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Efficacy of different natural herbs in improving qualitative, sensory and microbiological properties of wood apple jam

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Abstract

An experiment was conducted to study the effect of addition of different medicinal herbs like Ashwagandha powder @2%, Tulsi extract @2%, Mint extract @2%, Lemon grass @2% and Mango ginger @2% on quality of wood apple jam. The jam was prepared using standardized process and was evaluated for quality, sensory and microbiological properties up to 12 months of ambient storage. After studying the jam for several biochemical and sensory parameters for 12 months, it was concluded that addition of 2% mango ginger resulted in the best quality of product. Mango ginger addition in wood apple jam resulted in higher retention of vitamin C content through out the storage. The antibacterial property of mango ginger was also evident with a lower total colony count. The sensory properties of the product blended with mango ginger 2% exhibited a very high hedonic score and acceptability. Hence, this treatment can be commercialized.

1. Introduction

Jam is a delicious food product which is prepared by cooking fruit pulp with sufficient quantity of sugar and pectin in presence of acid. Jam is a very popular processed product which is not only delicious but also nutritious. Jam can be prepared using several types of fruits including wood apple. Wood apple (*Feronia limonia* L.) belongs to the family Rutaceae and is an under exploited fruit in India. The fruit is rich in pectin (3-5%) and is an excellent material for preparation of jam. Wood apple has got high medicinal value. Every part of the fruit possesses medicinal property. Fruits, leaves and stem bark of wood apple have been studied for anti-tumour and antimicrobial activity (Rahman and Gray, 2002). Fruit pulp has anti-inflammatory, antipyretic and analgesic activity (Ahamed *et al.*, 2008). Wood apple has antidiabetic and antioxidant potential by reducing the level of blood glucose and malondialdehyde (Patel *et al.*, 2012). Fruit is much used in India as a liver and cardiac tonic and when unripe, as a means of halting diarrhoea and dysentery and for effective treatment for high cough, sore throat and disease of the gums (Sonawane and Arya, 2013). In addition to this, wood apples also have hypoglycaemic activity, antitumour, larvicidal and antimicrobial activity and hepatoprotective activity (Vidhya and Narain, 2011). Wood apple fruit is considered to be one of the natural sources of antioxidants due to its potential radical scavenging activity of various phytochemicals (Nithya and Saraswathi, 2010). Processed products prepared from wood apple have superb thirst

quenching capability and have tremendous potential to be an important crop for processing. Traditionally in Indian homes, wood apple is even consumed raw but its exquisite flavour and perfect sour-sweet blend can be harnessed by value adding it in form of jam (Mani and Mitra, 2020).

Ashwagandha (*Withania somnifera* D.) is Indian ginseng which is both a tonic and a sedative due to its adaptogenic properties (Jana and Charan, 2018). Ashwagandha is also known to have a wide range of health benefits, including its ability to fight against cancer and diabetes, as well as reduce inflammation, arthritis, asthma, hypertension, stress and rheumatism (Verma and Kumar, 2011). Ashwagandha is effective in recovering from urogenital, gastrointestinal and respiratory tract infections when consumed orally (Apte, 2007). Tulsi (*Ocimum sanctum* L.) is believed to have health benefits due to their anthelmintic activity and polyphenols (Gangrade *et al.*, 2000). Juice or infusion of the tulsi leaves used in the treatment of bronchitis, catarrh, digestive complaints, arthritis, ringworms, hypertension, heart attack, cancer, viral hepatitis and diabetes (Luthra, 2010). The leaves and seeds of tulsi are reported to have diuretic and laxative properties (Cohen, 2014). Lemon grass (*Cymbopogon citratus* L.) can be widely used in food products due to its desirable aroma (Majewska *et al.*, 2019). Lemon grass is used for treating digestive tract spasms, stomach ache, high blood pressure, pain, vomiting, cough, achy joints (rheumatism), fever, the common cold and exhaustion. It is also used to kill germs and as a mild astringent (Olorunnisola *et al.*, 2014). Health benefits of lemongrass include relief from stomach disorders, fever, aches, infections, rheumatism and edema. It is antibiotic, antifungal and plays an important role to defeat cancer (Silva *et al.*, 2008; Danlami *et al.*, 2011). Mango ginger (*Curcuma amada* R.), is a plant of family Zingiberaceae and is closely related

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to turmeric. The flavours of the rhizome are very similar to ginger but have a raw mango taste (Policegoudra, 2011; Rao *et al.*, 1989). Mango ginger extracts are known to have cytotoxic activities on the human cancer cell lines MCF-7 (Malek *et al.*, 2011). It is a rich source of antioxidants and also has antimicrobial properties (Tamta *et al.*, 2016; Dosoky and Setzer, 2018).

Even though wood apple jam is slightly acidic in nature but it starts spoiling after 6 to 7 months of ambient storage. There is a dire need to enhance its shelf life and augment its sensory and quality characters. Considering these above factors, there appears a possibility to improve traditional wood apple jam using natural herbs like ashwagandha, tulsi extract, mint extract, lemon grass and mango ginger.

2. Materials and Methods

2.1 Methodology of preparation of jam

The wood apple jam was prepared according to the procedure as standardised by Vidhya and Narain (2011). At first perfectly ripened fruits were selected followed by extraction of wood apple fruit pulp. The pulp was weighed because the ingredients were added depending on pulp weight. The pulp was cooked in low - medium flame for 5 min. The cooked pulp was sieved to remove seeds and fibres. Sugar was added to the jam at the rate of 750 g per kg pulp. Then, the natural product extract and herbs were added properly. The pulp was cooked slowly and occasionally stirred for 15-20 min. During the entire process of cooking, end point judgement was done to ensure over cooking and loss of vital nutrients. The product was ready when the TSS reading was 68.5°B. The hot jam was filled in clean, dried and sterilized glass jars. The jars were lidded properly and stored in clean dry place.

Ingredients: The products were prepared with 100% wood apple pulp. In T₆ (Control), no herbal extracts were added while preparation of jam. In other treatments, 2% herbal extracts were added while cooking of the pulp

2.2 Experiment site

This experiment was conducted in Post Graduate Lab, Department of Post-Harvest Technology, BCKV, Mohanpur in the year 2018 to 2019. Wood apple was purchased from Local Market and the processed product was prepared out of it. The design of the experiment is completely randomized design (CRD) with 6 treatments and 4 replications. Medicinal products like tulsi, lemon grass, mint and mango ginger were procured from Department of Plantation, Spice, Medicinal and Aromatic plants, BCKV.

2.3 Storage study of jam

The jam was stored in sterilized glass jar for 12 months. The stored jam was analyzed for several quality parameters, sensory and microbiological properties at an interval of 3 months up to 12 months of storage. The jam was stored at ambient conditions. The highest and lowest temperature during the year of study was 38°C and 12°C, respectively. The humidity varies from 98% during monsoon to 45% during winter.

2.4 Treatment details

Jam was prepared by addition of the following medicinal products, aromatic herbs and spice. The treatment details were: T₁-Wood

apple pulp + ashwagandha @ 2%; T₂-Wood apple pulp + tulsi extract @ 2%; T₃-Wood apple pulp + mint extract @ 2%; T₄-Wood apple pulp + lemon grass @ 2%; T₅-Wood apple pulp + mango ginger @ 2% and T₆- Control (no addition).

2.5 Observations recorded

TSS of the prepared jam was determined using a digital refractometer. Total sugar, reducing sugar, titratable acidity and ascorbic acid content of the prepared jam was determined according to the standard procedures (AOAC, 2012). pH value of the prepared jam was determined using a standard pH meter. Microbiological analysis for the pickle was carried out by the method of Ranganna (2010). All the enumerations of Bacteria and Lactobacillus were carried out following serial dilution technique using specific media. Plates were incubated at 34 ± 1°C for 48 h and colony forming units (CFU/g) were recorded. Observations for microbial count were made at prescribed intervals. The principle behind this is that the population of total bacterial population tends to decline with the decimal reduction in the concentration of the sample analysed. Usually in a culture, the microbial population was expected to be higher in 10⁻¹ which tends to decline with 10⁻², 10⁻³, 10⁻⁴, 10⁻⁵ and 10⁻⁶ sample concentration. Higher the sample concentration, higher would be the expected microbial concentration. As the colonies tends to coalesce or merge at higher concentration, hence the readings for Total Plate Count and Total Bacterial Population Count have been studied at 10⁻⁵ concentration. 9-point hedonic scale was used for the purpose of sensory evaluation of the prepared wood apple jam. Twenty judges of diverse age groups were asked to rate from 1 to 9 based on different columns like colour, texture, flavour, taste and overall organoleptic score (Peryam *et al.*, 1957).

3. Results

3.1 Physicochemical properties of wood apple used for jam preparation

Table 1 shows the physicochemical property of wood apple used for jam preparation. It was observed that the fruits used for jam preparation have a TSS of 16.33°B, titratable acidity of 5.48%. Total sugar and reducing sugar content were 14.20% and 5.12%, respectively. The ascorbic acid content was 11.97 mg/100 g.

Table 1: Physicochemical properties of wood apple pulp used for jam preparation

Attributes	Value per 100 g
TSS (°B)	16.33
Titratable acidity (%)	5.48
Total sugar (%)	14.20
Reducing sugar (%)	5.12
Ascorbic acid (mg/100 g)	11.97

3.2 Change in total soluble solid (TSS) of jam during ambient storage

Table 2 highlights the effect of natural herbs on TSS (°B) of wood apple jam during 12 months of ambient storage. During the storage period of 12 months, the total soluble solids (°B) is steadily increasing. In all the treatments, TSS was 68.43°B which gradually

increases with storage. At the 2nd month of storage, TSS shows a slight increase up to 68.45°B in T₁, T₂, T₃, T₄ and T₅. In T₆, the increase in TSS was slightly more which was 68.53 °B. At 4th month of storage, highest TSS was observed in T₆ (Control) followed by T₂, T₅, T₃, T₁ and T₄ which was 68.73°B, 68.73°B, 68.68°B, 68.63°B and 68.63°B, respectively. At 6th month of storage, highest TSS was observed in T₆ followed by T₄, T₃, T₁, T₅ and T₂ which was 70.03°B, 69.15°B, 69.05°B, 69.00°B, 68.88°B and 68.83°B, respectively. At 8th month of storage, highest TSS was observed in T₆ followed by T₄, T₃, T₁, T₅ and T₂ which was 70.18°B, 69.33°B, 69.00°B, 68.98°B, 68.98°B and 68.90°B, respectively. At 10th month of storage, highest TSS was observed in T₆ followed by T₄, T₃, T₂, T₁ and T₅ which was 72.50°B, 70.43°B, 70.33°B, 70.25°B, 69.98°B and 69.68°B, respectively. At 12th month of storage, highest TSS was observed in T₆ followed by T₄, T₂, T₃, T₁ and T₅ which was 74.18°B, 71.68°B, 71.08°B, 71.08°B, 70.98°B and 70.18°B, respectively.

3.3 Change in titratable acidity of jam during ambient storage

Table 3 depicts the effect of natural herbs on titratable acidity (%) of wood apple jam during 12 months of ambient storage. Throughout the storage period, there is a constant decrease in the titratable

acidity. A drastic change in titratable acidity is not evident in this case. Treatments do not have significant effect on titratable acidity of wood apple jam throughout the storage period. At 0 months of storage, highest titratable acidity (%) was observed in T₄ and T₅ which was 0.95% and 0.95%. T₂, T₃, T₆ and T₁ also shows a titratable acidity of 0.93%, 0.93%, 0.93% and 0.92%, respectively. At 2nd month of storage, highest titratable acidity was observed in T₄, T₅, T₃, T₆, T₁ and T₂ which was 0.94%, 0.94%, 0.93%, 0.92%, 0.91% and 0.91%, respectively. At 4th month of storage, highest titratable acidity was observed in T₄ and T₅ followed by T₃, T₁, T₂ and T₆ which was 0.94%, 0.94%, 0.92%, 0.9%, 0.9% and 0.9%, respectively. At 6th month of storage, highest titratable acidity was observed in T₄ and T₅ followed by T₃, T₆, T₁ and T₂ which was 0.93%, 0.93%, 0.91%, 0.89%, 0.88% and 0.88%, respectively. At 8th month of storage, highest titratable acidity was observed in T₄ followed by T₃, T₅, T₁, T₂ and T₆ which was 0.93%, 0.91%, 0.91%, 0.88%, 0.87% and 0.87%, respectively. At 10th month of storage, highest titratable acidity was observed in T₃ followed by T₅, T₁, T₂, T₄ and T₆ which was 0.9%, 0.9%, 0.89%, 0.89%, 0.88% and 0.85%, respectively. At 12th month of storage, highest titratable acidity was observed in T₁ and T₃ followed by T₂, T₅, T₄ and T₆ which was 0.90 %, 0.90 %, 0.89%, 0.89%, 0.88% and 0.84%, respectively.

Table 2: Effect of natural herbs on TSS (°B) of wood apple jam

Treatment details	Months of storage						
	0	2	4	6	8	10	12
T ₁ (Wood apple pulp + ashwagandha powder @2%)	68.43	68.45	68.63	69.00	68.98	69.98	70.98
T ₂ (Wood apple pulp + tulsi extract @2%)	68.43	68.45	68.73	68.83	68.90	70.25	71.08
T ₃ (Wood apple pulp + mint extract @2%)	68.43	68.45	68.68	69.05	69.00	70.33	71.08
T ₄ (Wood apple pulp + lemon grass @2%)	68.43	68.45	68.63	69.15	69.33	70.43	71.68
T ₅ (Wood apple pulp + mango ginger @2%)	68.43	68.45	68.73	68.88	68.98	69.68	70.18
T ₆ (Control)	68.43	68.53	69.00	70.03	70.18	72.50	74.18
S.E. (±)	0.22	0.22	0.03	0.03	0.05	0.03	0.14
C.D. at 5%	NA	NA	0.09	0.09	0.14	0.10	0.43

Table 3: Effect of natural herbs on titratable acidity (%) of wood apple jam

Treatment details	Months of storage						
	0	2	4	6	8	10	12
T ₁ (Wood apple pulp + ashwagandha powder @2%)	0.92	0.91	0.90	0.88	0.88	0.89	0.90
T ₂ (Wood apple pulp + tulsi extract @2%)	0.93	0.91	0.90	0.88	0.87	0.89	0.89
T ₃ (Wood apple pulp + mint extract @2%)	0.93	0.93	0.92	0.91	0.91	0.90	0.90
T ₄ (Wood apple pulp + lemon grass @2%)	0.95	0.94	0.94	0.93	0.93	0.88	0.88
T ₅ (Wood apple pulp + mango ginger @2%)	0.95	0.94	0.94	0.93	0.91	0.90	0.89
T ₆ (Control)	0.93	0.92	0.9	0.89	0.87	0.85	0.84
S.E. (±)	0.02	0.01	0.02	0.03	0.03	0.02	0.02
C.D. at 5%	N/A	N/A	N/A	N/A	N/A	N/A	N/A

3.4 Change in pH of jam during ambient storage

Table 4 highlights the effect of natural herbs on pH of wood apple jam during 12 months of ambient storage. Throughout the storage period, there is a constant increase in the pH of prepared jam. At 0 days of storage, pH reading was highest in T₃ followed by T₁, T₂, T₆, T₄ and T₅ which was 3.15, 3.14, 3.14, 3.14, 3.13 and 3.13, respectively. At 2nd month of storage highest pH was observed in T₃ followed by T₄, T₁, T₂, T₆ and T₅ which was 3.17, 3.16, 3.15,

3.15, 3.15 and 3.13, respectively. At 4th month of storage, highest pH was observed in T₃, T₂, T₄, T₁, T₆ and T₅ which was 3.18, 3.17, 3.17, 3.16, 3.15 and 3.13, respectively. At 6th month of storage, highest pH was observed in T₃ and T₄ followed by T₁, T₂, T₆ and T₅ which was 3.19, 3.19, 3.18, 3.18, 3.17 and 3.14, respectively. At 8th month of treatment highest pH value was observed in T₃, T₄ and T₆ followed by T₁, T₂ and T₅ which was 3.2, 3.2, 3.2, 3.19, 3.19 and 3.15, respectively. At 10th month of storage, highest pH reading

was observed in T₆ followed by T₄, T₂, T₃, T₁ and T₅ which was 3.24, 3.23, 3.21, 3.21, 3.2 and 3.17, respectively. At 12th month of storage, highest pH value was observed in T₆ (Control), T₄, T₂, T₁, T₃ and T₅ which was 3.29, 3.25, 3.23, 3.22, 3.22 and 3.18, respectively.

3.5 Change in total sugar content of jam during ambient storage

Table 5 depicts the effect of different medicinal herbs on total sugar content of wood apple jam under 12 months of ambient storage. A clear increase in total sugar content of the jam was observed during the storage in all the treatments. At 0 days of storage, highest total sugar content was observed in T₆ (Control) followed by T₅, T₁, T₄, T₂ and T₃ which is 56.24%, 56.23%, 56.2%, 56.18%, 56.17% and 56.13%, respectively. No significant difference among treatment was observed. At 2nd month of storage, highest total sugar content was observed in T₆ followed by T₃, T₄, T₁, T₅ and T₂ which was 57.24%, 57.19%, 57.19%, 57.10%, 57.10% and 57.04%,

respectively. No significant difference among treatment was observed. At 4th month of storage, highest total sugar content was observed in T₆ (Control) followed by T₃, T₁, T₄, T₂ and T₅ which was 58.48%, 58.30%, 58.29%, 58.24%, 58.07% and 58.04%, respectively. No significant difference among treatment was observed even at 4th month of storage. At 6th month of storage, highest total sugar content was observed in T₆ (Control) followed by T₅, T₄, T₃, T₂ and T₁ which was 61.00%, 58.60%, 59.55%, 59.45%, 59.24% and 59.14%, respectively. At 8th month of storage, highest total sugar content was observed in T₆ (Control) followed by T₄, T₁, T₃, T₂ and T₅ which was 63.89%, 60.82%, 60.45%, 60.39%, 60.31% and 59.2%, respectively. At 10th month of storage, highest total sugar content was observed in T₆ (Control) followed by T₄, T₃, T₂, T₁ and T₅ which was 65.22%, 62.35%, 61.48%, 61.26%, 61.14% and 60.51%, respectively. At 12th month of storage, highest total sugar content was observed in T₆ followed by T₂, T₁, T₄, T₃ and T₅ which was 67.45%, 63.27%, 63.20%, 63.17%, 63.03% and 62.59%, respectively.

Table 4: Effect of natural herbs on pH of wood apple jam

Treatment details	Months of storage						
	0	2	4	6	8	10	12
T ₁ (Wood apple pulp + ashwagandha powder @2%)	3.14	3.15	3.16	3.18	3.19	3.2	3.22
T ₂ (Wood apple pulp + tulsi extract @2%)	3.14	3.15	3.17	3.18	3.19	3.21	3.23
T ₃ (Wood apple pulp + mint extract @2%)	3.15	3.17	3.18	3.19	3.20	3.21	3.22
T ₄ (Wood apple pulp + lemon grass @2%)	3.13	3.16	3.17	3.19	3.20	3.23	3.25
T ₅ (Wood apple pulp + mango ginger @2%)	3.13	3.13	3.13	3.14	3.15	3.17	3.18
T ₆ (Control)	3.14	3.15	3.15	3.17	3.20	3.24	3.29
S.E. (±)	0.02	0.02	0.02	0.03	0.01	0.02	0.02
C.D. at 5%	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 5: Effect of natural herbs on total sugar (%) of wood apple jam

Treatment details	Months of storage						
	0	2	4	6	8	10	12
T ₁ (Wood apple pulp + ashwagandha powder @2%)	56.20	57.10	58.29	59.14	60.45	61.14	63.20
T ₂ (Wood apple pulp + tulsi extract @2%)	56.17	57.04	58.07	59.24	60.31	61.26	63.27
T ₃ (Wood apple pulp + mint extract @2%)	56.13	57.19	58.30	59.45	60.39	61.48	63.03
T ₄ (Wood apple pulp + lemon grass @2%)	56.18	57.19	58.24	59.55	60.82	62.35	63.17
T ₅ (Wood apple pulp + mango ginger @2%)	56.23	57.10	58.04	58.60	59.20	60.51	62.59
T ₆ (Control)	56.24	57.24	58.48	61.00	63.89	65.22	67.45
S.E. (±)	0.13	0.05	0.10	0.14	0.10	0.11	0.18
C.D. at 5%	N/A	N/A	N/A	0.42	0.31	0.34	0.53

3.6 Change in reducing sugar content of jam during ambient storage

Table 6 depicts the effect of different medicinal herbs on reducing sugar (%) of wood apple jam during 12 months of ambient storage. Just like the total sugar content, this parameter also showed an increase in value during period of ambient storage. An increasing trend was observed in reducing sugar content throughout the storage months. At 0 month of storage, no significant difference in reducing sugar was observed among the treatments. Highest reducing sugar content was observed in T₆ followed by T₄, T₂, T₃, T₁ and T₅ which

was 26.20%, 26.16%, 26.12%, 26.11%, 26.10% and 26.10%, respectively. No significant difference among treatment was observed. At 2nd month of storage, highest reducing sugar content was observed in T₆ (Control) followed by T₄, T₂, T₁, T₃, T₅ which was 26.98%, 26.93%, 26.91%, 26.90%, 26.89% and 26.74%, respectively. No significant difference among treatment was observed even at 2nd month. At 4th month of storage, highest reducing sugar content was observed in T₆ (Control) followed by T₃, T₄, T₅, T₁ and T₂ which was 28.94%, 27.80%, 27.80%, 28.12%, 27.12%, and 27.26%, respectively. At 6th month of storage, highest reducing sugar content was observed in T₆ followed by T₄, T₂, T₁, T₃ and T₅

which was 30.90%, 28.30%, 28.25%, 29.23%, 28.23% and 28.04%, respectively. At 8th month of storage, highest reducing sugar content was observed in T₆ followed by T₁, T₃, T₄, T₂ and T₅ which was 31.60%, 30.89%, 30.47%, 29.80%, 29.16% and 28.97%, respectively. At 10th month of storage, highest reducing sugar content was observed in T₆ followed by T₁, T₃, T₂, T₄ and T₅ which was 32.10%, 31.40%, 30.97%, 30.90%, 30.90% and 29.12%, respectively. At 12th month of storage, highest reducing sugar content was observed in T₆ followed by T₁, T₂, T₃, T₄ and T₅ which was 33.90%, 32.10%, 31.15%, 31.12%, 31.10% and 30.89% respectively.

3.7 Change in ascorbic acid content of jam during ambient storage

Table 7 highlight the effect of natural herbs on ascorbic acid (mg/100 g) content of wood apple jam during 12 months of ambient storage. A clear decline was observed in ascorbic acid content throughout the storage period. The treatments have a significant effect on the ascorbic acid content of wood apple jam in the 2nd month, 4th month, 6th month, 8th month, 10th month and 12th month of storage period. At 0 days of storage, the treatment exhibits no significant difference. At 0 days of storage, highest amount of ascorbic acid was observed in T₆ (Control) followed by T₁, T₃, T₄,

T₅ and T₂ which was 1.77 mg/100 g, 1.76 mg/100 g, 1.76 mg/100 g, 1.75 mg/100 g, 1.75 mg/100 g and 1.74 mg/100 g, respectively. At 2nd day of storage, highest ascorbic acid content was observed in T₅, T₁, T₂, T₄, T₆ and T₃ which was 1.64 mg/100 g, 1.61 mg/100 g, 1.59 mg/100 g, 1.56 mg/100 g, 1.51 mg/100 g and 1.49 mg/100 g, respectively. At 4th month of storage, highest amount of ascorbic acid was observed in T₅ followed by T₁, T₂, T₆, T₄ and T₃ which was 1.53 mg/100 g, 1.49 mg/100 g, 1.48 mg/100 g, 1.4 mg/100 g, 1.36 mg/100 g and 1.34 mg/100 g, respectively. At 6th month of storage, highest ascorbic acid was observed in T₅ followed by T₁, T₄, T₂, T₃ and T₆ which was 1.43 mg/100 g, 1.39 mg/100 g, 1.35 mg/100 g, 1.34 mg/100 g, 1.32 mg/100 g, 1.24 mg/100 g, respectively. At 8th month of storage, highest ascorbic acid content was observed in T₅ followed by T₁, T₄, T₂, T₃ and T₆ which was 1.34 mg/100 g, 1.26 mg/100 g, 1.21 mg/100 g, 1.19 mg/100 g, 1.16 mg/100 g and 1.03 mg/100 g, respectively. At 10th month of storage, highest ascorbic acid content was observed in T₅ followed by T₁, T₄, T₂, T₃ and T₆ which was 1.28 mg/100 g, 1.20 mg/100 g, 1.16 mg/100 g, 1.11 mg/100 g, 1.08 mg/100 g and 0.83 mg/100 g, respectively. At 12th month of storage, highest ascorbic acid content was observed in T₅ followed by T₄, T₁, T₂, T₃ and T₆ which was 1.17 mg/100 g, 1.11 mg/100 g, 1.08 mg/100 g, 1.03 mg/100 g, 0.96 mg/100 g and 0.51 mg/100 g, respectively.

Table 6: Effect of natural herbs on reducing sugar (%) of wood apple jam

Treatment details	Months of storage						
	0	2	4	6	8	10	12
T ₁ (Wood apple pulp + ashwagandha powder @2%)	26.10	26.90	28.12	29.23	30.89	31.40	32.10
T ₂ (Wood apple pulp + tulsi extract @2%)	26.12	26.91	27.12	28.25	29.16	30.90	31.15
T ₃ (Wood apple pulp + mint extract @2%)	26.11	26.89	27.80	28.23	30.47	30.97	31.12
T ₄ (Wood apple pulp + lemon grass @2%)	26.16	26.93	27.80	28.30	29.80	30.90	31.10
T ₅ (Wood apple pulp + mango ginger @2%)	26.10	26.74	27.26	28.04	28.97	29.12	30.89
T ₆ (Control)	26.20	26.98	28.94	30.90	31.60	32.10	33.90
S.E. (±)	0.17	0.18	0.09	0.13	0.05	0.16	0.10
C.D. at 5%	N/A	N/A	0.26	0.40	0.16	0.49	0.31

Table 7: Effect of natural herbs on ascorbic acid (mg/100 g) of wood apple jam

Treatment details	Months of storage						
	0	2	4	6	8	10	12
T ₁ (Wood apple pulp + ashwagandha powder @2%)	1.76	1.61	1.49	1.39	1.26	1.20	1.08
T ₂ (Wood apple pulp + tulsi extract @2%)	1.74	1.59	1.48	1.34	1.19	1.11	1.03
T ₃ (Wood apple pulp + mint extract @2%)	1.76	1.49	1.34	1.32	1.16	1.08	0.96
T ₄ (Wood apple pulp + lemon grass @2%)	1.75	1.56	1.36	1.35	1.21	1.16	1.11
T ₅ (Wood apple pulp + mango ginger @2%)	1.75	1.64	1.53	1.43	1.34	1.28	1.17
T ₆ (Control)	1.77	1.51	1.4	1.24	1.03	0.83	0.51
S.E. (±)	0.01	0.02	0.02	0.01	0.02	0.02	0.02
C.D. at 5%	N/A	0.05	0.07	0.04	0.06	0.05	0.07

3.8 Change in total plate count (10⁵ log CFU) of jam during ambient storage (1 to 9 hedonic scale)

Table 8 highlights the effect of natural herbs on total plate count (10⁵ log CFU) of wood apple jam during 12 months of ambient storage. However, wood apple itself is an acidic product with a low pH till then the bacterial population was found significantly growing

in the control. At 0 days of storage, no significant differences among the treatments were observed. At 0 days of storage, the total plate count (10⁵ log CFU) of wood apple jam was 1.25, 1.00, 0.75, 1.00, 1.00 and 1.00 in T₁, T₂, T₃, T₄, T₅ and T₆, respectively. At 2nd month of storage, no significant differences among the treatments were observed. Total colony count in T₁, T₂, T₃, T₄, T₅ and T₆ was

3.25, 3.00, 4.00, 3.00, 3.00 and 3.75, respectively. At 4th month of storage, highest total bacteria colony count was observed in T₆ followed by T₃, T₄, T₂, T₁ and T₅ which was 27.75, 12.5, 12.5, 11.75, 10.5 and 7.5, respectively. At 6th month of storage, highest total bacteria colony count was observed in T₆ followed by T₂, T₄, T₁, T₃ and T₅ which was 51.25, 24.25, 23, 21.75, 21 and 12.75, respectively. At 8th month of storage, highest total bacterial colony count was observed in T₆ followed by T₄, T₃, T₁, T₂ and T₅ which was 65.50, 36.75, 33.25, 31.00, 30.00 and 26.50, respectively. At 10th month of storage, highest total bacterial colony count was observed in T₆ followed by T₃, T₄, T₁, T₂ and T₅ which was 96.75, 53.50, 53.50, 52.00, 47.50 and 42.25, respectively. At 12th month of storage, highest total bacterial colony count was observed in T₆ followed by T₃, T₄, T₂, T₁ and T₅ which was 123.00, 67.75, 60.25, 59.50, 58.75 and 49.00, respectively.

3.9 Change in overall acceptability of jam during ambient storage

Overall response of any consumer towards its acceptability is most important factor towards determining success of any processed

product. Table 9 highlights the effect of different natural herbs on overall acceptability of wood apple jam based on 9-point hedonic scale. At 0 days of storage, overall acceptability was highest in T₅ followed by T₆, T₃, T₄, T₁ and T₂ which was 9.00, 8.50, 7.75, 7.75, 7.25 and 7.00, respectively. At 2nd month of storage, overall acceptability was highest in T₅ followed by T₆, T₃, T₄, T₁ and T₂ which was 9.00, 8.75, 8.00, 8.00, 7.50 and 7.25, respectively. At 4th month of storage, overall acceptability was highest in T₅ followed by T₆, T₃, T₄, T₁ and T₂ which was 9.00, 8.75, 8.00, 8.00, 7.50 and 7.25, respectively. At 6th month of storage, overall acceptability was highest in T₅ followed by T₆, T₃, T₄, T₁ and T₂ which was 9.00, 8.75, 7.75, 7.50, 7.25 and 7.00, respectively. At 8th month of storage, overall acceptability was highest in T₅ followed by T₆, T₄, T₃, T₁ and T₂ which was 9.00, 8.50, 8.25, 7.75, 7.25 and 7.00, respectively. At 10th month of storage, overall acceptability was highest in T₅ followed by T₆, T₄, T₃, T₁ and T₂ which was 9.00, 8.50, 8.25, 8.00, 7.25 and 7.00, respectively. At 12th month of storage, overall acceptability was highest in T₅ followed by T₄, T₆, T₃, T₁ and T₂ which was 8.75, 8.25, 8.25, 7.75, 7.25 and 7.00, respectively.

Table 8: Effect of natural herbs on total plate count of wood apple jam (10⁻⁵ log CFU)

Treatment details	Months of storage						
	0	2	4	6	8	10	12
T ₁ (Wood apple pulp + ashwagandha powder @2%)	1.25	3.25	10.50	21.75	31.00	52.00	58.75
T ₂ (Wood apple pulp + tulsi extract @2%)	1.00	3.00	11.75	24.25	30.00	47.50	59.50
T ₃ (Wood apple pulp + mint extract @2%)	0.75	4.00	12.50	21	33.25	53.50	67.75
T ₄ (Wood apple pulp + lemon grass @2%)	1.00	3.00	12.50	23	36.75	53.50	60.25
T ₅ (Wood apple pulp + mango ginger @2%)	1.00	3.00	7.50	12.75	26.50	42.25	49.00
T ₆ (Control)	1.00	3.75	27.75	51.25	65.50	96.75	123.00
S.E. (±)	0.28	0.40	0.76	1.03	1.42	2.14	2.49
C.D. at 5%	N/A	N/A	2.273	3.09	4.26	6.39	7.46

Table 9: Effect of natural herbs on overall acceptability of wood apple jam (1 to 9 hedonic scale)

Treatment details	Months of storage						
	0	2	4	6	8	10	12
T ₁ (Wood apple pulp + ashwagandha powder @2%)	7.25	7.50	7.50	7.25	7.25	7.25	7.25
T ₂ (Wood apple pulp + tulsi extract @2%)	7.00	7.25	7.00	7.00	7.00	7.00	7.00
T ₃ (Wood apple pulp + mint extract @2%)	7.75	8.00	8.00	7.75	7.75	8.00	7.75
T ₄ (Wood apple pulp + lemon grass @2%)	7.75	8.00	8.00	7.50	8.25	8.25	8.25
T ₅ (Wood apple pulp + mango ginger @2%)	9.00	9.00	9.00	9.00	9.00	9.00	8.75
T ₆ (Control)	8.50	8.75	8.50	8.75	8.50	8.50	8.25
S.Em. (±)	0.21	0.25	0.28	0.26	0.21	0.19	0.23
C.D. at 5%	0.62	0.76	0.84	0.78	0.64	0.56	0.68

4. Discussion

It is clearly visible that the wood apple jam which was subjected to ashwagandha, tulsi, mint, lemon, mango ginger exhibited a lower increase in TSS (°B), total sugar (mg/100 g) and reducing sugar (mg/100 g). The higher increase of TSS value in case of control, indicates a higher rate of conversion of starch and other carbohydrate to simple sugar. In control clearly the increase in TSS is more. Significantly high total sugar content in T₆ is due to the fact that rate of degradation of complex carbohydrate was more as compared to other treatment. Higher total sugar content in T₆ is evident of the

fact that the other treatments were able to somewhat retard the degradation process of the carbohydrate. The breakdown of more carbohydrate led to accumulation of more total sugar in wood apple jam prepared with no additives (T₆). This is because of the fact that in control treatment rate of degradation of complex carbohydrate to simple sugar was higher. The minimum rate of decline was observed in case of jam incorporated with mango ginger.

A higher decline in titratable acidity implies a higher rate of degradation of organic acid. Clearly, T₆ with no herbal additives showed an enhanced rate of fall in titratable acidity. A faster increase

in pH can be due to the reduction in titratable acidity of the jam. Vitamin C is important component of wood apple pulp. Retention of Vitamin C throughout the storage period is of utmost importance. Throughout the storage period, maximum loss in ascorbic acid was observed in jam prepared with no additives. Herbal additives ensured reduced loss of ascorbic acid in jam. Hence, the treatments with herbal additives exhibited minimum loss in ascorbic acid content as compared to that of the control where no additives were added (T_6). Shelf-life enhancement was possible only through addition of natural herbs. It was also evident that addition of ashwagandha, tulsi extract, mint extract, lemon grass and mango ginger resulted in lesser bacterial colony formation throughout the storage. Clearly effects of additives were very much prominent in reducing the total bacterial colony in jam. The jam with no additives (T_6) has significantly higher bacterial colony count at 10^{-5} log CFU. The antibacterial property of the additives used can be a vital reason why the TPC was low in T_1 , T_2 , T_3 , T_4 and T_5 . Antibacterial property of ashwagandha was observed by Meher *et al.* (2016) and Mirjalili *et al.* (2009). Antibacterial property of tulsi extract was observed by Mishra and Mishra, (2011) and Singh *et al.* (2007). Antibacterial property of mint extract was also reported by Mickiene *et al.* (2011) and Biswas *et al.* (2014). Antibacterial property of lemon grass was reported by Naik *et al.* (2010). The main reason for poor acceptability of jam prepared with tulsi extract (T_2) is its poor texture and off flavour. Ashwagandha powder mixed jam (T_1) also renders the jam a slight bitter after taste and unpleasant aroma. Overall acceptability of T_5 , T_6 and T_4 is consistently higher throughout the storage period. Throughout the storage period, the jam which was subjected to mango ginger treatment 2%, exhibited a high acceptability in terms of hedonic score throughout the storage period. The mango ginger flavour along with the sour-sweet blend of the wood apple pulp was probably liked by the judges.

5. Conclusion

From the above study, it can be concluded that all the natural herbs have some desirable effect on improving the overall quality of wood apple jam. mango ginger can effectively be substituted in wood apple jam to ensure its consumable quality up to 12th month of storage. It can be concluded that T_5 (WAP + Mango ginger @ 2%) could be an ideal treatment to ensure quality wood apple jam which can not only enhance the product quality but also retain the quality up to 12th month of ambient storage. The jam prepared with wood apple blended with mango ginger 2% (*Curcuma amada*) can be commercially utilized.

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Conflict of interest

The authors declare that there are no conflicts of interest relevant to this article.

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