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High-pressure processing for the production of vegetable baby puree with enhanced nutritional, microbial, and sensory qualities

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Abstract: High-pressure processing (HPP) was used as a post-processing treatment for vegetable puree. Microbiological, physicochemical, nutritional, and sensory analyses of puree were investigated at room temperature. HPP (600 MPa, 5 min) was compared with thermal treatment (117 °C, 30 min) and fresh samples. Treatments did not change pH or total soluble solids. For both methods treated samples exhibited a lower microbial count (< 1.0 log CFU·g^{-1}) over storage, compared with fresh puree. During storage, other parameters, including total phenolic contents and antioxidants also demonstrated similar or better performance than controls (P < 0.05). Overall, HPP-treated puree received a higher sensory evaluation score. Thus, HPP can be used as an alternative processing technology to improve nutritional quality and microbial safety.

Keywords: non-thermal processing; storage; shelf life; nutritional quality

There has been a rapid increase in demand for baby food throughout the world (Featherstone 2016). In recent years, baby food producers have emphasised organic, healthy, nutritional, and sustainable foods and fortified these foods with functional ingredients to enhance immunity and reduce allergies (Sevenich et al. 2014). National and international laws and regulations govern baby food production and food safety concerns (Featherstone 2016). Also, baby food producers must be careful about the quality of raw materials and processing since babies are more likely to acquire illnesses and toxins from food (Featherstone 2016).

Fruit and vegetables are typically used in baby food products and are an excellent source of heat-sensitive micronutrients and functional components (Houška and Da Silva 2017). In addition, non-traditional and underutilised vegetables, including beet leaves and stems that are high in nutrition, can be converted into valuable products by blending them into purees (Fernandez et al. 2018). Sensory characteristics of purees, particularly their appearance, flavour, and readiness for consumption, play key roles in product acceptance (Andrés et al. 2016b).

Most baby food products are thermally sterilised to ensure shelf stability and safety under ambient conditions (Gratz et al. 2021). However, food quality is compromised with optimum thermal sterilisation because intensive heat treatment destroys vital nutri-

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ents in food. Heat-sensitive vitamins are also degraded by thermal sterilisation and foods also suffer reductions in organoleptic qualities (Gratz et al. 2021). Total amino acid contents are also reduced after retort sterilisation of vegetable baby foods (Mesías et al. 2016).

Alternative processing methods have been used in place of conventional thermal treatments. high-pressure processing (HPP) is a non-thermal preservation technology that can be used as an in-package processing treatment in place of conventional thermal sterilisation to process baby foods because it has less effect on nutrient content and bioactive compounds. HPP uses high hydrostatic pressure at room temperature to inactivate microbes to increase the safety and shelf-life of products. It produces minimally processed baby food with a long shelf-life, without chemical preservatives, resulting in products that are tasty, healthy, and nutritious. Packaged products can be processed with HPP (in-pack), avoiding cross-contamination, and bulk liquids can be processed directly with HPP (in-bulk), for greater productivity and flexibility in packaging. HPP is primarily an in-package food processing technology in which foods in final form and packaging are processed together and the food content remains protected until the product is opened by the customer (Denoya et al. 2020). HPP has applications in the preparation of vegetable and fruit-based food purees (Kultur et al. 2017; Fernandez et al. 2019). Several studies have demonstrated the ability of HPP to inactivate spoilage and pathogenic microorganisms in raw fruit and vegetable products (Houška and Da Silva 2017). Therefore, the present study aimed to evaluate the efficacy of HPP as a non-thermal treatment for the development of nutritious, healthy, and safe vegetable-based baby puree.

MATERIAL AND METHODS

Raw material. Raw materials, including carrot, beetroot, pumpkin, potato, peas, rice flour, sugar, tomato, salt, sweet corn, corn starch, and coconut oil were selected on the basis of a previous study (Denoya et al. 2016). All ingredients were purchased from the local market in Lahore.

Preparation of vegetable puree. A published puree formulation and procedures (Kultur et al. 2017) were followed with modification using water 21%, potato 20%, peas 15%, pumpkin 12%, carrot 10%, tomato 6%, rice flour 5%, sweet corn 5%, corn starch 2%, coconut oil 4%, and salt 0.2%. After washing under tap water for five min, all vegetables were air dried. Vegetables were sliced into small sizes and then mixed with water and other ingredients, including rice flour, salt, sugar, and sweet corn. All ingredients were then blended for 60 s in a homogeniser (AG-6032; Anex, China). In order to apply the HPP treatment, 100 g of puree was packed into a ready-to-eat flexible pouch and stored at 4 °C until further analysis. For thermal treatment, samples were put in glass bottles and stored at 4 °C prior to further analysis. The samples without any treatment and packed in glass bottles were considered fresh samples.

High-pressure processing (HPP) treatment. Puree samples were subjected to HPP treatment in the pressure vessel of a laboratory-scale HPP unit (HPP TL2-600-2, Telide Shenzhen High Pressure Fluid Systems Co., Ltd., China) with a 2.0 L capacity at 600 MPa for 5 min. Water was used as a pressure transmission fluid. The rate of pressure increase was 2 $MPa \cdot s^{-1}$ and the decompression time was 3 to 4 $MPa \cdot s^{-1}$ (Shahbaz et al. 2018). Pressure increase and release times were not included in the pressurisation time reported in this study. Treated samples were transferred to glass bottles and then stored at 4 °C until analysis.

Thermal treatment. Glass bottles were loaded into a retort for treatment at 117 °C. The holding time was 30 min. The temperature profile in the retort was measured using type T thermocouples (PT100; Wenzhou Longwan Wanyuan Food Machinery Factory, China) (Sevenich et al. 2014). After sterilisation, glass bottles were immediately placed in ice to halt further chemical reactions. Treated samples were kept at 4 °C prior to analysis.

Storage. Treated samples were stored at room temperature for 90 days. Samples for analysis (fresh, thermal, and HPP-treated) were taken on days 0, 14, 28, 60, and 90. All three sample types were analysed for each sampling day. All samples were stored in sterilised glass bottles.

Microbial analysis. For total mesophilic aerobic (TMA) bacteria, a 1.0 g puree sample was suspended in peptone water (0.1%) for serial dilution (1 : 10). Three different plates were surface plated with the suspension (1 mL). The plates were incubated at 37 °C for 48 h after which colonies were counted (Kultur et al. 2017). Total yeasts and moulds (TYM) values were enumerated using the same procedure as for TMA, excluding medium and incubation times. A 1.0 g puree sample was suspended in peptone water (0.1%) for serial dilution (1 : 10). A suspension (1 mL) of the developed product was surface plated on potato dextrose agar on three different plates. Then 10% tartaric acid (14 mL) was

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added to a 1 L medium to prevent bacterial growth. Incubation followed at 25 °C for 3–5 days after which colonies were counted (Kultur et al. 2017).

pH and total soluble solids (TSS). Puree pH at room temperature was measured using a digital pH meter (HI8424, Hanna, UK) equipped with a pH electrode. a digital refractometer (Rhb0-80, Sinotech; DR 101-60, Kruss, Germany) was used to measure the TSS values of puree at room temperature. Three measurements were performed for each sample and average results were reported.

Total phenolic content (TPC). A 5.0 g sample of puree was placed in a 150 mL Erlenmeyer flask with ethanol (20 mL acidified with 2% citric acid) and an extracting solvent. Extraction was carried out at 28 °C for 1 h, followed by centrifugation at 11 000 rpm for 15 min at 4 °C. The supernatant was collected in a separate Eppendorf tube (Fernandez et al. 2019). TPC was analysed following the Folin-Ciocalteau methodology in which Folin-Ciocalteau reagent (0.12 mL) was added to the product (4 mL) after which a sodium carbonate solution (4 mL, 70 g·L^{-1}) was used for dilution with distilled water for a final volume of 10 mL after 6 min. A spectrophotometer was used to measure the absorbance at 730 nm compared with gallic acid (ranging from 72 to 200 mg·L^{-1}). Samples were analysed and results were reported as mg of gallic acid equivalent/100 g of the developed product.

Antioxidant activity. Sample preparation for antioxidant activity analysis was done using the method of Fernandez et al. (2019). An extract (50 µL) was added to 1 mL of a 2,2-diphenyl-1-picryl-hydrazyl (DPPH) methanolic solution, followed by 30 min incubation at room temperature. An absorbance measurement was performed using a spectrophotometer at 517 nm. A blank sample was run along with the experimental sample. A 100 g sample was evaluated for antioxidant activity as mol of Trolox equivalent oxidant capacity.

Sensory evaluation. Organoleptic evaluation of puree was carried out by selecting 15 mothers having a baby of age between 6 and 12 months as judges of babies who are regular users of these baby foods. For this, each judge signed a consent form. The panellists were asked to score the samples based on their preference for flavour, colour, mouth feel, appearance, and overall acceptability according to a 5-point scale (Zeb et al. 2017).

Statistical analysis. Experiments were conducted in triplicate (n = 3) for each puree sample. Collected data were analysed using the Statistical Package for Social Sciences (SPSS) and expressed as a mean ± SD. The combination effect of treatments and different time intervals was assessed using a two-way analysis of variance (ANOVA). The individual effects of treatments and different time intervals of the trial were analysed using a one-way ANOVA. Significant differences concerning individual treatments and time intervals were assessed using the Duncan Multiple Range Test (DMRT). The level of significance was 5% (P < 0.05).

RESULTS AND DISCUSSION

Effect of processing treatments on microbial inactivation. Microbial counts were examined in fresh, HPP-treated, and thermally treated purees. Effects of storage (room temperature) on microbial counts were also determined. Microbiological counts in purees were significantly reduced by HPP and thermal treatments. Counts of TMA bacteria at 600 MPa were below the detection limit (Table 1). The mean value of aerobic mesophilic bacteria observed in fresh puree was 6.34 log CFU·g^{-1} (Table 1). The mean value of aerobic mesophilic bacteria observed in the fresh puree was

Table 1. Counts of total mesophilic aerobic (TMA) bacteria, yeasts, and moulds of fresh, high-pressure processed, and thermally treated baby food puree and their effect during storage at room temperature (RT) (n = 3)

Storage day	Fresh		HPP-treated		Thermally treated	
	TMA	yeasts and moulds	TMA	yeasts and moulds	TMA	yeasts and moulds
0	6.34 ± 0.38	5.82 ± 0.34	ND	ND	ND	ND
14	6.87 ± 0.41	6.25 ± 0.37	ND	ND	ND	ND
28	7.45 ± 0.52	7.54 ± 0.43	ND	ND	ND	ND
60	NT	NT	1.31 ± 0.07	ND	1.35 ± 0.07	1.25 ± 0.08
90	NT	NT	1.40 ± 0.09	1.23 ± 0.06	1.41 ± 0.09	1.35 ± 0.09

fresh – unprocessed puree; HPP – high-pressure processed puree; thermal – thermally pasteurised puree; RT – room temperature; TMA – total mesophilic aerobic; ND – not detected; NT – not tested; values are reported as $\log_{10}$ CFU·g^{-1}, mean ± standard deviation

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6.34 log CFU·g^{-1} (Table 1). Treatment times of less than 5 min under a pressure of fewer than 600 MPa did not have a significant detrimental effect on TMA bacteria. As the time increased to 5 min and pressure reached 600 MPa, TMA counts fell to less than the detection limit. In a previous study, HPP was successful in reducing the microbial load in avocado puree after HPP processing at 689 MPa and 5–20 min at 25 °C (Fernandez et al. 2019). Microbial growth is generally associated with high pH values, such as 5.8 log CFU·mL^{-1} in carrot juice with a pH of 6.5 (Patterson 2014).

Processing conditions (pressure, time, and temperature), the food matrix, and the type of microorganism determine the rate and extent of microbial inactivation by HPP (Kultur et al. 2017). Many mechanisms for microbial inactivation by HPP have been reported. These include modification of cell structure and physiological functions, disruption of DNA strands, disruption of cell membrane integrity, inactivation of key enzymes, and irreversible denaturing of proteins (Houška and Da Silva 2017; Kultur et al. 2017). Microbial counts were reduced by 600 MPa pressure with a holding time of 5 min. The contributing factors might be variability in bacterial populations, mixed bacterial populations, yield points or points where bacteria are adapted to pressures (Kultur et al. 2017).

HPP was also found to be effective for the inactivation of yeasts and moulds, counts of which were 5.82 log CFU·g^{-1} for fresh puree. Non-detection of moulds and yeasts was observed in both HPP and thermally treated purees (Table 1). Yeast and mould populations were directly related to the pressure level and the pressure holding time. There was a reduction in microbial counts immediately after both processing treatments. TMA bacteria and yeasts and moulds were sensitive to HPP treatment at 600 MPa for 5 min, which reduced microbial counts below the detection limit. Thermal treatment also reduced microbial counts to a non-detectable value.

In order to determine whether HPP-treated puree has a longer shelf life after storage at room temperature, all samples were kept in glass bottles to avoid the evolution of compounds during storage. In plastic packaging, the compounds [additives, di(2-ethylhexyl) adipate, acetyl tributyl citrate for polyvinyl chloride, antioxidants for polypropylene, oligomers for polyethylene terephthalate, caprolactam monomer for polyamide (nylon), and styrene monomer for polystyrene] migrated to food during storage (Bhunia et al. 2013). Keeping in mind this issue, all samples were kept in sterilised glass bottles during storage as glass is inert and does not react with the food or migrate into food products (Sarkar and Aparna 2020).

During storage, the seal integrity and barrier properties to oxygen, water vapour and carbon dioxide must be retained during and post-processing to ensure the product quality. Packaging material must withstand the rigours of rapid compression and decompression and the accompanying volume and temperature changes during processing as well as during storage. To ensure long shelf-life products with excellent nutritional and organoleptic properties, the retention of barrier properties and freshness is essential (Bull et al. 2010). The study conditions, the nature of the chemicals, and the complexity of foods were the reasons for the migration of chemicals. The initial concentration of substances in polymer packaging was responsible for the number of substances migrating into food. The migration of additives was influenced by the nature of food, food-additive interaction (lipophilic or hydrophilic), and time-temperature conditions (Bhunia et al. 2013).

The microbial counts were determined over 90 days in order to determine the shelf life of the puree. Untreated puree showed rapid growth of TMA bacteria as the counts reached 8.92 log CFU·g^{-1} on day 14 of storage. Yeast and mould growth were also fast as the counts increased from 5.82 to 6.25 log CFU·g^{-1} on day 14 of storage (Table 1). On the other hand, HPP treatment effectively suppressed TYM until day 60 of storage. However, a small population of TMA bacteria was observed in HPP-treated puree on day 60 with a further rise in the population after continued storage. In comparison, thermal treatment, a well-established industrial process for microbial reduction in food systems, retarded the growth of all naturally occurring microorganisms until day 28 of storage. Only a low count of 1.35 log CFU·g^{-1} was observed in thermally treated puree on day 60 of storage. Counts of TMA and yeasts and moulds gradually increased in fresh purees over storage (Table 1). This study showed that the counts were increased and reached a level of 6.87 log CFU·g^{-1} within 14 days of storage. In a previous study, bacterial populations were reduced to less than the detection limit after both HPP treatment at 600 MPa for 5 min and thermal treatment (Kultur et al. 2017).

Effects of processing treatments on pH and total soluble solids (TSS). Neither pH nor TSS values in fresh and treated samples were significantly changed, and the observed differences were found to be non-significant ($P > 0.05$) (Table 2). Previously reported results regarding the effect of HPP on vegetable-based purees (Barba et al. 2012; Chen et al. 2015) show that pH and

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Table 2. pH and total soluble solids for fresh, high-pressure processed, and thermally treated baby food puree and their effect during storage at room temperature (RT) (n = 3)

Physicochemical properties	Storage days	Fresh	HPP-treated	Thermally treated
pH	0	3.72 ± 0.25^{aB}	3.77 ± 0.26^{aA}	3.70 ± 0.25^{aB}
	14	3.7 ± 0.24^{abB}	3.74 ± 0.26^{bA}	3.68 ± 0.24^{abB}
	28	3.68 ± 0.23^{bA}	3.68 ± 0.25^{cA}	3.65 ± 0.24^{bA}
	60	3.67 ± 0.23^{bA}	3.69 ± 0.25^{cA}	3.56 ± 0.21^{cB}
	90	3.7 ± 0.24^{abB}	3.78 ± 0.26^{aA}	3.51 ± 0.20^{dC}
TSS (Brix)	0	8.62 ± 0.61^{aB}	8.68 ± 0.63^{aA}	8.67 ± 0.64^{aA}
	14	8.61 ± 0.60^{aB}	8.67 ± 0.61^{aA}	8.66 ± 0.59^{aAB}
	28	8.61 ± 0.60^{aA}	8.66 ± 0.59^{aA}	8.66 ± 0.59^{aA}
	60	7.68 ± 0.58^{bA}	7.67 ± 0.52^{bA}	7.68 ± 0.53^{bA}
	90	7.65 ± 0.52^{bB}	7.65 ± 0.52^{bB}	7.68 ± 0.52^{bA}

^{a,b} treatment-wise (individual treatments were observed at various intervals); ^{A,B} day-wise (treatments were observed at each interval together); fresh – unprocessed puree; HPP – high-pressure processed puree; thermal – thermally pasteurised puree; RT – room temperature; TSS – total soluble solids; values for TSS are expressed in °Brix; values are expressed as mean ± standard deviation

TSS values are generally unaffected by HPP treatment and showed stability after treatment.

Over storage (0, 14, 28, 60, and 90 days) the pH value in fresh and treated purees was observed statistically non-significant (Table 2). The results were in accordance with previous studies (Andrés et al. 2016a; Fernandez et al. 2019). TSS values of purees did not vary between treated and untreated samples (Table 2). In a previous study, a small decrease was reported in the TSS content of both HPP and thermally treated juices, but it was not statistically significant (Fernandez et al. 2019). However, another study showed opposite TSS results where fresh samples showed a significant decrease during storage, compared with treated samples (Andrés et al. 2016a).

Effect of processing treatments on total phenolic compounds. The total phenolic contents of untreated, thermally treated, and HPP-treated purees are shown in Table 3. TPC values were not significantly different after thermal treatment, compared with unpasteurised puree. The TPC increased significantly ($P < 0.05$) in HPP-treated purees (600 MPa). Several studies have also reported an increase in TPC contents after HPP treatment. The TPC values of pumpkins treated with HPP at 450 MPa and 550 MPa increased by 2.4% and 3.7%, respectively, according to Zhou et al. (2014). In addition to apricot nectars (Huang et al. 2013), carrot and tomato purees (Patras et al. 2009a), and cape gooseberries (Vega-Gálvez et al. 2014) showed similar results. According to Andrés et al. 2016b, HPP-treated smoothies at 450 MPa for 3 min and 600 MPa for 3 min showed improved TPC values by 6.6% and 4.2%, respectively.

HPP treatment influences the phenolic compound distribution and aggregation. Because of a modification in the microstructure of fruit pulp, phenolic compounds are highly permeabilised and antioxidants are released (Chen et al. 2015). Chen et al. (2015) found that TPC values were enhanced by antioxidant extraction. a reduction in the volume of the system during compression increases TPC, and the extraction solvent enters the cells and interacts with bioactive components. As a result of the increased permeability of pressurised cells, some components can be extracted more effectively (Chen et al. 2015). A previous study reported an increased extractability of coloured pigments in fruits and vegetables at extreme pressures during HPP pasteurisation; polyphenol content increases as compared to thermal pasteurisation (Gopal 2017). Another study has reported that several factors are associated with the enhanced concentration of bioactive compounds after HPP treatment. These factors include the increase in the extractability caused by the membrane rupture, the disassembling of compound-protein complexes involving modifications of the protein structure, and the pressure-induced modifications on the quaternary structure of synthetic and catabolic enzymes that lead to changes in their activity (Denoya et al. 2022).

Fresh untreated purees experienced significant losses in TPC, more than HPP-treated purees, by the end of the storage period. However, the greatest decrease was observed in thermally treated purees.

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Table 3. Total phenolic content and antioxidant capacity measured as 2,2-diphenyl-1-picryl-hydrazyl (DPPH) of fresh, high-pressure processed, and thermally treated baby food puree and their effect during storage at room temperature (RT) (n = 3)

Parameter	Storage days	Fresh	HPP-treated	Thermally treated
TPC (GAE 100 g^{-1})	0	60.3 ± 4.21^{aB}	61.27 ± 4.56^{aA}	59.52 ± 4.12^{aC}
	14	55.62 ± 3.86^{bC}	60.40 ± 4.22^{bA}	57.29 ± 4.03^{bB}
	28	50.91 ± 3.51^{cC}	58.81 ± 4.11^{cA}	56.10 ± 3.98^{cB}
	60	47.58 ± 3.32^{dC}	56.19 ± 3.96^{dA}	55.21 ± 3.78^{dB}
	90	45.04 ± 3.16^{eC}	$55.58^{eA} \pm 3.82^{eA}$	53.01 ± 3.61^{eB}
DPPH (TEAC 100 g^{-1})	0	303.11 ± 20.43^{aB}	320.03 ± 21.43^{aA}	301.23 ± 20.13^{aB}
	14	267.20 ± 17.13^{bA}	260.11 ± 18.32^{bB}	257.90 ± 16.16^{bC}
	28	259.34 ± 17.05^{cA}	254.67 ± 98^{cC}	256.11 ± 16.01^{cB}
	60	143.89 ± 13.24^{dA}	168.20 ± 11.61^{dC}	187.23 ± 13.10^{dB}
	90	129.20 ± 10.31^{eA}	149.11 ± 10.31^{eA}	145.34 ± 9.57^{eB}

^{a,b} treatment-wise (individual treatments were observed at various intervals); ^{A,B} day-wise (treatments were observed at each interval together); fresh – unprocessed puree; HPP – high pressure processed puree; thermal – thermally pasteurised puree; RT – room temperature; TPC – total phenolic content; GAE – gallic acid equivalent; TEAC – Trolox equivalent antioxidant capacity; DPPH – 2,2-diphenyl-1-picryl-hydrazyl; values for TPC are shown as mg of gallic acid equivalent/100 g of the developed product; values for DPPH are expressed as μmol of TEAC per 100 g sample; values are expressed as mean ± SD

Patras et al. (2009a) reported that the loss of total phenolics comes from a reaction of partially soluble polymers with the Folin-Ciocalteu reagent, oxidation of phenolic compounds, and polymerisation of phenolic compounds with proteins. HPP degrades phenolic compounds through enzymatic oxidation (polyphenol oxidase and peroxidase). TPC levels are reduced when samples are thermally treated and during storage due to enzyme and non-enzyme-mediated oxidation. Phenolics undergo non-enzymatic auto-oxidation into quinones and other degradation products during processing and storage (Patras et al. 2009a).

Effect of processing treatments on antioxidant activity. DPPH methods were used to measure the antioxidant activity of thermally and HPP-treated samples. Thermally treated purees did not show any significant differences in antioxidant activity ($P > 0.05$) compared with HPP-treated purees. The highest antioxidant capacity was observed after treatment at 600 MPa with a significant difference ($P > 0.05$), compared with thermally treated purees (Table 3).

A 60-day storage period resulted in significantly greater reductions in antioxidant activities in untreated puree than in thermally treated and HPP-treated samples. Strawberry purees showed high antioxidant activities after treatment at high pressures, compared with low-pressure treatments (600 vs. 400 MPa) (Patras et al. 2009b). In another study, Patras et al. (2009a) reported that carrot and tomato purees showed 37% and 27% respective increases in antioxidant activities after 600 MPa treatment for 15 min.

Antioxidant activity is increased or stable under HPP treatment, according to the pressure level and the holding time. a number of factors contribute to the effects of HPP on antioxidant activity, including pressurisation conditions, the type of food matrix, and the method used for evaluation (Fernandez et al. 2019). By increasing the extraction rate of antioxidant components from the tissue matrix, compounds with antioxidant properties are released into the extracellular environment (Fernandez et al. 2019).

Sensory acceptance of HPP-treated vegetable puree. A scale of one to ten (1 being the lowest acceptability level and 10 being the highest level) was used to evaluate the sensory attributes of fresh, HPP, and thermally treated purees. Figure 1 shows the sensory scores.

HPP better met consumer expectations concerning the quality of puree immediately after processing and during the storage period. The panel noted significant differences between HPP and thermally treated purees (Figure 1). Thermally treated puree scored lower for quality parameters of colour, appearance, taste, texture, and overall acceptability, compared with the HPP group on day 1. Scores were significantly higher in HPP puree for each tested parameter with a consistently higher

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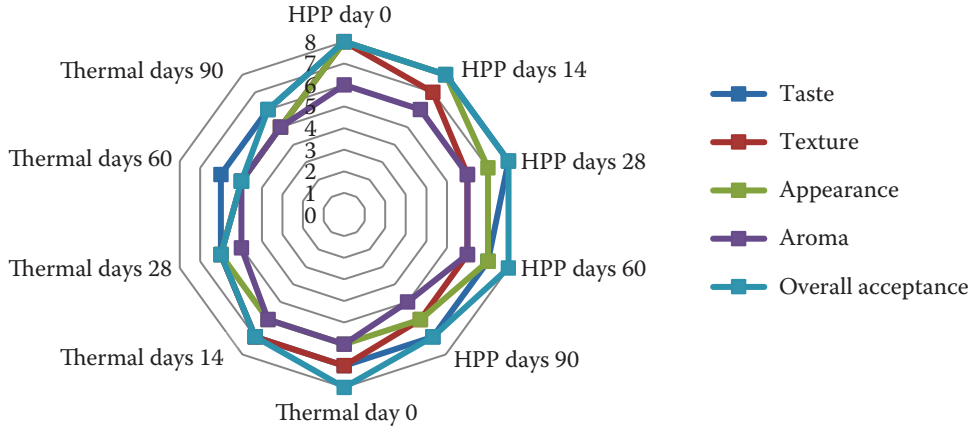

Figure 1. Spider web chart of the sensory analysis showing consumer preferences for high-pressure processed baby puree

HPP – high pressure processed puree

score for taste during the storage period, compared with thermally treated puree (Zeb et al. 2017).

Sensory evaluators provided a higher score for the overall acceptance of HPP puree, compared with thermally pasteurised puree. The overall sensory assessment showed that puree preserved using HPP was superior to puree treated with heat during the entire storage period.

CONCLUSION

A physicochemically stable product with antioxidant properties similar to fresh products can be produced using HPP treatment at 600 MPa for 5 min at 25 °C. This HPP product can be stored at room temperature while maintaining antioxidant properties. Microbiological criteria suggest a shelf life of 30 days, and antioxidant loss criteria suggest a shelf life of 28 to 60 days. Room temperature storage results in colour loss. For the development of a vegetable-based baby puree that can be stored at room temperature, HPP is a useful technology, but some adjustments will be necessary to achieve the desired overall product stability.

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