study on the changes during the fermentation of the wine prepared from palm (*Phoenix sylvestris*) sap. *Heliyon*. 2024. <https://doi.org/10.1016/j.heliyon.2024.e35799>
26. Dangal A, Timsina P, Dahal S. Review on: uses of cereals in traditional foods of Nepal and their preparation process. *EUREKA: Life Sci*. 2021;6:49-60. <https://doi.org/10.21303/2504-5695.2021.002122>
27. Rolle R, Satin M. Basic requirements for the transfer of fermentation technologies to developing countries. *Int J Food Microbiol*. 2002;75(3):181-7. [https://doi.org/10.1016/S0168-1605\(01\)00705-X](https://doi.org/10.1016/S0168-1605(01)00705-X)
28. Mani A. Food preservation by fermentation and fermented food products. *Int J Acad Res Dev*. 2018;1:51-7.
29. Moreno-Arribas MV, Polo MC. Winemaking biochemistry and microbiology: Current knowledge and future trends. *Crit Rev Food Sci Nutr*. 2005;45(4):265-86. <https://doi.org/10.1080/10408690490478118>
30. Mora F, Pérez K, Quezada C, Herrera C, Cassano A, Ruby-Figueroa R. Impact of membrane pore size on the clarification performance of grape marc extract by microfiltration. *Membranes*. 2019;9(11):1-15. <https://doi.org/10.3390/membranes9110146>
31. Ianni A, Di Luca A, Martino C, Bennato F, Marone E, Grotta L, et al. Dietary supplementation of dried grape pomace increases the amount of linoleic acid in beef, reduces the lipid oxidation and modifies the volatile profile. *Animals*. 2019;9(8):1-13. <https://doi.org/10.3390/ani9080578>
32. Bennato F, Di Luca A, Martino C, Ianni A, Marone E, Grotta L, et al. Influence of grape pomace intake on nutritional value, lipid oxidation and volatile profile of poultry meat. *Foods*. 2020;9(4):1-14. <https://doi.org/10.3390/foods9040508>
33. Torre E, Iviglia G, Cassinelli C, Morra M, Russo N. Polyphenols from grape pomace induce osteogenic differentiation in mesenchymal stem cells. *Int J Mol Med*. 2020;45(6):1721-34. <https://doi.org/10.3892/ijmm.2020.4556>
34. Olejar KJ, Ricci A, Swift S, Zujovic Z, Gordon KC, Fedrizzi B, et al. Characterization of an antioxidant and antimicrobial extract from cool climate, white grape marc. *Antioxidants*. 2019;8(7):1-13. <https://doi.org/10.3390/antiox8070232>
35. Nath A, Deka BC, Singh A, Patel R, Paul D, Misra L, et al. Extension of shelf life of pear fruits using different packaging materials. *J Food Sci Technol*. 2012;49(5):556-63. <https://doi.org/10.1007/s13197-011-0305-4>
36. Rhyu J, Kim MS, You M-K, Bang M-A, Kim H-A. Pear pomace water extract inhibits adipogenesis and induces apoptosis in 3T3-L1 adipocytes. *Nutr Res Pract* 2014;8(1):33-9. <https://doi.org/10.4162/nrp.2014.8.1.33>
37. Kosseva MR, Joshi VK, Panesar PS. Pear wine/perry. Science and technology of fruit wine production. United Kingdom: Elsevier; 2017. p. 315-8. <https://doi.org/10.1016/B978-0-12-800850-8.00011-9>
38. Gomes MH, Vieira T, Fundo JF, Almeida DP. Polyphenoloxidase activity and browning in fresh-cut 'Rocha' pear as affected by pH, phenolic substrates, and antibrowning additives. *Postharvest Biol Technol*. 2014;91:32-8. <https://doi.org/10.1016/j.postharvbio.2013.12.013>
39. Waites MJ, Morgan NL, Rockey JS, Higon G. Industrial microbiology: An introduction. Great Britain: Blackwell Science Ltd.; 2001.
40. Lalvin EC-1118™ [Internet]. 2023 [cited 20 April, 2023]. Available from: <https://admin.lallemandbrewing.com/wp-content/uploads/2017/03/EC1118-TDS-ENG-Lalvin.pdf>.

41. Jacob F, Archer T, Castor J. Thermal death time of yeast. *Am. J. Enol. Vitic.* 1964;15(2):69-74. <https://doi.org/10.5344/ajev.1964.15.2.69>
42. Rai BK, KC JB. Basic food analysis handbook. Anam Nagar, Kathmandu: Pragati prints; 2019.
43. Rangana S. Handbook of analysis and quality control for fruits and vegetables products. second ed. New Delhi, India: Tata McGraw-Hill Publishing; 1986.
44. Hansen E. Factors affecting post-harvest color development in pears. *Proc. Am. Soc Hort Sci.* 1955;66:118-24.
45. Quamme HA, Gray JI. Pear fruit quality and factors that condition it. In: Pattee HE, editor. Evaluation of quality of fruits and vegetables. Westport, Connecticut: The Avi Publishing Company; 1985. p. 47-59. https://doi.org/10.1007/978-1-4613-2549-9_2
46. Reiland H, Slavin J. Systematic review of pears and health. *Nutr Today.* 2015;50(6):301-5. <https://doi.org/10.1097/NT.0000000000000112>
47. Layne REC, Quamme HA. Pears. In: Janick J, Moore JN, editors. *Advances in Fruit Breeding.* Lafayette, IN: Purdue University Press; 1975. p. 38-70.
48. Pearl GG. Inedible. In: Jensen W, Devine C, Dikemann M, editors. *Encyclopedia of meat sciences* London, UK: Elsevier Science Ltd; 2004. p. 112-25. <https://doi.org/10.1016/B0-12-464970-X/00047-7>
49. Baniwal P, Hathan BS. Physico-chemical, nutritional, functional, textural and morphological characterization of sand pear fruit (*Pyrus pyrifolia* L.) from northern region of India. *Asian J Chem.* 2017;29(4):805-9. <https://doi.org/10.14233/ajchem.2017.20317>
50. Verma A, Kushwaha A. Effect of maturation on physico-chemical characteristics of 'Gola' Pear (*Pyrus pyrifolia*) fruit. *Int.J.Curr.Microbiol.App.Sci.* 2018(7):2985-95.
51. Hwang I-G, Woo K-S, Kim T-M, Kim D-J, Yang M-H, Jeong H-S. Change of physicochemical characteristics of Korean pear (*Pyrus pyrifolia* Nakai) juice with heat treatment conditions. *Korean J. Food Sci. Technol.* 2006;38(3):342-7.
52. Visser T, Schaap A, De Vries D. Acidity and sweetness in apple and pear. *Euphytica.* 1968;17:153-67. <https://doi.org/10.1007/BF00021205>
53. Amerine MA, Berg HW, Cruess WV. The technology of wine making. 4th ed. Westport: Avi publishing company; 1980.
54. Subba J, Rai BK, Limbu DK, Rai SR. Evaluation of fermentation potential of wild and UV-mutated yeasts screened from traditional murcha. *Himalayan J Sci and Technol.* 2018;2:84-9. <https://doi.org/10.3126/hijost.v2i0.25848>
55. Muzaiifa M, Rohaya S, Nilda C, Harahap K, editors. Kombucha fermentation from cascara with addition of red dragon fruit (*Hylocereus polyrhizus*): Analysis of alcohol content and total soluble solid. International conference on tropical agrifood, feed and fuel (ICTAFF 2021); 2022: Atlantis Press. <https://doi.org/10.2991/absr.k.220102.020>
56. Berry DR, Brown C. Physiology of yeast growth. In: Berry DR, Russell I, Stewart GG, editors. *Yeast biotechnology.* Dordrecht: Springer; 1987. p. 159-99. https://doi.org/10.1007/978-94-009-3119-0_6
57. Maga J, Kim CH. Co-extrusion of rice flour with dried fruits and fruit juice concentrates. *Lebensmittel-Wissenschaft+ Technologie.* 1989;22(4):182-7.