EFFECT OF FABA BEAN AND CHICKPEA MUCILAGE INCORPORATION IN THE STRUCTURE AND FUNCTIONALITY OF KEFIR

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ABSTRACT

This investigation aimed to investigate the viability of kefir enrichment with mucilage extracted from faba bean and chickpea. Four formulations of kefir were studied: fermented milk (control); milk with 3% of faba bean mucilage, milk with 3% of chickpea mucilage and milk with 3% of inulin from artichoke (as prebiotic control). Kefirs were evaluated during 28 days storage time at refrigerated temperature. Microbial viability, physico-chemical properties (total titratable acidity, syneresis and pH), rheological properties (flow and dynamic shear rheology) and consumer's acceptability were evaluated. The number of bacteria significantly increased during storage period in all formulations. The pH decreases during storage whereas total titratable acidity increased as was expected. Kefir supplemented with mucilage showed slightly lower but not significantly different sensory acceptability scores in comparison to the control. The novel mucilage ingredients could be prebiotic source for improving kefir quality.

KEYWORDS: Kefir, legumes, mucilage, rheology, sensory test

INTRODUCTION

Kefir is a traditional beverage originated from Western and Central Asia obtained by fermentation of milk using kefir grains. It was part of the diet of people from Europe and America, but recently, it is getting popularity around the world. kefir grain have a complex and variable microbiological composition including lactobacilli (*Lactobacillus brevis*, *Lactobacillus acidophilus*, *Lactobacillus casei*, *Lactobacillus lactis*, *Lactobacillus bulgaricus* and *Lactobacillus plantarum*), which represent the largest portion (65-80%), *lactococci* (*Lactococcus lactis*, *Streptococcus thermophilus*, *Leuconostoc mesenteroides* and *Lactococcus cremoris*) and yeasts (*Kluyveromyces*, *Candida* and *Saccharomyces*) (Farnworth, 2003).

Similarly, to other dairy products, the enrichment of kefir with functional and nutritious ingredients is a topic of recent interest. A noteworthy trend in recent times is the addition of prebiotics for the improvement of the nutritional properties of fermented dairy products. Several studies involving the addition of prebiotic ingredients to dairy products have reported a positive effect, both on the growth of probiotic bacteria and on the sensory, rheological and physicochemical properties (Cruz et al., 2013; Oliveira et al., 2009).

There is great economic interest in finding new prebiotic-rich food matrices. Some plant-based matrices are good source of prebiotic compounds like inulin-containing chicory. Published data suggest that probiotic grow better in milk supplemented with legumes flour, thus suggesting a prebiotic potential. Lentil flour supplementation (1-3%) stimulated the growth of yoghurt strains with marginal pH change during 28 days storage (Zare et al., 2011). Lentil flour was superior to soy and other pulse ingredients (pea protein, pea fibre, chickpea flour and soy protein) in improving probiotic *Lactobacilli* growth in yoghurt (Zare et al., 2012). Also green lentil flour (4%) supplementation increased microbial growth selectively for yoghurts containing *Lb.acidophilus* and *B. lactis* during storage for 28 days (Agil and

Hosseinian, 2012). Faba bean flour supplementation (4%) stimulated bifidogenic microbial growth, increased titratable acidity and reduced pH during kefir storage (Boudjou et al., 2014).

Légumes appear to be a good source of dietary fibre, mucilage is a complex carbohydrate, that constitue a part of the dietary fiber (Motiwala et al., 2015; Sáenz et al., 2004) . Literature survey reveals that mucilage is used as a good source of prebiotic, enhancing lactic acid bacteria growth in kefir model (HadiNezhad et al., 2013; Saadi et al., 2017).

To the best of our knowledge, there is no information available about the effects of mucilage from legumes seeds addition on the rheological properties and sensory acceptability of dairy products.

This study aimed to evaluate the effect of mucilage incorporation from Faba bean minor and Chickpea mucilage in kefir. The effect on total bacteria count, physicochemical and rheological properties during 4 weeks of cold storage was investigated. Furthermore, the kefir consumer's acceptability was evaluated.

MATERIALS AND METHODS

Sample preparation

Legume samples consisting of faba bean (*Vicia faba L.*) minor and chickpea (*Ciser arietinum*) were from Skikda-Algeria and Bejaia-Algeria, respectively. Samples were cleaned, air dried, initially crushed in a traditional stone mill followed by an electric mill (Moulinex, France) then sieved (Tap sieve shaker AS200; Retsch GmbH, Haan, Germany) to pass a 500 µm screen. The powders were stored in refrigeration in sealed plastic bags until use.

Extraction of Crude Mucilage

It was followed the method described by HadiNezhad et al., (2013) ground chickpea and faba bean were extracted with distilled water (10:400, w/v), stirred for 3 h at 60 °C. The extracts were allowed to cold at room temperature and then centrifuged with a Sorvall Legend XTR centrifuge (Thermo Scientific, Ashville, NC, USA) at 4000 *g* for 20 min. Consequently, the supernatant was freeze-dried and the obtained fraction corresponded to the crude mucilage.

Preparation and Characteristics of Kefir

Kefir preparation was done according to the methodology described by Saadi et al., (2017). Four formulations were investigated: kefir with raw mucilage of faba bean minor (MWF), mucilage of chickpea (MCP), inulin of artichoc (IN) (at 3 %), and a control without fiber. The pH, total tritratable acidity (TTA), bacteria count in MRS agar at 37 °C during 24 h (Saadi et al., 2017)**.** Syneresis index of different kefir samples was determined according to the methodology described by Han et al., (2016) with modifications. Kefir (5 g) was prepared in centrifuge cups and centrifuged at 4000 *g* (Thermo Electron Led GmbH D-27520 osterode, Germany) for 10 min at 4°C. The clear supernatant was collected and weighed, the syneresis was calculated according to the following the Eq. 1:

$$\text{Syneresis (\%)} = (\text{Weight of supernatant (g)}/\text{weight of kefir sample (g)}) \times 100 \qquad \text{(Eq. 1)}$$

The color of kefir samples was measured by reflectance in spectrocolorimeter (Konica Minolta CM-3500) at 1, 7, 14, 21 and 28 days of storage by introduce them in a measurement window cap. Results were expressed in accordance with the CIELAB system using the illuminant D65 and 10º viewing angle. The parameters measured were L* (L*=0 [black], L*=100 [white], a*(+a*= red) and b* (+b*=yellow). For each formula measurements were carried out in three different batches, and four measurements were carried out in each batch.

Rheological analysis

The rheological analyses were carried out on days 1, 7, 14, 21 and 28 of refrigerated storage at 4°C by a control stress rheometer (ARG2TA Instruments). Stainless steel serrated plate geometry with 40 mm of diameter and 1 mm *gap* was employed. Rheological measurements were carried out at 20.0ºC. Time dependence behavior was studied by the hysteresis loop method. Shear stress was determined at shear rates between 1 and 100 s^{-1} in (up curve) and from 100 s^{-1} to 1 s^{-1} (down curve). Areas under the upstream data points (Aup) and under the downstream data points (Adown) as well as the Relative hysteresis area ((Aup-Adown)/Aup) x 100 were calculated. Shear stress versus shear rate in the up curve were adjusted to the power law model (Eq. 1)

$$\sigma = k\dot{y}^{n} \quad \text{(Eq. 2)}$$

Where σ is the shear stress (Pa), *k* is the consistency index (Pa s^{n}), $\dot{y}$ the shear rate (s^{-1}), and *n* the flow behavior index (dimensionless).

Oscillatory shear experiments were carried out at a maximum strain of 1% and the frequency varied between 10 and 0.01 Hz. The storage moduli (G'), loss moduli (G") moduli and loss tangent (tan δ), were determined. Before measurement the samples were always kept at room temperature for around 20 min, sample syneresis was removed and the samples were mixed softly with a spatula. All trials were carried out in triplicate.

Sensory test

Sensory test was carried out in a standardised test room (ISO, 2007). A total of 65 consumers recruited from IATA staff was employed. Samples were prepared the day before the test and were served (~15 ml) at refrigerated temperature in white plastic cups codified with three digit-numbers. Mineral water was served to consumers for cleaning their mouths. Samples were presented monodically to consumers following a Williams design for three samples (Macfie & Bratchell, 1989; Sahan, Yasar, & Hayaloglu, 2008; Macfie & Bratchell, 1989).

The consumers evaluated the odour, flavour, texture and overall acceptability of each sample using a 9-point hedonic scale ranging from 1 ("*dislike extremely*") to 9 ("*like extremely*"). The purchase intention of each sample was evaluated using a 5-point scale from 1 ("*definitely would not buy*") to 5 ("*definitely would buy*").

Statistical analysis

Statistical analyses were carried out with the software Statgraphics Plus 7.1 (Bitstream, Cambridge, Mn), and differences were considered significant at $p<0.05$.

For the sensory test, the data acquisition and statistical analysis were performed using Compusense *five* release 5.0 software (Compusense Inc., Guelph, Ontario, Canada).

RESULTS AND DISCUSSION

Physicochemical and microbiological analysis

The evolution of total bacteria (log CFU/mL) during kefir storage at days 1, 7, 14, 21 and 28 is shown in Table 1. All kefir samples showed marked increase in the total bacteria count on the day 7 compared to day 1. After day 7, the count remained constant until day 21 and decreased thereafter. Titratable acidity of kefir varied depending on storage time and supplementation (Table 1). K+MWF and K+MCP provided the greatest increase in the acidity between the 14 and 21 days of refrigerated storage around 16% and 10% respectively. Statistically significant ($p<0.05$) differences were found in TTA content between 1 and 28-day storage for all kefir samples.

In all the kefir samples studied pH decrease with storage time (Table 1). After 28 days' storage, K+IN had the lowest pH, followed by those supplemented with K+MCP and K+MWF. Similar results on the evolution of bacteria count , the TTA increment and pH decreasement during kefir storage were reported in recent works in kefir supplemented with faba bean flour, inulin, chickpea mucilage and flaxseed mucilage (Boudjou et al., 2014; HadiNezhad et al., 2013; Saadi et al., 2017). At the last day of cold storage (day 28), the number of total bacteria in kefir samples range from 7.4 to 8.16 log CFU/mL, which is upper the minimum recommended level of 7 log CFU/mL defined by the legislation during cold storage (Cruz et al., 2013; Purwandari et al., 2007).

Syneresis. At day 1 of storage all supplemented kefirs showed higher syneresis than the control (Table 1). Kefir supplemented with chickpea mucilage showed the highest percentage of syneresis followed by faba bean mucilage and inulin.

The control kefir showed a significant increase in syneresis with storage time, as was previously observed by Aryana and Mcgrew, (2007). The authors described that post acidification and reduction of pH in fermented milk causes the contraction of the casein micelles, which in turn results in a firmer and more cohesive structure. Therefore, syneresis was directly linked to acidification during storage.

On the contrary, in the supplemented kefir no increase in syneresis was observed during storage. After 21 days storage time both the mucilage kefirs showed a decrease in syneresis. After 28 days, the lowest significant syneresis value was found by the faba bean kefir. The reduction in syneresis from day 1 to 21 may be associated to an increase in total solid content, especially protein , starch, and fiber which have hydrocolloidal properties in the supplemented kefirs, which confers a stronger and more homogenous texture (Lucey et al., 2001). According to Brennan and Tudorica, (2008) ; Montanuci et al., (2012) higher firmness makes fermented milk less susceptible to serum separation. Fibers, have been reported to reduce syneresis in fermented milks during storage because of their high water holding capacity (Aportela-Palacios et al., 2005; Guven et al., 2005).

Rheological properties

Flow properties. Shear stress versus shear rate for the up and down curves are shown in Figure 1. The increase in shear stress with the increase in shear rate reveals the shear thinning behaviour of all the kefir samples. In all the shear rate range studied both mucilage kefir showed the highest values of shear stress and the control kefir the lowest.

Values of shear stress versus shear rate corresponding to the up curve were satisfactorily adjusted to the power law model for all formulations and storage time (values of R^2 always higher than 0.95). The values of the consistency (K) and pseudoplastic index are shown in Table 2. All kefirs were pseudoplastic fluids as evidenced by the flow behavior index (n<1). At all storage times, the kefirs supplemented with mucilage had the highest consistency index (*K*), and the lowest flow behavior index (values of n closer to 0), which reflects a thicker structure of the mucilage kefirs in comparison to inulin kefir and control. The thicker structure of mucilage kefirs is explained due to the protein, starch and fiber present in the crude mucilage.

Over the shear rate range of 0.1-100/s the power law equation was also successfully applied to study the flow properties of fermented milks (yoghurt) (Cruz et al., 2013; Debon et al., 2010; Yu et al., 2016).

In the experimental conditions applied (shearing time and range of shear rates) all the sample show hysteresis area. The hysteresis area among the up and down curves indicates that the sample's flow is time dependent. The area between the up and down curves (hysteresis area) is an index of the energy per unit time and unit volume needed to eliminate the influence of time in flow behaviour. To compare the hysteresis areas among the different kefir samples the parameter relative hysteresis was calculated, as comparison of straight loop areas between differently viscous systems may not render valid conclusions on the extension of time-dependent structural breakdown (Dolz et al., 2000). The relative hysteresis area for all the kefir samples are shown in Table 3. The highest relative hysteresis area was found in both the mucilage kefir, whereas the inulin kefir showed the lowest hysteresis area, implying that the energy required to break the structure was higher in the mucilage kefirs, which also indicates the most complex structure provided by the crude mucilage.

Viscoelasticity: dynamic testing. The dynamic testing provides information on the viscoelastic properties of kefirs. Figure 2a shows the dependence of the storage modulus (G') and the loss modulus (G") with frequency in the first day of storage. Figure 2b shows the tan δ versus frequency in the first day of storage. In Table 2 the values of G', G'' and tan δ at 1 Hz are shown. Similarly to yoghurt viscoelastic properties, the kefir reveal a weak gel behavior with values of G' always higher than G'' and a soft dependence with frequency (Cruz et al., 2013; Yu et al., 2016).

The addition of inulin and mucilages influenced the viscoelastic behavior significantly (p<0.05). Independently of storage time, the values of G' and G" were higher in MCP (sample with mucilage of chickpea), followed in decreasing order by MWF (sample with mucilage of faba bean) and IN (sample with inulin), which showed significantly the lowest G' values. A very small difference in viscoelasticity tan δ (G''/G') was found among the different kefirs. The lowest viscoeslasticity (values of tan δ closer to 1) was found by the control kefir sample, with no significant differences among the inulin and the mucilage kefirs.

The lowest G' and G'' values of the inulin kefir agree with previous results found with the addition of inulin to yoghurt samples. Paseephol et al., (2008) found a decrease in gel strength in yoghurt supplemented with inulin at different levels (0.2-0.8%). This trend was explained by the fact that inulin formed aggregates with proteins in yoghurt through hydrogen bonds playing as structure breaker, preventing the formation of the protein network (Chiavaro et al., 2007).

The values of G' and G" in all the kefirs samples increase with the storage time p<0.05. In fact other authors observed the same trend with yoghurt (Cruz et al., 2013; Donkor et al., 2007; Vasiljevic et al., 2007). The effect was associated with the large number of protein interactions and rearrangements occurring during storage (Ozer et al., 1997).

Colour. The effect of kefir supplementation and storage in the instrumental colour parameters is shown in Table 3. On the first day of cold storage inulin and faba bean mucilage supplemented samples had significantly lower lightness and higher a* and b* values comparing to control and MCP sample. Colour parameters did not show differences along the storage time, this behaviour was similar to that observed in yoghurts supplemented with dietary fibre from apple, inulin and oligofructose (Aryana and Mcgrew, 2007; Staffolo et al., 2004). According to these authors, a factor that influences the colour of the product is the colour of the ingredients used. The color measurements indicate that the inulin and faba bean mucilage supplemented kefir had lower lightness, less greenness and more yellowness in comparison with control kefir and chickpea mucilage ingredient.

Sensory test. Table 4 shows the results of sensory hedonic evaluation of the different kefirs by a consumer panel. The supplemented kefir showed lower values of acceptability than the control, although the differences found were small and no significantly different. No significant (p<0.05) differences in odour, texture, overall acceptability and purchase intention among the control and the mucilage enriched kefir were found. These results indicate that mucilage supplementation of kefir will not alter significantly consumer acceptability of the product. Ertekin and Guzel-seydim, (2010) found that odour and taste scores of kefir samples with or without supplementation of inulin were no different.

CONCLUSION

This study was conducted to investigate the potential of faba bean minor and chickpea mucilages to boost the bacterial growth in a kefir system, followed by rheological behavior during storage and sensory acceptability of the final product. In the rheological evaluation was observed an increase in viscoelasticity with storage time. Mucilage supplementation increased the viscosity comparing to kefir control. Mucilage from chickpea and faba bean in kefir resulted in a slight decrease of sensory acceptability but without significant differences in odor and texture attributes. The results demonstrated that mucilages act as a good source of complex carbohydrates, enhancing lactic-acid bacteria growth in kefir. Legume's mucilage as food ingredient could also affect the probiotic functionality in human gut. Clinical investigations to determine in vivo prebiotic and probiotic activity of mucilage’s will be an interesting future study.

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Figure captions

Fig 1. Flow curves of Kefir samples in the first day of storage. Control Kefir (K), Kefir supplemented with faba bean mucilage (K+MWF), with chickpea mucilage (K+MCP) and with inulin (K+IN).

Fig 2.a Storage modulus (G') and loss modulus (G") versus frequency in the first day of storage. Control Kefir (K), Kefir with faba bean mucilage (K+MWF), chickpea mucilage (K+MCP) and inulin (K+IN).

Fig 2.b Tan δ versus frequency in the first day of storage. Control Kefir (K), Kefir with faba bean mucilage (K+MWF), chickpea mucilage (K+MCP) and inulin (K+IN).

Table 1. Effect of storage on the characteristic of kefir[ab]

Parameter	Units	Days	Kefir samples			
			K	K+IN	K+MCP	K+MWF
Bacterial enumeration	Log UFC/ml	1	7.46±0.05aA	7.65±0.07aA	7.78±0.01aB	7.82±0.01aC
		7	7.57±0.02bA	8.25±0.02bB	9.06±0.4cC	9.36±0.04eD
		14	7.71±0.04cA	8.40±0.05cB	9.0±0.2cC	9.1±0.2dD
		21	7.6±0.1bcA	8.22±0.03bcB	8.2±0.3bC	8.31±0.09cD
		28	7.4±0.1aA	7.8±0.1dB	8.16±0.09bC	7.94±0.09bD
pH		1	4.3±0.2cA	4.31±0.03cdB	4.2±0.1cC	4.33±0.01dC
		7	4.23±0.05cA	4.12±0.05cB	4.22±0.01cC	4.23±0.04cB
		14	3.96±0.05bB	3.78±0.02bA	3.76±0.05bcC	4.06±0.05bcC
		21	4.03±0.02bB	3.80±0.05bA	3.4±0.1bC	3.9±0.1bCD
		28	3.80±0.01aB	3.03±0.05aA	3.2±0.1aC	3.51±0.02aC
TTA	%	1	0.73±0.02aB	0.81±0.01bA	0.58±0.04aC	0.76±0.04aCD
		7	0.79±0.02bB	0.63±0.01aA	0.64±0.02bC	0.79±0.02aC
		14	0.76±0.04abAB	0.87±0.05cA	0.72±0.01cB	0.82±0.04bBC
		21	0.79±0.07bB	0.84±0.05bcA	0.83±0.07dC	0.9±0.09cD
		28	0.81±0.08cB	0.90±0.01dAB	0.94±0.04eD	0.87±0.05bcCD
Syneresis	%	1	70.7±1.2bB	73.7±0.8dA	72.5±0.1cC	74.1±2.1eD
		7	68.9±0.2aB	71.3±1.6cA	69.2±0.3abC	72.4±1.7dC
		14	70.7±0.2bB	68.9±0.1abA	68.7±0.6aC	68±2.7aC
		21	72.7±0.8cB	66.7±0.7aA	71.3±0.8cBC	69.1±1.0abBC
		28	75.0±0.2dB	71.3±0.5cAB	78.4±0.3dC	70.8±0.6cC

[a]Means ± SD, n=3, the values of the same column by parameter with different tiny letters are significantly different and the values in the same row with different capital letters are significantly different ($P<0.05$). [b]K, Control kefir; K+MWF, kefir with mucilage of faba bean; K+MCP, kefir with chickpea mucilage, K+IN, and kefir with inulin, storage at 4 °C during 28 days; UFC: Unit forming colonies; TTA: Total Titrable Acidity %.

Table 2. Storage modulus (G'), loss modulus (G"), loss angle (Tg δ) on shear stress at 1H and flow parameters during storage time

Viscoelasticity (dynamic testing)	Units	Storage Time Days	Kefir Samples			
			K	K+IN	K+MCP	K+MWF
G'	Pa	1	122.3±1.4aB	99.5±2.6aA	109.9±12.4aAB	119.4±6.5aB
		7	140.5±2.9bB	116.0±3.0bcA	137.8±0.4bB	162.6±10.6cC
		14	143.4±11.2abB	122.9±0.8cA	173.1±13.4cC	133.8±9.8bB
		21	159.3±7.4cB	148.7±9.6cA	138.7±4.9bAB	153.1±0.6bcB
		28	121.6±6.1aA	111.8±8.1bA	152.4±4.3bB	150.8±8.6bcB
G"	Pa	1	34.1±0.1bB	27.3±0.6 aA	28.4±3.0aA	32.1±1.7aB
		7	34.6±0.6bcB	28.2±0.8aA	33.5±0.07bB	39.2±2.4eC
		14	35.0±2.5bA	32.7±1.7bA	42.8±3.3cB	34.1±2.6bcA
		21	37.4±1.6cB	37.2±3.6bA	33.1±0.8bcA	35.2±1.0deAB
		28	29.9±1.7aA	28.1±2.6aA	36.5±0.2bB	34.3±1.5abB
Tg δ		1	0.290±0.002cC	0.270±0.002dB	0.250±0.002cA	0.270±0.002cB
		7	0.250±0.001aB	0.240±0.005aA	0.240±0.001bA	0.240±0.009bA
		14	0.25±0.02baAB	0.26±0.02cB	0.250±0.002cA	0.240±0.004bA
		21	0.270±0.001bC	0.250±0.008bB	0.240±0.002bA	0.240±0.003bA
		28	0.250±0.001aB	0.250±0.005bB	0.230±0.001aA	0.230±0.002aA
Flow parameters		1	10.8±0.2aA	11.3±0.1 bA	14.7±1.6 aB	13.0±2caAB
K	Pa s^{-1}	7	12.48±0.08bB	10.72±0.01aA	14.7±0.9abC	15.0±0.9abC
		14	12.7±0.2bcB	12.1±0.3cA	16.9±0.2bcD	13.1±0.3abC
		21	12.7±0.2cA	12.1±0.3cA	16.9±0.2bcB	13.1±0.3abB
		28	13.0±0.1cA	11.89±0.06bcA	15.6±1.2bB	16.7±0.2bB
n		1	0.190± 0.007bC	0.173±0.004bC	0.090±0.002aA	0.13±0.02aB
		7	0.216±0.003dBC	0.222±0.004dC	0.19±0.02cAB	0.18±0.02bA
		14	0.209±0.003cC	0.180±0.004bB	0.16±0.01bA	0.19±0.09bB
		21	0.213±0.0005cdB	0.199±0.010cB	0.173±0.009bcA	0.178±0.005bA
		28	0.183±0.003aB	0.145±0.005aB	0.15±0.01bA	0.175±0.003bA
		1	12.2±0.7aB	10.9±1.1aA	14.4±0.1aD	13.3±0.3aC
Relative Hysteresis	Pa s^{-1}	7	13.74±0.07bcB	11.4±0.2abA	15.6±1.3abC	14.7±2.8abC
		14	10.8±0.2aA	13.6±0.3cB	16.5±1.3bcC	16.7±1.0bC
		21	10.3±0.6aA	12.5±1.6bcB	17.2±0.3bcC	16.9±0.7bC
		28	13.8±0.1aA	15.33±0.06dB	17.9±0.3cC	19.8±0.7cD

[a]Means ± SD, n=3, the values of the same column by parameter with different tiny letters are significantly different and the values in the same row with different capital letters are significantly different (P<0.05). [b]K, Control kefir; K+MWF, kefir with mucilage of faba bean; K+MCP, kefir with chickpea mucilage, K+IN, and kefir with inulin, storage at 4 °C during 28 days; G': Dependence of storage modulus; G": loss modulus. Tg δ: loss angle=G"/G'; k: consistency index, Pa s^{-1}; n: flow behavior index, dimensionless.

Table 3. Color parameter changes during cold storage

Color Parameters	Storage Time Days	Kefir Samples			
		K	K+IN	K+MCP	K+MWF
L*(D65)	1	91.00±0.08aB	89.20±0.03aA	91.00±0.01aB	89.2±0.03aA
	7	91.2±0.1bC	89.86±0.01cB	91.23±0.02bC	89.5±0.2bA
	14	91.27±0.04cC	89.72±0.01bB	91.26±0.08bC	89.43±0.07bA
	21	91.31±0.02bcC	89.94±0.02dB	91.37±0.07bC	89.6±0.2abA
	28	91.36±0.01cC	89.84±0.01cB	91.38±0.03bC	89.69±0.08bA
a*(D65)	1	-1.02±0.02cB	-0.34±0.02dA	-1.05±0.01dB	-0.01±0.009cC
	7	-1.18±0.02aA	-0.68±0.01aB	-1.18±0.01aA	-0.17±0.04abC
	14	-1.11±0.01bcA	-0.58±0.01cB	-1.12±0.02cA	-0.18±0.02abC
	21	-1.13±0.01bcA	-0.66±0.01abB	-1.16±0.01abA	-0.14±0.04bC
	28	-1.16±0.03aA	-0.65±0.01bB	-1.17±0.01aA	-0.20±0.08aC
b*(D65)	1	9.99±0.09aA	12.02±0.02eC	10.25±0.04bB	10.23±0.02cB
	7	9.58±0.05aA	10.82±0.01cC	9.57±0.04aA	9.8±0.1abB
	14	9.55±0.07aA	10.93±0.01dB	9.7±0.2aA	9.70±0.05aA
	21	9.55±0.05aA	10.71±0.01bD	9.72±0.01aB	9.81±0.01bC
	28	9.49±0.02aA	10.36±0.01aB	9.72±0.01aA	9.71±0.07aA

Kefir (K, control) supplemented with mucilage faba bean (K+MWF), chickpea mucilage (K+MCP) and inulin (K+IN) during refrigerated storage (4 °C, 28 days). Lightness (L*=0 black, L*=100 white), a* (+a*= red, -a*=green) and b* (+b*=yellow, -b*=blue). Each value represents the Mean ± Standard Deviation, n=3, the values of the same column by parameter with different tiny letters are significantly different and the values in the same row with different capital letters are significantly different ($P<0.05$).

Table 4. Sensory analysis of kefir

	Kefir samples				
	K	K+MCP	K+MWF	*F*	*P*
Odour	6.6 a	6.4 a	6.3 a	1.26	0.279
Flavour	6.1 a	5.1 b	4.7 b	18.66	<0.001
Texture	5.7 a	5.3 a	5.6 a	1.52	0.22
Overall acceptability	5.9 a	5.0 b	5.3 b	7.68	<0.001
Purchase intention	3.0 a	2.3 b	2.6 b	10.38	<0.001

Kefir (K, control) supplemented with mucilage faba bean (K+MWF), chickpea mucilage (K+MCP) during refrigerated storage (4 °C, 28 days). Acceptability (9-point hedonic scale) and purchase intention (5-point scale) data. F from one-way ANOVA (samples) and probability. Each value represents (means, n=3). Means in a same row with different letters are significantly different ($p<0.001$).

Fig.1

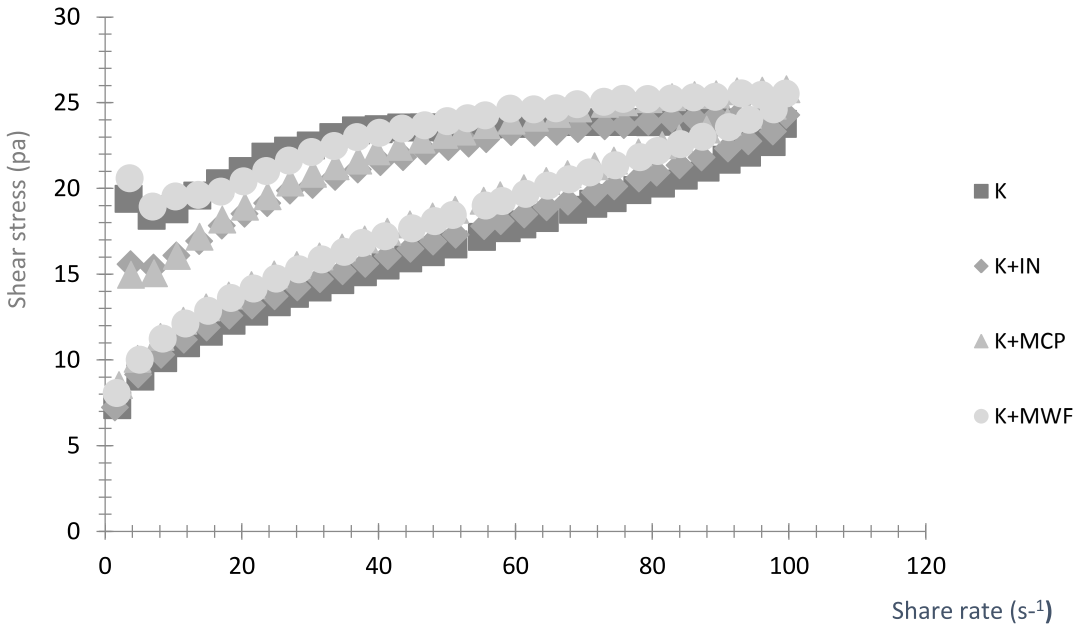
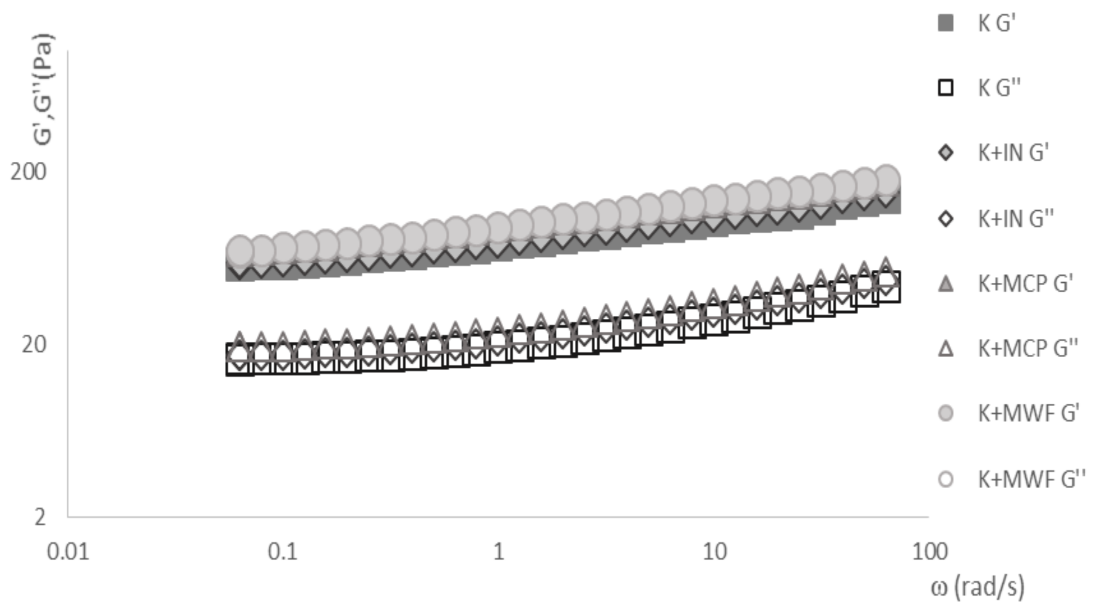
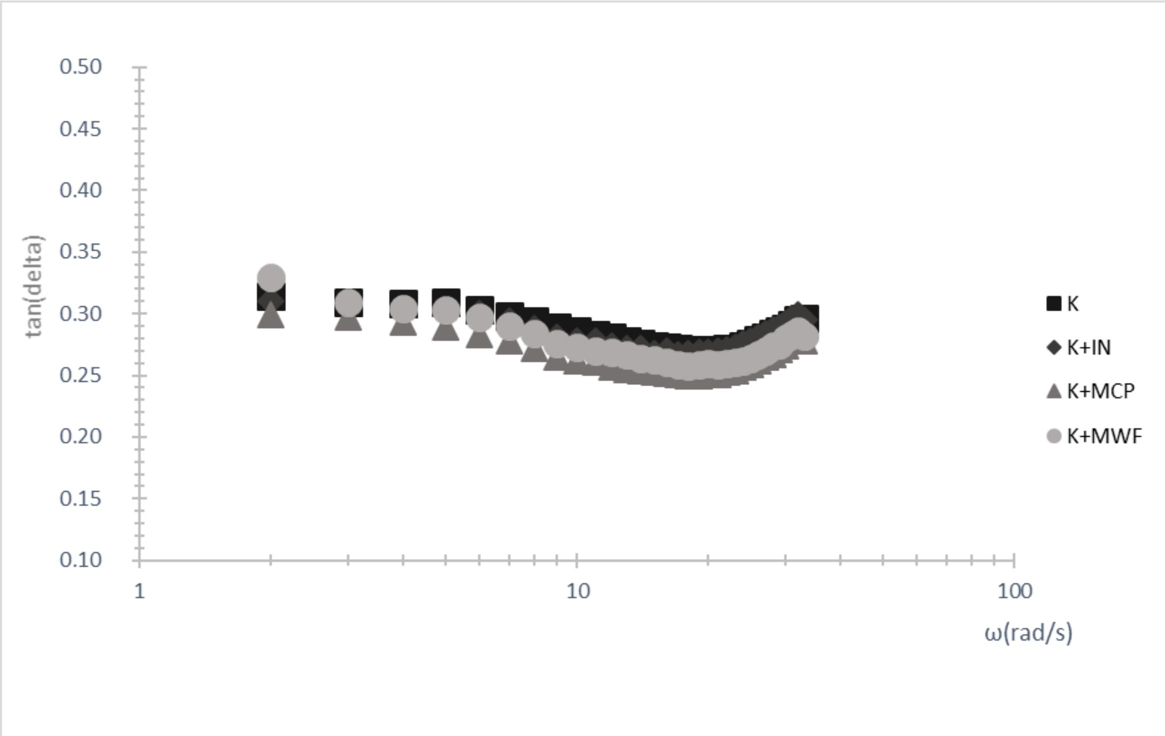

30
25
20
15
10
5
0
Shear stress (pa)
0
20
40
60
80
100
120
Share rate (s-1)
K
K+IN
K+MCP
K+MWF

Fig. 2a



G',G''(Pa)
200
20
2
0.01
0.1
1
10
100
ω (rad/s)
K G'
K G''
K+IN G'
K+IN G''
K+MCP G'
K+MCP G''
K+MWF G'
K+MWF G''

Fig.2b


0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
tan(delta)
1
10
100
ω(rad/s)
K
K+IN
K+MCP
K+MWF