Journal of Food Research; Vol. 4, No. 5; 2015
ISSN 1927-0887 E-ISSN 1927-0895
Published by Canadian Center of Science and Education

Functional, Physical and Sensory Properties of Pulse Ingredients Incorporated into Orange and Apple Juice Beverages

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Received: February 27, 2015 Accepted: August 23, 2015 Online Published: September 14, 2015

doi:10.5539/jfr.v4n5p143 URL: http://dx.doi.org/10.5539/jfr.v4n5p143

Abstract

The objective of this study was to explore the use of pulse ingredients in the development of orange juice and apple juice supplemented beverages. Commercially available pulse ingredients including pea protein (PP), chickpea flour (CPF), lentil flour (LF) and pea fibre (PF) were selected and characterized with respect to specific functional properties (water holding capacity, fat absorption capacity, protein solubility, emulsifying and foaming properties). Apple juice was supplemented with 1-4% pulse ingredients, whereas a supplementation level of 1-2% was used for orange juice. The physical and sensory properties of the supplemented beverages were measured after production and during 3 weeks of refrigerated storage. Sensory attributes for both orange and apple juice supplemented with 1% and 2% pulse ingredients were similar to their respective controls (with and without pectin added). In terms of turbidity, supplementation increased the turbidity of apple juice and orange juice beverages at all levels, in comparison with control and pectin-added control samples. Supplemented samples, showed less satisfactory results in terms of cloud stability and color especially for orange juice beverages in comparison with their respective controls. Overall, while there are some hurdles to be overcome, the results suggest that when used at the 1-2% levels, PP, PF, CPF and LF could serve as potential value-added ingredients for beverage supplementation based on their physical and sensory properties. Further studies are, however, required in this promising area to improve the stability of the final production especially during storage.

Key words: pulse, functional properties, supplementation, apple juice, orange juice

1. Introduction

Pulses are the dry seeds of low fat legumes including bean (*Phaseolus vulgaris*), pea (*Pisum sativum*), lentil (*Lens culinaris*), chickpea (*Cicer arietinum)* and lupin (*Lupinus perennis*). They are nutritional and contain high amounts of complex carbohydrates (e.g., resistant starch and oligosaccharides), protein, vitamins and minerals (e.g., folate and iron) as well as antioxidants, and only very small amounts of unsaturated fats (Ofuya & Akhidue, 2005; Curran, 2012).

Various research studies have suggested that regular dietary intake of pulses may reduce the risk of developing chronic diseases such as obesity, diabetes, heart disease and cancer (Hu, 2003; Jacobs & Gallaher, 2004; Kelly, Frost, Whittaker & Summerbell, 2004; Williams, O'Shea, & Gafenauer, 2004; Schatzkin & Mouw, 2007; Curran, 2012). Furthermore, regular consumption of pulses may assist with weight management by increasing the feeling of satiety and also controlling blood sugar and appetite due to their low glycemic index (Koh-Banerjee et al., 2004; Curran, 2012).

In addition to their health and nutritional benefits, the functional properties of pulse ingredients could play an important role in food systems. Techno-functional properties of interest in food formulations include solubility, water binding, fat binding, emulsification, foaming, gelation, thickening and flavour binding capacity. These physico-chemical properties play an important role during food processing, storage, preparation and consumption (Kinsella, 1976). Amino acid composition, structure and conformation and interactions between proteins and other food components (e.g., salts, fats, carbohydrates and phenolics) as well as pH, temperature and other process specifications all affect to some extent the quality and functionality of food ingredients (Boye, Zare, & Pletch, 2010).

Beverage supplementation with nutraceutical components and traditional nutritional ingredients has been shown to improve the nutritional and rheological quality of beverages (Renuka, Kulkarni, Vijayanand, & Prapulla, 2009). Several studies have reported beverage supplementation with different food ingredients such as fiber (Dahl, Whiting, Isaac, Weeks, & Arnold, 2005; Beristain et al., 2006), whey and whey protein (Vojnovic, Ritz, & Vahcic, 1993; Kazmierski, Agboola, & Corredigi, 2003; Pescuma, Hébert, Mozzi, & Valdez, 2010), soy flour and soy protein (Jasentuliyana, Toma, Klavons, & Medora, 1998; Kent & Harper, 2003; Tiziani, & Vodovotz, 2005), peanut (Deshpande, Chinnan, & McWatters, 2008), fructooligosaccharide (Renuka et al., 2009), β-Glucan (Temelli, Bansema, & Stobbe, 2004; Din, Anjum, Zahoor, & Nawaz, 2009) and more. So far, however, only a few studies have considered beverage supplementation using pulses (Luz-Fernandez de Tonella, & Berry, 1987) and pulse ingredients (Jackman & Yada, 1989).

In spite of their high nutritional value, pulses do not represent a significant share of the western diet. Food supplementation with pulse ingredients could offer a promising opportunity to improve the nutritional properties of formulated food products. To ensure market acceptability, however, supplemented products made with pulse ingredients need to be comparable to non-supplemented products in terms of quality, shelf life and consumer acceptability.

In this study, therefore, beverage (i.e., apple juice and orange juice) supplementation with pulse ingredients was considered as a potential avenue to increase pulse utilisation and consumption. Commercially available pulse ingredients, including pea protein, chickpea flour, lentil flour and pea fiber, were selected and their functional properties were studied. Subsequently the physical and sensory properties of beverages supplemented with the pulse ingredients (in the presence and absence of pectin which was used as a stabilizer) were studied and compared with soy supplemented beverage as well as non-supplemented control beverages (i.e., apple and orange juice with and without pectin).

2. Materials and Methods

2.1 Materials

Pulse ingredients used in this study were as follows: chickpea flour from Diefenbaker Seeds Company (Elbow, SK, Canada), lentil flour from K2 Milling Company (Tottenham, ON, Canada), pea fiber from Best Cooking Pulses Inc (Rowatt, SK, Canada) and pea protein from Nutri-Pea Company (Portage La Prairie, MB, Canada). Soy protein concentrate (71.6% protein content) was from Oleanergie F2001 Company (St. Hyacinthe, QC, Canada). Unfiltered and unpasteurized apple juice prepared from the McIntosh variety was obtained from Quinn farm (Ile Perrot; QC, Canada) and fresh oranges (Navel Orange variety) were purchased from the retail market. Low-methoxy pectin was purchased from TIC Gum Company (PA, USA).

2.2 Functional Properties of Pulse Ingredients

Proximate analysis of the pulse ingredients including protein, moisture, fat and ash measurements were done using standard AOAC methods (AOAC, 1990). pH was measured using a pH meter (Accumet AP61, Fisher Scientific Inc, ON, Canada). Functional properties studied included water holding capacity using AACC method 88-04 (AACC, 1983); fat absorption capacity according to the method described by Lin, Humbert, & Sosulski (1974); protein solubility was measured based on the amount of protein in solution at specified pH values as measured using UV-visible light according to the Bradford method (1976); emulsifying properties were determined with the method described by Pearce & Kinsella (1978); and foaming capacity was studied using the method described by Waniska & Kinsella (1979).

2.3 Sample Preparation and Supplementation

Apple juice was stored in the refrigerator at 4 °C before use. Oranges were washed with tap water and the juice extracted with a household juice extractor model E415 (Presse-Agrumes, France) and stored in a refrigerator prior to use. Figure 1 presents a schematic diagram of the processes used for juice supplementation. With consideration of the supplementation range used for commercial fruit juices, which is mostly 0.5-3% of thickening agents such as pectin, this study considered a range of 1-4% for apple juice and orange juice supplementation. Apple juice was supplemented with 1-4% pulse ingredients, whereas a supplementation level of 1-2% was used for orange juice. For comparison, apple juice and orange juice were also supplemented with 2% soy protein concentrate. Furthermore, as control samples, non-supplemented apple and orange juices (with and without 2% pectin) were prepared. All samples were stored for 3 weeks and they were analyzed to determine their physico-chemical (i.e., pH, turbidity, loss of cloud stability and color) and sensory properties (i.e., flavour, mouthfeel and overall acceptance).

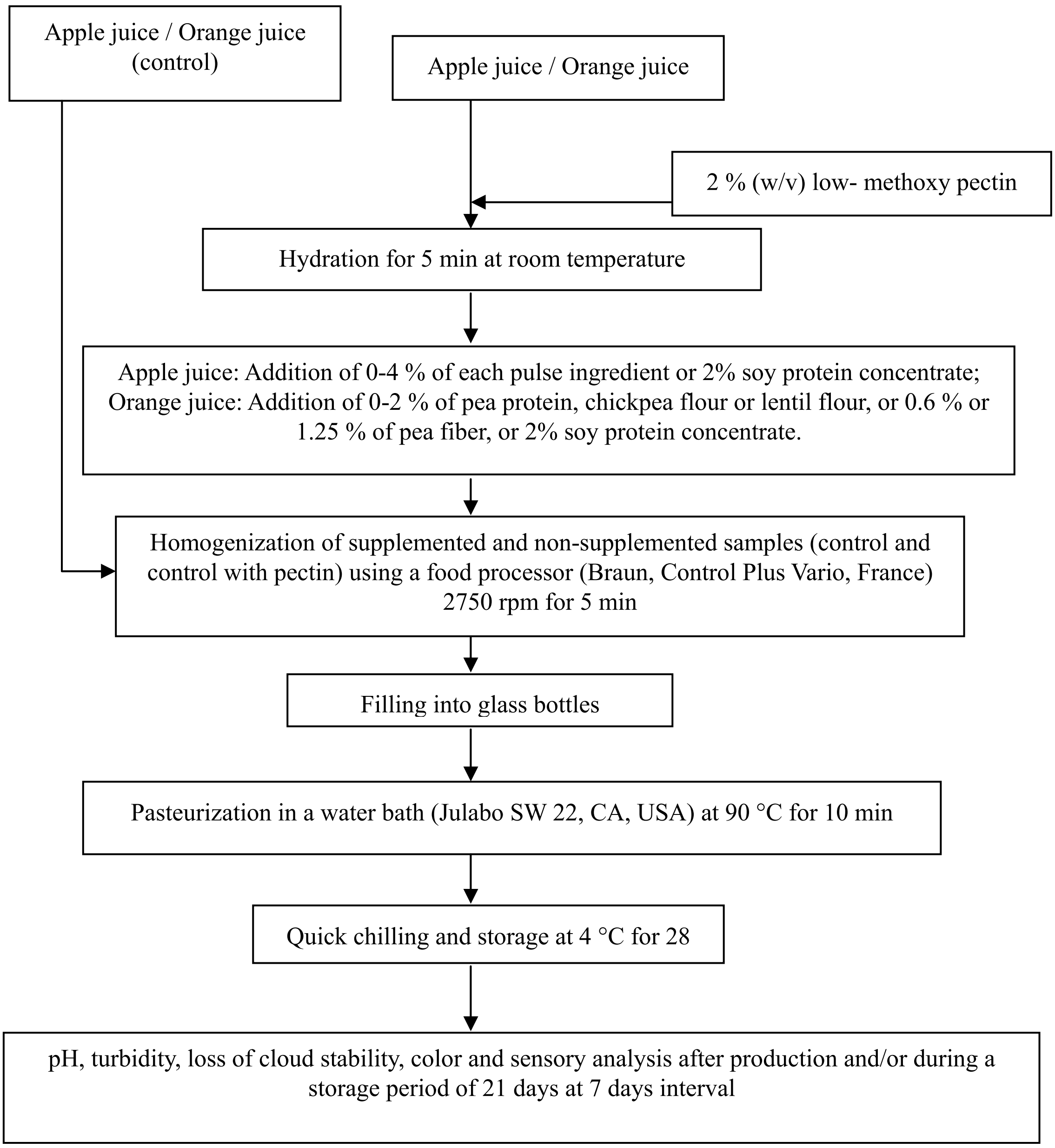


Figure 1. Schematic processes used for supplementation of apple juice and orange juice with pulse ingredients

2.4 Beverage Characterization

Turbidity of the beverages was measured according to the method described by Stähle-Hamatschek & Gierschner (1989); with some modifications. Briefly, the transparency of 100 mL of sample was measured (Ts) using a UV-Visible spectrophotometer (Cary 300 Bi, Varian, Canada) at 695 nm. Samples were then centrifuged at 20 °C for 20 min at 2015 g (4200 rpm) using a SARSTEDT centrifuge (AG & Co., Germany). Subsequently, the transparency of the supernatant was measured (Tc) and the percentage of turbidity (% T) was calculated as (Tc/Ts)*100. Cloud stability in fortified juices was measured by the method described by Kazmierski et al. (2003). Transparency of the supernatant of the centrifuged samples (20 °C /15 min/1028 g (3000 rpm), SARSTEDT centrifuge, AG & Co., Germany) was measured at 659 nm using a UV-Visible spectrophotometer

(Cary 300 Bi, Varian, Canada). An increase in transparency was considered as an indication of loss of cloud stability. This measurement was carried out at 7-day intervals during the storage period. The color of the beverages was also measured using a Labscan II colorimeter (Hunter Associate Laboratory, Inc., Restone, VA). Beverage pH was measured with an Accumet pH meter (Accumet AP61, Fisher Scientific Inc, ON, Canada).

2.5 Sensory Analyses of Beverages

Sensory analyses (flavour, mouthfeel and overall acceptance) of the supplemented and control samples were evaluated after production by 25 untrained panelists, adult males and females; using the nine point hedonic scale method. Each panelist was provided with a maximum of 3 samples at a time and they were asked to score samples from extremely like (1) to extremely dislike (9). The sensory room was equipped with red light to blind the panelists to the color of the beverages.

2.6 Statistical Analysis

Excel 2007 was used for the calculation of means and standard deviations. Statistical analysis was conducted using ANOVA analysis (SAS 9.1, SAS Institute Inc. NC, US). Comparisons were made using the Student–Newman-Keuls test and the two sample t-test for comparison of two means. All experiments were done in three separate independent trials.

3. Results and Discussion

3.1 Proximate analysis of pulse ingredients

Proximate composition of the pulse ingredients are summarized in Table 1. As expected, the pea protein concentrate showed the highest protein content (79.97% w/w) whereas pea fibre contained the lowest (7.21% w/w). Fat content of the pulse ingredients ranged between 0.06% (w/w) for lentil flour to 7.39% (w/w) for chickpea flour. Moisture content varied from 3.18% to 9.99% for the different pulse ingredients.

Table 1. Proximate analysis of pulse ingredients

Sample	Protein % (w/w)	Moisture% (w/w)	Fat % (w/w)	Ash% (w/w)
	Average ± SD	Average ± SD	Average ± SD	Average ± SD
Pea protein	79.97 ± 0.13 a	3.18 ± 0.07 b	0.53 ± 0.86 b	4.79 ± 0.42 a
Chick pea flour	23.52 ± 0.09 b	9.99 ± 0.01 a	7.39 ± 12.77 a	3.16 ± 0.36 b
Lentil flour	24.83 ± 0.12 b	9.45 ± 0.14 a	0.06 ± 0.10 b	2.68 ± 0.27 b
Pea fiber	7.21 ± 0.17 c	5.29 ± 0.04 b	0.38 ± 0.14 b	1.95 ± 0.29 c

Means with the same letters are not significantly different, for a given column ($P<0.05$).

3.2 Functional Properties of Pulse Ingredients

Results of the functional properties of the samples studied are summarised in Table 2. The water holding capacity (WHC) of pulse ingredients ranged from 0.8 to 3.1 (mL/g). WHC of pea protein concentrate was 3.13 mL/g and was the highest among the pulse ingredients (Table 2). This value is similar to the WHC reported for soy protein concentrate (3.9 mL/g) and soy protein isolates (4.3 mL/g) (L'Hocine, Boye, & Arcand, 2006). Not surprisingly, pea fibre had the next highest WHC (2.73 mL/g). This value is close to the value reported by Wang & Toews (2011). Chickpea flour and lentil flour exhibited very low WHC of 0.83 and 0.88 mL/g, respectively; which are comparable with the WHC of sunflower flour (107.01 % or 1.07 mL/g; Lin et al., 1974). WHC is affected by percentage of protein, cultivar and processing treatments (Kaur & Singh, 2007) as well as the number of hydrophilic sites on the protein molecules (Lin et al., 1974) and fiber content (Heller & Hackler, 1977). The higher protein content in pea protein in comparison with the other pulse ingredients may explain its higher water holding capacity. Pea fiber's second ranking for WHC is likely due to its high capacity of fiber to absorb water molecules (Heller & Hackler, 1977).

Solubility profiles of pulse ingredients at pH ranging from 1-11 are presented in Figure 2. The isoelectric point of legume proteins is generally between pH 4 and pH 6 (Fernandez-Quintela, Macarulla, Del Barrio, & Martõanez, 1997). Thus, for most pulse proteins, solubility is highest at low acidic and high alkaline pH values. In this study, the isoelectric point of pea protein and lentil flour ranged between pH 3.5 to 4.5 (region of lowest solubility), whereas that of chickpea flour was between pH 2.5 to 4.5. Interestingly, the solubility of both the chickpea flour and lentil flour (at the region of highest solubility) was higher (60 – 80%) than for pea protein concentrate (20-25%). Processing treatments used for the production of pulse ingredients can affect their functionality (Obatolu, Fasoyiro, & Ogunsunmi, 2007). In particular, production methods such as precooking and drum-drying or spray-drying can reduce the nitrogen solubility of pulse flours and ingredients (Carcea-Bencini, 1986). Processing treatments used for preparing the pulse ingredients are proprietary; nevertheless, the lower solubility of pea protein concentrate, in spite of its higher protein content, suggests protein denaturation and changes to the molecular structure (L'hocine et al., 2006).

Fat absorption capacities (FAC) of all samples ranged from 76 % to 116 % (w/w). The lowest FAC was found for lentil flour (76%, w/w) and highest for pea fibre (116% w/w). FAC of pea protein and chickpea flour were 79% and 87% (w/w) respectively. All the FACs measured in this study were lower than for soy protein concentrate (SPC) or soy protein isolate (SPI) (FAC= 218-251 % reported by L'hocine et al., 2006), but they are comparable with FACs of soy flour, SPC and SPI ranging from 84.4 % to 154.5 % (w/w), reported by Lin et al., 1974. Fernandez-Quintela et al. (1997) also reported higher FAC of 160 % and 120 % (w/w) for faba bean isolate and pea protein isolate, respectively. The fat absorption mechanism is attributed to either oil entrapment and/or absorption and/or the lipophilic properties of the proteins contained in the pulses. The size of each particle offers different surface area to absorb the oil (Wang &Toews, 2011). The particle size of the pulse ingredients was not measured however as part of this study. Future studies focusing on the impact of particle size will therefore need to be undertaken. Non-polar sides of protein chains could also bind the hydrocarbon chains of fat molecules (Lin et al., 1974; Kinsella, 1976). In general, the difference of FAC of pulse ingredients could be attributed to a variety of factors including potential differences in protein structure. Specifically, the high FAC of pea fibre compared to the other samples could be due to the superior ability of fiber to physically entrap or bind with fat molecules (Kinsella, 1976).

Emulsifying activity index (EAI) of the pulse ingredients ranged between 11-14 m^2/g, whereas the emulsifying stability index (ESI) varied between 26-33 min (Table 2). Due to the nature of the sample, it was impossible to determine the emulsifying properties of pea fibre. Of the other samples, lentil flour and chickpea flour had the lowest emulsifying properties, whereas pea protein had the highest emulsifying properties. Barac et al. (2010), studied the EAI and ESI of pea protein isolates at different pH and they reported that the EAI of neutral pea protein (pH=7) ranged between 25 -115 m^2/g and their ESI ranged between 20-80 min; the ESI values are in the same range as that reported in this study. Proteins can form a thin layer or film around oil droplets in a food system to make an emulsion. EAI may be defined as the amount of oil that can be emulsified per unit of protein whereas ESI shows the ability of the emulsion to oppose changes to the structure of the emulsion over a period of time (Pearce & Kinsella, 1978; Boye et al., 2010). Emulsifying properties are affected by hydrophobicity and hydrophilicity properties of proteins and amino acids that are contained in the structure of proteins. The total protein content can also affect the EAI and ESI (Paredes-Lopez, Ordorica-Falomir, & Olivares-Vázquez, 1991). Thus, the higher emulsifying property of pea protein in comparison with the other samples is likely due to its higher protein content.

Foaming expansion of our pulse ingredients ranged between 400-1500 %. The highest value was found for chickpea flour and the lowest for lentil flour. The foaming expansion of pea protein and lentil flour however, was not significantly different ($P<0.05$). In comparison with soy protein isolates which gave foaming expansion (FE) values ranging from 400-550 % (L'hocine et al., 2006), pulse ingredients such as chickpea flour may have better foaming properties. Foaming capacity (FC) or foaming expansion (FE) is expressed as the volume (%) of foam increase due to whipping whereas foam stability (FS) is defined as the change in the volume of foam over a time period (Boye et al., 2010). Foaming properties (FC or FE) are related to protein content, protein structure and processing treatments (Paredes-Lopez et al., 1991; Obatolu, et al., 2007). Obatolu et al., (2007), reported greater foaming capacities in raw yam bean in comparison with boiled yam bean, which suggested that a thermal processing treatment may lower the FC. The differences in foaming properties of the pulse ingredients could thus be due to differences in protein content as well as processing treatments which could in some instances result in protein denaturation.

Table 2. Functional properties of pulse ingredients

Sample	WHC (mL/g)	FAC % (w/w)	Emulsifying Properties		Foam Expansion (FE %)
			EAI (m^2/g)	ESI (min)	
	Average ± SD	Average ± SD	Average ± SD	Average ± SD	Average ± SD
Pea protein	3.13 ± 0.02 a	79.70 ± 4.85 c	13.37 ± 0.00 a	32.75 ± 0.30 a	514.97 ± 49.50 b
Chickpea flour	0.83 ± 0.01 d	87.69 ± 5.18 b	11.93 ± 0.01 a	25.79 ± 4.46 a	1348.20 ± 114.94 a
Lentil flour	0.88 ± 0.01 c	76.70 ± 2.71 c	12.98 ± 0.02 a	26.11 ± 4.18 a	478.26 ± 7.62 b
Pea fiber	2.73 ± 0.00 b	116.28 ± 3.67 a	ND	ND	ND

Means with the same letters are not significantly different (*P*<0.05); ND: not defined.

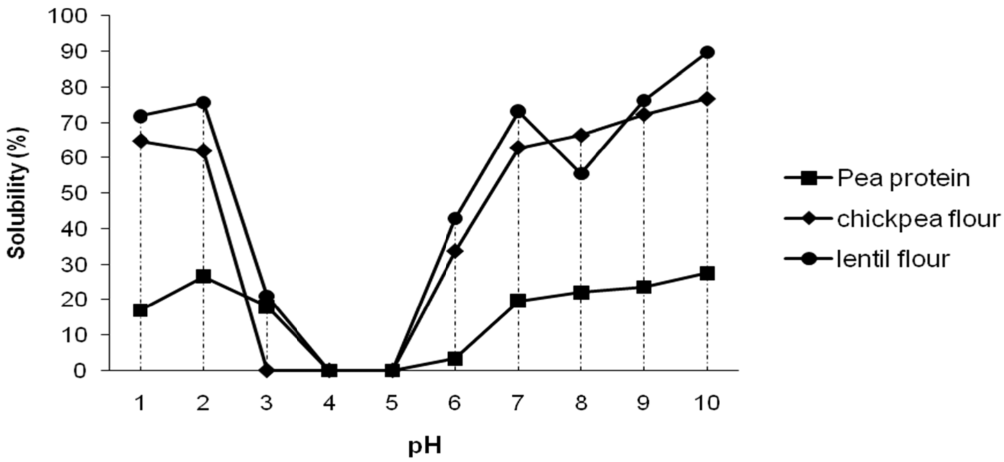
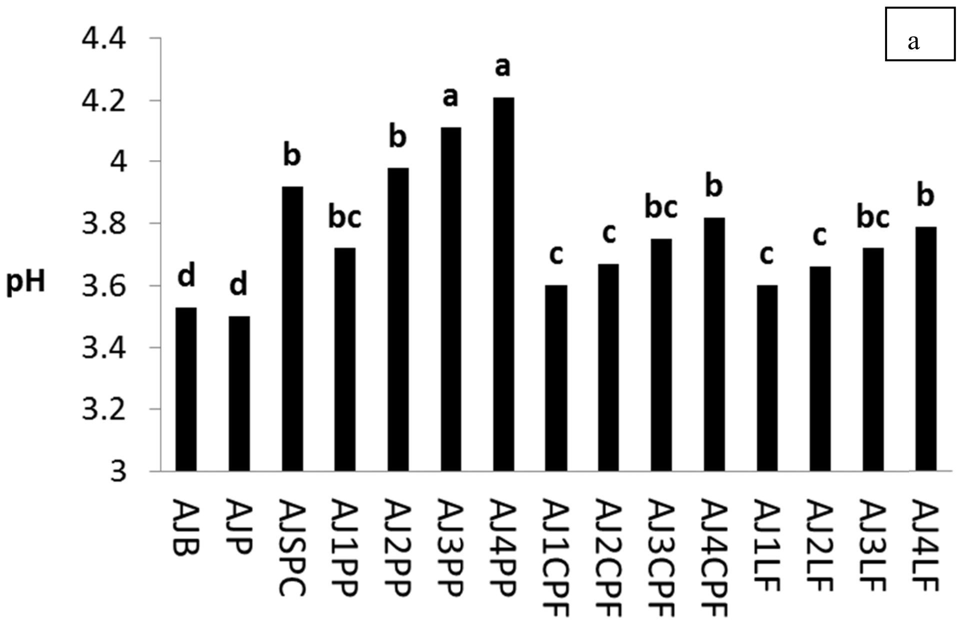


Figure 2. Solubility profile of pulse ingredients

3.3 Physico-chemical Properties of Beverages Supplemented with Pulse Ingredients

3.3.1 pH

Figure 3 (a, b), presents data on the pH values of apple and orange juice supplemented with the pulse ingredients. pH of apple juice beverages ranged from 3.50 to 4.21 and the pH of orange juice beverages ranged from 3.75 to 4.02. Pulse supplementation significantly increased the pH in all apple juice beverages compared to both control samples (i.e., non-supplemented juice with and without pectin added) (*P*<0.05). This could be due to the fact that pulse ingredients, by themselves are less acidic than fruit juices and so they add lower acidity and therefore lead to a higher pH of the matrices. Also, the higher protein content (pea protein) of the pulses resulted in a higher pH value, which could be due to a buffering capacity of the pulse protein. Supplementation with 2% soy protein concentrate also significantly increased the pH in comparison with the control samples. SPC supplemented samples were comparable with pea protein supplemented apple juice at the same level of supplementation (*P*<0.05). For orange juice beverages, pH significantly increased as a result of supplementation in all samples in comparison with control samples (*P*<0.05), except for the pea fiber supplemented beverages and 1% chickpea flour and 1% lentil flour supplemented samples. A comparison of the two control samples (with and without pectin) for both apple and orange juices showed that addition of pectin did not alter the pH of the juices (*P*<0.05).



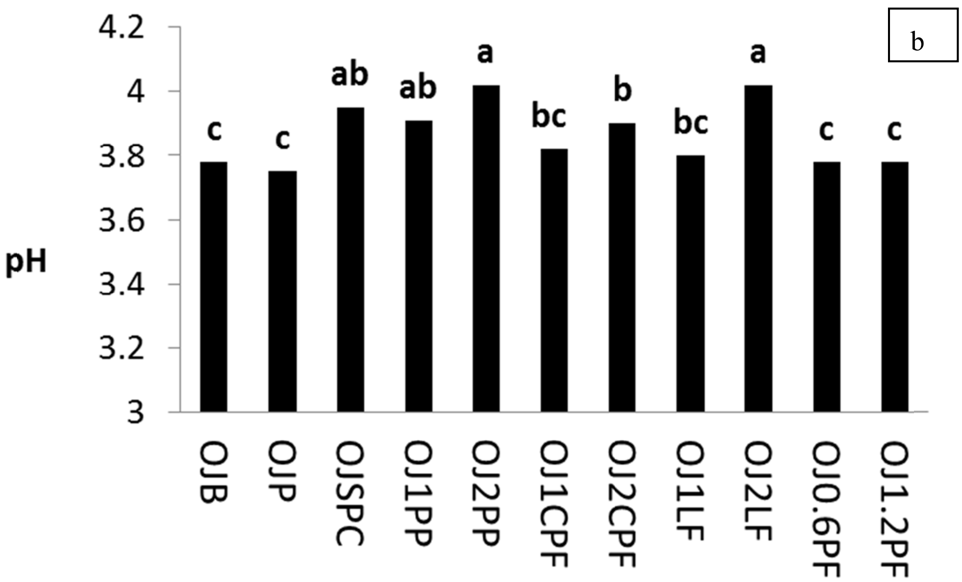


Figure 3. a): pH of supplemented and non-supplemented apple juice with 1-4% of pulse ingredients, b): pH of supplemented and non-supplemented orange juice with 1-2% of pulse ingredients; (AJ: apple juice, OJ: orange juice, B: blank, P: pectin, SPC: soy protein concentrate, PP: pea protein, CPF: chickpea flour, LF: lentil flour, 0.6PF: 0.6 % pea fiber, 1.2PF: 1.25% pea fiber; means with difference letters are significantly different *($P<0.05$)*)

3.3.2 Turbidity

Figure 4 (a,b), present data on turbidity of apple and orange juice supplemented with pulse ingredients. For both apple juice and orange juice beverages, supplementation significantly increased turbidity of all samples in comparison with both control samples (i.e., non-supplemented juices with and without pectin added) and it was also concentration dependent for both beverages ($P<0.05$). Considering the protein solubility of pulse ingredients which is generally lowest at pH 3-6 (Figure 2), it is reasonable to expect that they would have lower solubility in both apple and orange juice; this may explain why the turbidity increased as a result of supplementation and pulse concentrations. The effect of soy protein concentrate and pea protein in increasing the turbidity was greater than for lentil flour and chickpea flour for both apple juice and orange juice supplemented beverages ($P<0.05$).

Addition of pectin did not alter the turbidity of both apple juice and orange juice in comparison with the control sample with no pectin.

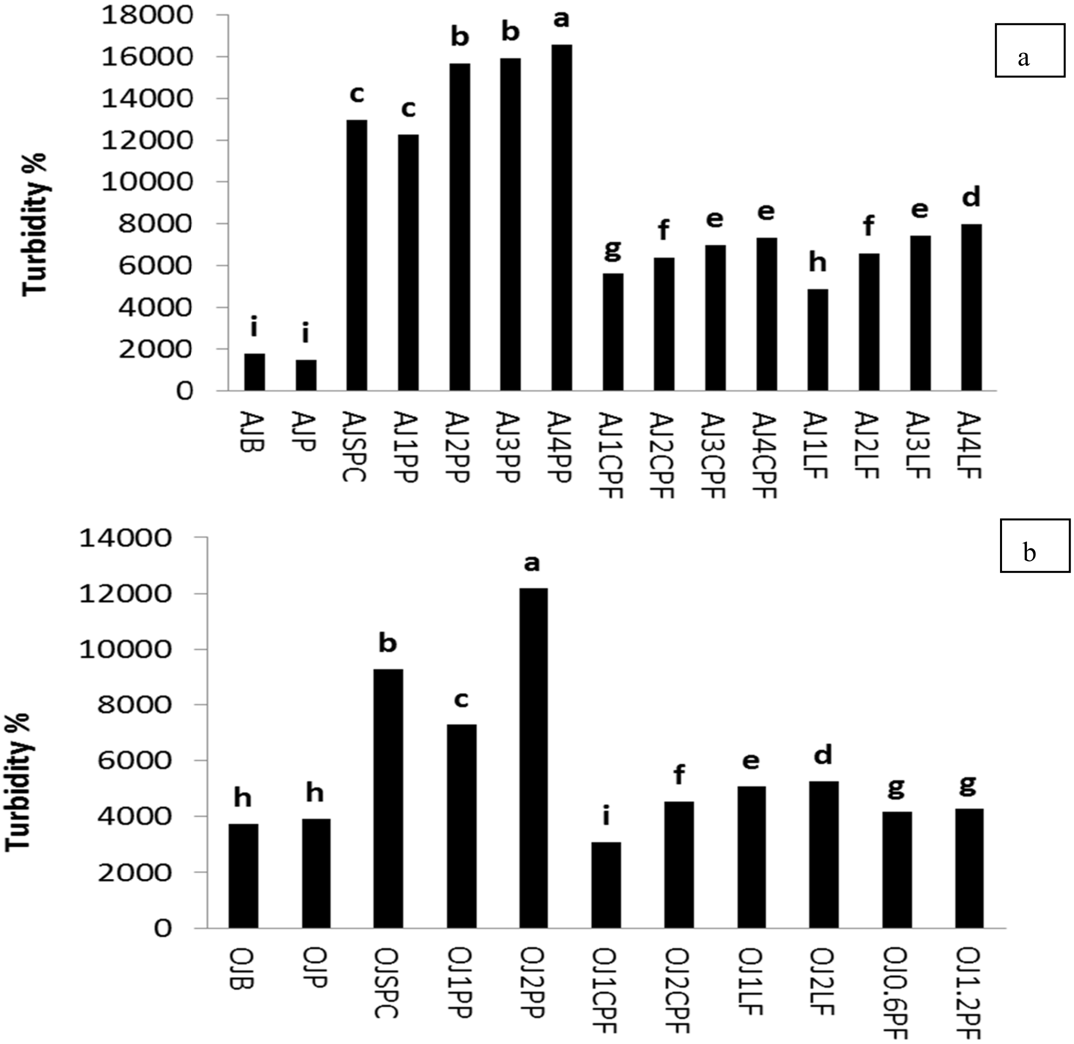


Figure 4. a): turbidity of supplemented and non-supplemented apple juice with 1-4% of pulse ingredients, b): turbidity of supplemented and non-supplemented orange juice with 1-2% of pulse ingredients; (AJ: apple juice, OJ: orange juice, B: blank, P: pectin, SPC: soy protein concentrate, PP: pea protein, CPF: chickpea flour, LF: lentil flour, 0.6PF: 0.6 % pea fiber, 1.2PF: 1.25% pea fiber; means with difference letters are significantly different *(P<0.05)*)

3.3.3 Loss of Cloud Stability (L.C.S)

Loss of cloud stability (L.C.S) in supplemented apple juice and orange juice after 1 week and during 3 weeks refrigerated storage are presented in Figures 5 (a,b). Our results showed that cloud stability of supplemented samples decreased during storage, and loss of cloud stability is negatively related to the level of supplementation. Cloud stability of the apple juice supplemented beverages was higher than for the orange juice supplemented beverages. Supplementation with soy protein concentrate also, resulted in greater cloud stability in comparison with all other apple juice and orange juice supplemented samples. Addition of pectin helped to maintain the cloud stability of both supplemented beverages in comparison with blank samples.

Cloudiness of fruit juice occurs due to the presence of pulp particles and pectin naturally present in the apple and orange juices (Kazmierski et al., 2003). As a result of gravity, settling of the pulp in both apple and orange juices is expected to increase during storage. Kazmierski et al. (2003) reported that the most important cause of cloud de-stabilization and clarification of fresh juice is the activity of the enzyme pectin methyl esterase (PME). It is, therefore, important to inactivate the PME enzyme by heating to minimize its activity on the juice pectin. This was not an issue in the present study as the pasteurization process of the juices would have inactivated the PME enzyme. Kazmierski et al. (2003) further indicated that the introduction of proteins, the electrical charge of the juice particles, pH and temperature may also affect cloud stability due to possible interactions between pulse proteins and juice components. In our study, supplementation may have affected the cloud stability of the beverages due to the changes in protein content, electrical charge of juice particles and also the pH (as presented in section 3.3.1).

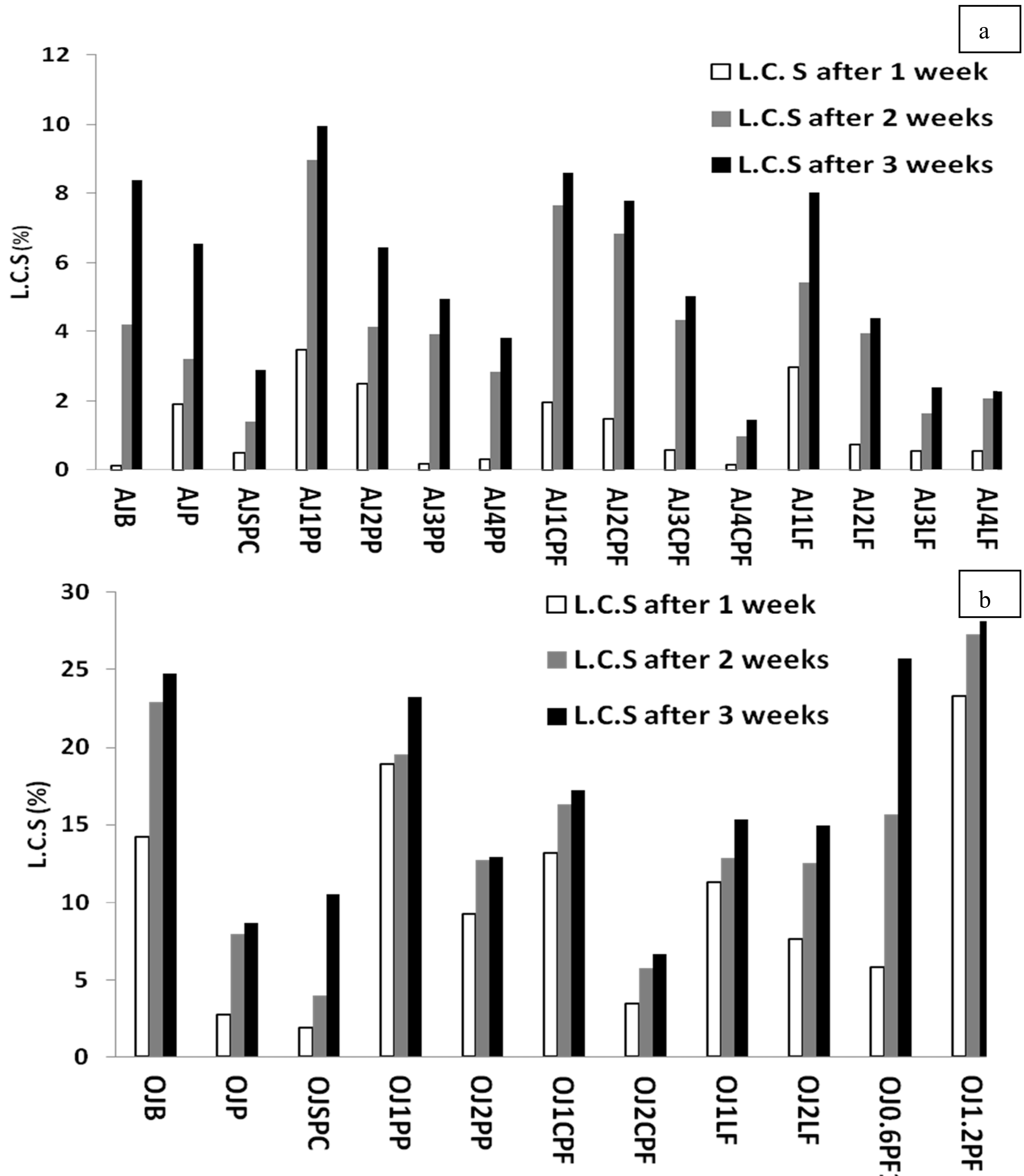


Figure 5. a): loss of cloud stability (L.C.S) of supplemented apple juice and control sample after 1 week and 3 weeks storage, b): loss of cloud stability of supplemented orange juice and control sample after 1 week and 3 weeks storage (AJ: apple juice, OJ: orange juice, B: blank, P: pectin, SPC: soy protein concentrate, PP: pea protein, CPF: chickpea flour, LF: lentil flour, 0.6PF: 0.6 % pea fiber, 1.2PF: 1.25% pea fiber)

3.3.4 Color

Color measurements obtained for the supplemented apple juice, orange juice and control samples are presented in Table 3. In apple juice the "L" factor (representing lightness, 0 = black to 100 = white) remained in the same range of 22.3- 42.3 in all supplemented samples as well as the control. The "a" value (negative values indicate green whereas positive values indicate red) increased in all samples supplemented with chickpea flour and pea protein but it was almost equal to the control sample for apple juice supplemented with the lentil flour. The "b" value (negative values indicate blue and positive values indicate yellow) dramatically increased in all samples. Results for ΔE (color difference between supplemented apple juices and control samples) showed that addition of the pulse ingredients changed the color of the juices. Addition of soy protein concentrate also changed the colour of the apple juice significantly except when it was compared with samples supplemented with 3% and 4% chickpea flour. Pea protein had the largest effect when compared to chickpea and lentil flours, however, there were no significant differences between 1 to 3% pea protein supplemented samples (P<0.05). There was also, no notable color difference between 2% chickpea flour and 2% lentil flour supplemented apple juice sample compared to the control sample with pectin.

Table 3. Color parameters (L), (a), (b) and color difference (ΔE) in supplemented apple and orange juice and control samples

Sample	L (Average ± SD)	a (Average ± SD)	b (Average ± SD)	ΔE (Average ± SD)
AJ control	31.40 ± 2.64	3.98 ± 0.22	0.13 ± 2.71	-----------------
AJ control+ pectin only	22.31 ± 1.56	3.19 ± 0.10	11.76 ± 3.65	14.81 ± 3.8 f
AJ + 2%SPC	31.36 ± 0.48	3.36 ± 0.04	21.44 ± 1.37	21.32 ± 1.36 cd
AJ + 1%PP	26.17 ± 0.06	5.16 ± 0.01	32.66 ± 0.06	32.97 ± 0.07 b
AJ + 2 %PP	34.16 ± 0.15	6.12 ± 0.03	32.62 ± 0.01	32.68 ± 0.02 b
AJ + 3 %PP	35.97 ± 0.05	6.33 ± 0.01	32.40 ± 0.08	32.68 ± 0.08 b
AJ + 4 %PP	37.89 ± 0.01	7.60 ± 0.02	36.43 ± 0.16	37.05 ± 0.16 a
AJ + 1 %CPF	30.8 ± 0.21	4.29 ± 0.04	26.55 ± 0.49	11.40 ± 0.16 g
AJ + 2 %CPF	34.68 ± 0.14	5.16 ± 0.07	31.18 ± 0.30	16.29 ± 0.03 ef
AJ + 3 %CPF	37.07 ± 0.00	6.89 ± 0.00	25.25 ± 0.00	20.46 ± 3.38 d
AJ + 4 %CPF	42.38 ± 0.07	4.99 ± 0.05	24.73 ± 0.17	22.92 ± 0.06 c
AJ + 1 %LF	28.03 ± 0.05	2.87 ± 0.02	21.97 ± 0.08	9.36 ± 0.07 h
AJ + 2 %LF	34.84 ± 0.01	2.86 ± 0.03	21.48 ± 0.09	15.94 ± 0.03 ef
AJ + 3 %LF	37.05 ± 0.13	3.13 ± 0.06	21.18 ± 0.12	18.13 ± 0.16 e
AJ + 4 %LF	42.27 ± 0.12	3.68 ± 0.02	23.61 ± 0.08	22.88 ± 0.13 c
OJ control	36.35 ± 0.30	5.64 ± 0.20	48.90 ± 1.54	-----------------
OJ control+ pectin only	35.33 ± 0.21	7.1 ± 0.27	55.42 ± 0.93	6.76 ± 0.998 d
OJ + SPC	44.02 ± 1.48	7.49 ± 0.71	47.83 ± 6.36	9.32 ± 2.80 cd
OJ + 1 %PP	43.03 ± 0.81	8.17 ± 0.35	55.38 ± 3.79	10.05 ± 1.75 c
OJ + 2 %PP	46.49 ± 0.17	9.42 ± 0.05	57.24 ± 0.34	13.66 ± 0.12 b
OJ + 1 %CPF	48.39 ± 0.07	5.93 ± 0.09	43.0 ± 0.65	13.43 ± 0.34 b
OJ + 2 %CPF	47.96 ± 0.03	7.05 ± 0.05	46.22 ± 0.66	12.01 ± 0.13 bc
OJ + 1 %LF	38.24 ± 0.08	7.60 ± 0.24	57.54 ± 0.14	9.06 ± 0.17 cd
OJ + 2 %LF	43.52 ± 0.97	8.69 ± 1.58	65.28 ± 3.03	18.24 ± 2.59 a
OJ + 0.6% PF	26.26 ± 0.07	16.30 ± 0.06	45.09 ± 0.126	15.17 ± 0.04 b
OJ + 1.25% PF	28.42 ± 0.61	17.46 ± 0.20	48.78 ± 1.07	14.26 ± 0.47 b

Means with the same letter are not significantly different (P<0.05); AJ: apple juice; OJ: orange juice; SPC: soy protein concentrate; PP: pea protein; CPF: chickpea flour; LF: lentil flour; PF: pea fiber

For supplemented orange juice the results indicated that supplementation slightly affected “b” and “L” compared to the control sample (non-supplemented without pectin) (i.e., “b” was 42.9 - 57.23 in comparison to 48.9 for the non-supplemented control sample and “L” was 26.25 - 48.93 in comparison with 36.35 for the non-supplemented control sample). “a” increased for all samples supplemented with pea fiber (16.3 and 17.3) but it remained in the same range (between 5.6-8.6) for all the other supplemented and control samples. ΔE, which represents the color difference between the supplemented orange juice and control samples, varied between 6.7 and 18.25. ΔE values were generally higher for samples supplemented with higher amounts of the pulse ingredients, but there was no significant difference between ΔE of 1% and 2% chickpea flour, 2% pea protein and 0.6% and 1.2% pea fiber samples. Besides, 1% lentil flour and 2% soy protein concentrate supplemented orange juice showed no significant color difference when compared with the control sample containing pectin ($P<0.05$). The smallest color difference was observed between the two control samples for both orange and apple juices, which indicated that pectin did not affect the color of both juices ($P<0.05$).

3.4 Sensory Properties of Beverages

Results of the sensory evaluation for flavour, mouthfeel and overall acceptance of the supplemented apple juice and orange juice samples are presented in Table 4. Samples were ranked from extremely like (1) to extremely dislike (9). Overall, the results showed that apple juice supplemented with 1% of all the pulse ingredients and also 2% soy protein concentrate were acceptable in terms of flavour in comparison with both control samples ($P<0.05$). For mouthfeel and overall acceptance, all supplemented samples were ranked significantly higher (i.e., less acceptable) in comparison with both controls. The control apple juice containing pectin was found to be as good as the control sample without pectin in terms of flavour, mouthfeel and overall acceptance. For orange juice, in terms of flavour, mouthfeel and overall acceptance, there were no significant differences found between all the supplemented beverages and the non-supplemented control sample, except for the 2% soy protein concentrate and 2% pea protein supplemented samples ($P<0.05$). It is also notable that apple juice or orange juice supplementation with 1% of each of the pulse ingredients resulted in overall acceptance scores of 5 or lower (i.e., neither like nor dislike or better scores). This may suggest that a 1% supplementation level could be a promising target for the creation of innovative products using pulse ingredients. Future studies and further formulation development work could therefore target this supplementation level.

Table 4. Sensory evaluation scores (ranged from extremely like = 1 to extremely dislike = 9) of supplemented apple and orange juice and control samples

Sample	Flavour	Mouthfeel	Overall acceptance
	Average ± SD	Average ± SD	Average ± SD
AJ control	3.64 ± 1.46 b	3.44 ± 1.26 b	3.40 ± 1.22 b
AJ control+ pectin only	3.48 ± 1.66 b	3.44 ± 1.15 b	3.44 ± 1.32 b
AJ + 2%SPC	4.68 ± 1.93 ab	5.16 ± 1.77 a	5.24 ± 1.69 a
AJ +1 %PP	4.64 ± 2.03 ab	5.00 ± 2.08 a	4.96 ± 2.07 a
AJ + 2 %PP	5.32 ± 1.93 a	5.28 ± 2.05 a	5.40 ± 1.80 a
AJ + 1 %CPF	4.92 ± 1.95 ab	5.20 ± 2.0 a	4.92 ± 1.77 a
AJ + 2 %CPF	5.48 ± 1.75 a	5.44 ± 1.29 a	5.48 ± 1.35 a
AJ + 1 %LF	4.32 ± 1.34 ab	4.68 ± 2.13 a	4.56 ± 1.52 a
AJ + 2 %LF	5.6 ± 2.08 a	5.72 ± 1.81 a	5.88 ± 1.92 a
OJ control	4.56 ± 1.91 cd	4.24 ± 2.00 c	4.68 ± 2.05 b
OJ control+ pectin only	4.88 ± 2.38 bcd	5.04 ± 2.14 bc	4.92 ± 2.28 ab
OJ + %SPC	6.24 ± 1.98 ab	6.28 ± 1.79 a	6.44 ± 1.73 a
OJ + 1 %PP	5.96 ± 1.88 abc	5.48 ± 1.80 abc	6.16 ± 1.97 ab
OJ + 2 %PP	6.4 ± 2.04 a	6.12 ± 2.18 ab	6.4 ± 2.10 a
OJ + 1 %CPF	4.48 ± 1.87 cd	4.96 ± 1.79 abc	5.00 ± 1.95 ab
OJ + 2 %CPF	5.48 ± 1.73 abcd	5.52 ± 1.32 abc	5.56 ± 1.41 ab
OJ + 1 %LF	4.32 ± 1.46 d	4.64 ± 1.70 bc	4.68 ± 1.77 b
OJ + 2 %LF	4.56 ± 1.35 cd	5.52 ± 1.19 abc	5.28 ± 1.36 ab
OJ + 0.6% PF	4.84 ± 1.31 bcd	4.32 ± 1.46 c	4.60 ± 1.25 b
OJ +1.25% PF	5.8 ± 1.63 abcd	5.36 ± 1.57 abc	5.72 ± 1.56 ab

Means with the same letter are not significantly different ($P<0.05$); AJ: apple juice; OJ: orange juice; SPC: soy protein concentrate; PP: pea protein; CPF: chickpea flour; LF: lentil flour; PF: pea fiber.

4. Conclusion

Functional properties of food ingredients in beverage applications are affected by a variety of factors including protein content, pH, ionic strength and temperature. This research illustrated differences in the functional properties of the different pulse ingredients studied. The physical analysis on the beverage systems showed that supplementation at all levels and in both orange and apple juice matrices increased pH and turbidity. Also, apple juice and orange juice supplementation with pulse ingredients decreased cloud stability, however higher level of supplementation resulted in a lower loss of cloud stability over storage time. Color of apple juice and orange juice was significantly affected by pulse supplementation and they were altered towards red and yellow hues respectively. In terms of sensory attributes (flavour, mouthfeel and overall acceptance), 1% or 2% of all pulse ingredients in apple juice and orange juice supplementation gave relatively acceptable products in comparison with the control samples. This result was highlighted for chickpea flour and pea fiber supplemented orange juice.

Considering the growing interest in healthier food products and the importance of continued innovation in different product streams, including the development of heathier beverages, there is good potential to examine the use of pulse ingredients in the formulation of pulse supplemented beverages. Further research on the sensory properties, storage stability and marketability of such pulse supplemented beverages would be useful.

Acknowledgement

The study was supported with funds from Pulse Canada and Agriculture and Agri-Food Canada.

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