Effect of some hydrocolloids blend on viscosity and sensory properties of raspberry juice-milk

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Abstract Raspberry juice-milk is an acidic dairy drink (ADD) including two main phases, milk phase (pH: 6.6–6.7) and raspberry juice phase (pH: 3.2 ± 0.1). Due to the low pH in this beverage, milk protein sedimentation is usual problem and therefore hydrocolloid is added as a stabilizer. Thus, in current study the influences of pectin, CMC and Kappa-carrageenan on the stability of the milk-raspberry juice drink and their blend synergistic effect were investigated. For this purpose milk-raspberry juice drink samples were prepared using pure pectin, CMC and Kappa-carrageenan at concentrations of 0.2 %, 0.3 % and 0.35 % respectively. Blends of pectin and Carboxymethylcellulose (ratios of 25:75, 33.4:66.6 and 34.3:65.7) at concentrations of 0.2 %, 0.3 % and 0.35 %, were added during a certain process. Moreover, the stabilization mechanisms were studied using apparent viscosity and sedimentation percent measurements. Based on the findings of the present study, the best fitted samples were the ones containing the blends of pectin and Carboxymethylcellulose which were more stable and viscose than samples including pure Carboxymethylcellulose ($P < 0.05$). Kappa-carrageenan can not prevent casein agglomeration in raspberry juice-milk individually, but in the presence of CMC or CMC and pectin it produces a stable drink. In general, with utilizing synergistic effect of gum blend

we can use lower gum concentration and decrease cost during manufacture.

Keywords Raspberry juice-milk · Stability · Sedimentation · Viscosity

Introduction

In many societies, more attention is given to the health effects of foods (i.e. mixed fruit juices and milk) (Pszczola 2005). Milk can be added to fruit beverages in order to improve iron bioavailability (Nebot et al. 2010). Studies have shown the anti-proliferative properties of black raspberry fruits in human colon (HT-29, HCT116), oral (KB, CAL-27), breast (MCF-7) and prostate (LNCaP) tumor cell lines (Seeram et al. 2006). But existence of agglomerated proteins in acidic milk drinks such as fruit juice-milk is a general problem. In the natural pH of milk casein micelles have negative charge but in acidic medium they have a net positive charge and trend to join with each other and undergo agglomeration. Hydrocolloids are added as stabilizers to prevent these phenomena (Tuinier et al. 2002; Saha and Bhattacharya 2010; Sakhale et al. 2011; Sanyal et al. 2011).

High methoxy pectin is a polysaccharide with negative charge and is a common stabilizer in acidic milk drinks (AMDs). (Jensen et al. 2010; Boulenguer and Laurent 2003; Kravtchenko et al. 1995; Tuinier et al. 2002). In addition stability of AMDs, depends on pH, the concentration and type of pectin used, the concentration of casein and the ionic strength as well as on homogenization and thermal treatment during processing (Sedlmeyer et al. 2004; Sejersen et al. 2007).

Carboxymethylcellulose (CMC) is an ionic derivative of cellulose and reported that in the pH below 5.2 electro-sorption of CMC caused CMC layer to adsorb on the surface of casein and prevent flocculation of casein micelles by

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steric repulsion. In addition, the non-adsorbed CMC increased the viscosity of serum and slowed down the sedimentation of casein particles (Du et al. 2009; Kotoki and Deka 2010).

Since CMC has lower cost than pectin and in same concentration it creates more viscous solution; therefore, pectin is going to be substituted with CMC in food industries. (Chen et al. 1996).

k-carrageenan exerts a stabilizing effect on milk k-casein due to the charge interaction, gets incorporated into the network and prevents whey separation (Yanes et al. 2002; Sanyal et al. 2011). The transition temperature (coil to helix (gelation)) of Kappa-carrageenan in aqueous solution depends on the ionic environment, mechanisms of carrageenan/milk mixtures investigated (Dalglish and Morris 1988; Xu et al. 1992). Kappa-carrageenan has a sulphate group per disaccharide (Langendorff et al. 2000).

The use of two or more hydrocolloids in the formulation of a food is to achieve a synergistic effect (Ahmed et al. 2005; Jana et al. 2010) and to improve rheological properties to the product, which may decrease cost during manufacture (Williams and Phillips 2000).

Materials and methods

Raspberry juice-milk samples supply

Black raspberry (*R. occidentalis*) fruits were purchased from a local market. Raspberry juice was extracted from the fruit and filtered with cotton cloth to remove pulp and seeds completely and stored at -18°C . For raspberry juice–milk preparation, 8 % (W/W) of sugar mixed with

hydrocolloids (W/W according to Table 1) was gradually added in water at 45°C (31.5%W/W), mixed for 5 min, then 30 % (W/W) fresh skimmed milk was added and mixed for 3 min. Finally 30 % (W/W) of raspberry juice added and mixed for 3 min. The beverages were homogenized (15 MPa, 50°C , APV homogenizer, Denmark), pasteurized (at 75°C for 25 second), and cooled down to 10°C . In the end, they were filled into 500 ml bottles, sealed and stored at 5°C for 7 days. The pH and Brix of the samples were 3.2 ± 0.1 , $11^{\circ}\pm0.3$, respectively. The overall experimental procedure was total of 14 formulations (Table 1).

Viscosity measurements

The apparent viscosity (cP) was measured at 20°C , 7 day after production (Brookfield Viscometer LVT, Massachusetts, USA). The speed was set from 1 rpm to 60 rpm and the appropriate spindle was used.

Sedimentation measurement

50 ml plastic centrifuge tubes were filled and sedimentation of the system was performed by centrifugation at 3000 g for 15 min (Omnifuge, Heraeus Sepatech, USA). The height of sediment was measured and its value (divided by the total height of sample in bottle and multiplied by 100) expressed as the sedimentation in percent. The total height of the drinks (HD) and the height of the sedimentations (HS) were measured. The extent of instability was characterized by sedimentation index (%) = 100 (HS/HE) . The higher the amount of sedimentation index, the larger the amount of aggregated proteins.

Determination of viscous synergism index (I_V)

When blended gum dispersion exhibited greater viscosity than the sum of the viscosities of the individual gum dispersions determined separately, the situation was considered as synergism.

These interactions were quantified using a “viscous synergism index”.

I_V viscous synergism index

$$IV = \eta_{i+j}/\eta_i + \eta_j$$

η_i, η_j apparent viscosity of each gum individually

η_{i+j} apparent viscosity of gum blend

For economical and practical reasons, blending of gum without synergism effect is not necessary (Hernandez et al. 2001).

Table 1 Composition of the used hydrocolloids (gums) of raspberry juice -milk samples

Sample	Pectin (%)	CMC (%)	Kappa-Carrageenan (%)
C ₁	–	0.2	–
C ₂	–	0.3	–
C ₃	–	0.35	–
P ₁	0.2	–	–
P ₂	0.3	–	–
P ₃	0.35	–	–
CP ₁	0.05	0.15	–
CP ₂	0.1	0.2	–
CP ₃	0.12	0.23	–
CK ₁	–	0.17	0.03
CK ₂	–	0.25	0.05
CK ₃	–	0.3	0.05
CPK ₁	0.05	0.2	0.05
CPK ₂	0.07	0.23	0.05

CMC carboxymethyl cellulose

Table 2 Influence of gum and gum blend on viscosity, Sediment % and sensory quality attributes of raspberry juice-milk samples

Formulation	Viscosity at 60 s ⁻¹ (cP)	Sediment (%)	Taste	Consistency	Odor	Overall acceptability
C ₁	46.0±0.21 ^a	53.0±0.27 ^a	3.4±0.13 ^a	2.7±0.17 ^a	3.6±0.12 ^a	3.4±0.13 ^a
C ₂	66.0±0.31 ^b	35.0±0.15 ^b	1.4±0.29 ^b	1.9±0.35 ^b	2.0±0.27 ^b	1.8±0.42 ^b
C ₃	72.0±0.34 ^b	53.0±0.27 ^a	0.0±0.00 ^c	0.0±0.00 ^c	0.0±0.00 ^c	0.0±0.00 ^c
P ₁	50.0±0.25 ^a	70.0±0.26 ^c	2.7±0.17 ^a	1.7±0.36 ^b	3.6±0.14 ^a	3.4±0.13 ^a
P ₂	97.0±0.33 ^b	82.0±0.29 ^c	2.7±0.17 ^a	3.3±0.12 ^d	3.0±0.10 ^a	3.6±0.12 ^a
P ₃	165.0±0.40 ^c	82.0±0.31 ^c	2.7±0.17 ^a	2.9±0.14 ^a	1.1±0.16 ^d	3.0±0.10 ^a
CP ₁	111.0±0.42 ^c	47.0±0.16 ^b	3.0±0.12 ^a	3.5±0.15 ^d	3.7±0.13 ^a	3.7±0.15 ^a
CP ₂	115.0±0.44 ^c	88.0±0.34 ^c	1.0±0.23 ^b	1.0±0.46 ^e	0.7±0.11 ^d	0.4±0.45 ^d
CP ₃	127.0±0.42 ^c	82.0±0.29 ^c	0.4±0.49 ^c	0.2±0.48 ^e	3.5±0.15 ^a	0.2±0.23 ^d
CK ₁	96.0±0.32 ^b	23.0±0.22 ^d	2.8±0.18 ^a	3.2±0.18 ^d	2.9±0.15 ^c	3.0±0.35 ^b
CK ₂	87.0±0.35 ^b	41.0±0.18 ^b	2.1±0.27 ^b	3.4±0.17 ^d	2.3±0.44 ^c	1.7±0.31 ^b
CK ₃	80.0±0.32 ^b	53.0±0.27 ^a	2.3±0.16 ^a	2.9±0.14 ^a	1.9±0.23 ^b	3.2±0.18 ^a
CPK ₁	115.0±0.39 ^c	41.0±0.16 ^b	2.9±0.11 ^a	3.0±0.11 ^d	3.2±0.19 ^a	1.6±0.32 ^b
CPK ₂	108.0±0.37 ^c	29.0±0.23 ^d	2.5±0.12 ^a	2.5±0.12 ^c	2.3±0.36 ^c	1.6±0.16 ^a

Different letters in a column differ significantly ($P<0.05$, $n=3$) C1–CPK2 refer to Table 1

Sensory analyses

Sensory properties including taste, consistency, odor and overall acceptability were evaluated using a multisampling difference test (4-points rating scale, 1=undesirable, 2=tolerable, 3=good, 4=desirable) based on a balanced incomplete block design by 10 trained panelists (Meilgaard et al. 1999; Azarikia and Abbasi 2009).

Statistical analysis

The analysis of variance (ANOVA) and least significant differences (LSD) tests were used to detect differences between mean values using SPSS software (Version 14.0, SPSS Inc.). All measurements were repeated at least 3 times.

Results and discussion

Apparent viscosity and sediment percent

The viscosity of raspberry juice-milk samples including pure and blend gums with different concentration at 20 °C determined in a shear rate of 60s⁻¹ is presented in Table 3. When the concentration of CMC and pectin was increased from 0.2 % to 0.35 % (w/w) the viscosity of samples increased but with increasing kappa-carrageenan concentration the viscosity decreased (Table 2).

Sulphate groups in kappa-carrageenan reacts with hydroxyl groups in CMC and pectin thus prevents their cooperation in increasing viscosity. In equal concentration of gums, Samples include pectin had more viscosity and lower sedimentation than those included CMC individually. In all samples the sedimentation increased with increasing in gum

concentration (Table 2). Lauren and Boulenguer 2003 showed that the sediment formed and viscosity in ADD increased with increasing the pectin concentration. Du et al. 2009 reported that above a certain concentration of CMC (0.2 %) depletion flocculation occurred leading to phase separation. At higher CMC concentrations, extended CMC chains start to overlap and entangle resulting in an unstable network structure. At higher polysaccharides concentrations with increasing steric repulsion between casein micelles, reaggregation of micelle droplets happen (Kastner et al. 1997).

Synergetic effects

Synergetic effects of gum blend have been found by different researchers (Zang 1999; Khouryieh et al. 2006; Abuin et al. 2010) in aqueous solutions of gums blend. The total gum concentration and ratio of gums in a blend affected the rate and the type of interaction (synergistic or antagonistic) as demonstrated by the viscosity measurements. These interactions were quantified using “viscous synergism index”, I_v (Eq. 1). Table 3 shows the I_v calculated at a shear rate of

Table 3 Viscous synergism index, I_v , of raspberry juice-milk samples with CMC and pectin gum blend at a shear rate of 60 s⁻¹ at 20 °C

Formulation	$\eta_i(\text{CMC})$	$\eta_j(\text{Pectin})$	$\eta_i + \eta_j$	$\eta_{(i+j)}$	I_v	Interaction between gum blend
CP ₁	46.1	50.3	96.4	111	1.15	Synergistic
CP ₂	66.5	97	163.5	115	0.7	Synergistic
CP ₃	72.5	175	247.5	127.5	0.5	No interaction

CMC carboxymethyl cellulose

CP₁, CP₂ and CP₃ refer to Table 1

60 s^{-1} . Synergistic interactions were observed in blends of pectin with CMC, under lower concentrations. Hydrogen bonding is responsible for synergistic interactions in a blend (Ghotra et al. 2009; Bresolin et al. 1998).

Kappa-carrageenan cannot prevent casein agglomeration in raspberry juice-milk individually, but in the presence of CMC or blend of CMC and pectin it produces a stable drink. In aqueous solutions, kappa-carrageenan undergoes a temperature and ionic environment dependent transition coil (disordered state) to helix (ordered or gelatin) structure (Piculell 1995). Pectin with low number of hydroxyl groups is disabling to prevent gel formation after the merely addition of kappa-carrageenan (Leskauskaitė et al. 1998).

Also, in the case of sedimentation amount cp_2 is lower than c_2 ($p < 0.05$), cpk_1 is lower than c_2 ($p < 0.05$), ck_2 is lower than c_2 ($p < 0.05$) and cpk_2 is lower than c_3 and p_3 ($p < 0.05$), in the same concentration.

Presence of κ -carrageenan showed the enhanced stabilization by CMC, as the sample with blend of this gums (Soukoulis et al. 2008).

Sensory

One main challenge in developing a beverage is to make it attractive from a sensory viewpoint (Lee and Coates 2003). Although hydrocolloids stabilize fruit juice-milk, they can influence the sensory properties (Soukoulis et al. 2008; Azarikia and Abbasi 2009). The sensory properties evaluated are shown in Table 2.

According to the sensory analyzing data, with increasing viscosity, odor decreases. An increase in gum concentration to determinate concentration has no effect on taste and more than that decrease the desirable taste of drinks. Before and after a distinctive viscosity, the consistency property became undesirable. Overall acceptability parameter is a resultant of odor, taste and consistency parameters. For an example P_1 and P_2 samples had equal taste score ($p > 0.05$), P_2 sample had more desirable consistency and P_1 sample had better odor, but in overall acceptability, P_1 sample had been superior.

Conclusion

In the presence of Pectin or kappa-carrageenan, sedimentation of samples including CMC decreased. Generally samples with pectin individually show more viscosity, lower sedimentation and better sensory property. In general, the gums concentration and gums blending, affected the stability of the raspberry juice-milk drinks.

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