Effect of Storage on Texture and Microbiological Stability of O-W Emulsions with Inulin

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Abstract

Glibowski P., Kordowska-Wiater M., Glibowska A. (2011): **Effect of storage on texture and microbiological stability of o-w emulsions with inulin**. Czech J. Food Sci., **29**: 137–144.

The aim of this study was to characterise the effect of storage at 8°C on the texture and microbiological stability of oil-in-water solid emulsions containing inulin (20% w/w) and rapeseed oil (20% w/w). The samples were analysed within 24 h from the production and after 7, 14, 28, 42, and 56 days of storage. Whey protein isolate (3% w/w) or polyglycerol polyricinoleate (1% w/w) were used as emulsifiers and half of the samples were chemically preserved with potassium sorbate (0.2% w/w). Hardness, adhesiveness, and cohesiveness did not change significantly ($P \leq 0.05$) during storage. Most of the samples were microbiologically stable. Only the application of the protein emulsifier had an effect on the intensive growth of microorganisms. The shelf-life of low-fat chemically preserved products based on inulin can be established to be two months. Chemical preservation of the products with non-protein emulsifiers is not necessary. Sensory evaluation of spreads containing inulin revealed a significant decrease in smoothness and meltability in the mouth and good spreadability comparable with commercial products without inulin.

Keywords: inulin; microbiological stability; oil-in-water emulsions; texture; spreads

Inulin is a storage carbohydrate found in many plants especially in *Composite* family. Industrially is it nearly exclusively produced from chicory (Franck 2002). Inulin is a mixture of fructose polymers of various lengths with β(2–1) glycosidic bonds, terminated generally by a single glucose unit (Ronkart *et al.* 2006). Native inulin has the DP (degree of polymerisation) of 2–60 (Franck 2002) but HP (high performance) inulin has an average DP of about 23–25, depending on the manufacturer.

Water inulin solutions turn into white paste-type gels which can be applied as a fat mimetic (Kim *et al.* 2001). Inulin was successfully applied as a fat substitute in sausages (Mendoza *et al.* 2001; Garcia *et al.* 2006; Hadorn *et al.* 2007) or yogurts (Guven *et al.* 2005). It improved the taste of ice cream (El-Nagar *et al.* 2002), and was applied for nutritional reasons in pasta (Brennan *et al.* 2004) or bread (Brien *et al.* 2003).

From the nutritional point of view, inulin is a dietary fiber (Hond *et al.* 2000; Slavin 2003), has prebiotic effects (Gibson & Roberfroid 1995), and is well fermented by intestinal bacteria (Roberfroid *et al.* 1998). It reduces the lipids level in blood (Williams 1999), and increases the absorption of calcium by the body (Griffin *et al.* 2003). Inulin present in starchy products reduces the glycaemic index (Brennan *et al.* 2004).

Many authors describe inulin as an ingredient used for margarine or spreads production

Supported from resources for the science in years 2007–2010 as research project.

(Niness 1999; Franck 2002), however, there is only a limited number of studies focusing on physico-chemical properties of model systems which could be useful in the table spreads production (Rooyakkers *et al.* 1994). Inulin application as a texture factor in food may present some problems. These result from inulin high susceptibility to thermal treatment (Bot *et al.* 2004; Glibowski & Wasko 2008). Nonetheless, inulin functional and nutritional properties seem to be so attractive that the worldwide consumption of this carbohydrate will probably increase in the coming years.

Chiavaro *et al.* (2007) studied the effect of storage time on rheological properties of inulin gels. However, to the best of our knowledge, there is no information available on microbiological stability of model systems containing inulin which can be applied in low fat table spreads. There is also limited information about inulin in emulsion systems. The aim of this study was to characterise the effects of storage on the texture and microbiological stability of oil-in-water solid emulsions containing inulin. Besides, the effects of two different emulsifiers, whey protein isolate (WPI) and polyglycerol polyricinoleate (PGPR), and chemical preservation with potassium sorbate (KS) were also analysed in this study. The last part of this study was the sensory evaluation of the spreads containing inulin.

MATERIALS AND METHODS

Materials. Inulin Frutafit® TEX! was kindly delivered by the Sensus Operations C.V. (Roosendaal, the Netherlands). Inulin was extracted from chicory root and its average degree of polymerisation was ≥ 23 (producer's data). GRINDSTED® PGPR 90 was donated by Danisco Poland. (Poznan, Poland). WPI Extensor (95% protein in dry mass, producer's data) was a gift from Lacma (Nadarzyn, Poland). KS was obtained from Hortimex (Lublin, Poland). Canola oil, spreads, and margarine were purchased from a local supermarket. Microbiological media: Plate Count Agar (PCA), Yeast Extract Chloramphenicol Agar, Brilliant Green Bile Broth, Baird-Parker Agar, Buffered Pepton Water, Rappaport-Vasiliadis Broth, Brilliant Green Agar, XLD Agar, Half-Fraser, Fraser Broths, Palcam, and Oxford Agars were obtained from BTL (Lodz, Poland), and all supplements were from Oxoid (Cambridge, UK) or Merck (Darmstadt, Germany). All other chemicals used were of analytical grade supplied by POCH Katowice SA (Katowice, Poland).

Sample preparation. The composition of the samples is given in Table 1. Samples I, IK, E, EK were prepared using inulin suspension in distilled water at 20°C. To avoid clump formation, inulin was sprinkled into the beaker through a sieve during mixing with a magnetic stirrer. Every suspension was mixed for 3 min including inulin addition (about 1 min). In the case of chemically preserved samples, KS was added immediately after inulin addition. The suspensions were poured into conical flasks and heated up to 70°C in a water bath at a heating rate of 16°C/minute. Samples I, IK after heating were poured into plastic cylindrical containers 35 mm in inner diameter, the lids were affixed to prevent evaporation. To obtain samples E and EK, inulin solutions were homogenised with hot (70°C) canola oil and PGPR in a laboratory homogeniser H 500 (Pol-EkoAparatura, Wodzislaw Slaski, Polska). Homogenisation lasted 1 min at rotational speed 10 000 per minute. Afterwards, the emulsions were poured into the final containers. In the case of W and WK samples, the

Table 1. Composition of the samples in % (w/w)

Sample	Inulin	Rapeseed oil	PGPR	WPI	KS
E	20	20	1	–	–
Ep	20	20	1	–	0.2
W	20	20	–	3	–
Wp	20	20	–	3	0.2
I	20	–	–	–	–
Ip	20	–	–	–	0.2

PGPR – polyglycerol polyricinoleate; WPI – whey protein isolate; KS – potassium sorbate

procedure differed only at the beginning when inulin suspension was followed by WPI dispersion. Because WPI was an instant product, the WPI solution was mixed for 3 minutes. All the containers and the homogeniser removable parts were sterilised at 121°C. The non-removable parts of the homogeniser coming into contact with the samples were wiped with 96% ethanol. Immediately after obtaining the samples, these were put into a thermostatic cabinet and stored at 8°C. The samples were analysed within 24 h from the production and after 7, 14, 28, 42, and 56 days of storage. The samples for the sensory evaluation were prepared by mixing commercial margarine (sample A) and spreads (samples B and C) with 20% inulin gel (sample I) at 2:1 ratio (samples 2A1I, 2B1I, and 2C1I, respectively) and 1:1 ratio (samples 1A1I, 1B1I, and 1C1I, respectively). The inulin gel and commercial products were mixed with 0.5% PGPR at room temperature using a hand mixer. Samples A, B, C were not mixed before the sensory analysis. The composition of the samples for sensory evaluation is given in Table 8. The samples were kept for 22 h at 8°C in a thermostatic cabinet before the sensory evaluation.

Rheometry. The apparent viscosity measurements were conducted using a Haake RS 300 rheometer (Haake GmbH, Karlsruhe, Germany) equipped with parallel plate geometry (both 35 mm diameter and serrated). The samples were analysed after their storage for 1 h at room temperature. Each sample was placed on the plate, the lift was moved and the upper plate took the measuring position (1 mm gap). All rheological experiments were conducted at 20°C. The temperature was controlled by a Haake DC30 circulator water bath (Haake Technik GmbH, Vreden, Germany). The apparent viscosity was measured at 20 s^{-1} shear rate for 120 seconds. For analytical purposes, the average value was calculated from the 90^{th}, 105^{th}, and 120^{th} s of measurement. The parameters chosen were the same as for the table fats analysis (Glibowski *et al.* 2008).

Texture analysis. The instrumental texture analyses were performed according to the modified TPA method previously described by Glibowski *et al.* (2008). Briefly, the texture was analysed by two sequential compression events at the crosshead speed 1 mm/s on 15 mm depth, separated by a relaxation phase of 15 s using a TA-XT2i texture analyser (Stable Microsystems, Godalming, UK) equipped with a cylindrical stainless steel probe (1 cm diameter). The analyses were performed immediately after storage at 8°C without removing the samples from the containers. Hardness, adhesiveness, and cohesiveness were followed for the purpose of this study. Hardness is defined as the force necessary for obtaining the defined probe deformation. Adhesiveness is the work necessary for overcoming the force of attraction between the area of foodstuff and other solids coming into contact with them. Cohesiveness is defined as the forces of internal bonds, which keep the product as a whole (Domagala *et al.* 2006).

pH. pH was measured with a pH meter CP-401 (Elmetron, Zabrze, Poland).

Microbiological analyses. Total aerobic mesophilic bacteria were enumerated on PCA after incubation of the plates at 30°C for 48 h (EN ISO 4833:2003). Yeasts and moulds were enumerated on yeast extract chloramphenicol agar by using the surface plating technique after incubation at 25°C for 72–96 h (PN-ISO 7954:1999). Coliforms detection was performed in brilliant-green bile broth by most probable number (MPN) method after incubation at 30°C for 48 h (PN-ISO 4831:1998). The formation of gas in Durham tubes and yellow colour were taken as positive results for coliforms. For *Staphylococcus aureus* enumeration, serial dilutions of the samples were plated on Baird-Parker agar with egg-yolk emulsion and telluride solution and incubated at 37°C for 48 h (PN-EN ISO 6888-1: 1999). The presence of *Salmonella* in 25 g was confirmed by pre-enrichment in buffered peptone water for 24 h at 30°C, followed by selective enrichment in Rappaport-Vasiliadis liquid medium at 43°C for 48 h and plating on brilliant green agar and XLD agar (PN-ISO 6579:1998). The incidence detection of *Listeria* sp. in 25 g consisted of pre-enrichment in Half-Fraser broth, selective enrichment in Fraser broth, and selection of colonies on Palcam and Oxford agars after incubation at 37°C for 48 h (PN-EN ISO 11290-1:1999). Lipolytic microorganisms were detected on agar with tributyrin according to the method described by Davis (1981). For the enumeration of microorganisms, from three to eight decimal dilutions of each sample were prepared depending on the foreseen contamination. Each microbiological analysis was performed in duplicate.

Sensory evaluation. The sensory evaluation was conducted according to PN-ISO 6564:1999. Six experts examined and tasted the samples and recorded their perceptions by making marks on a series of

Table 2. Apparent viscosity (Pa·s) changes in inulin pastes and inulin-oil emulsions as an effect of storage at 8°C

Sample	Storage time (days)				
	1	7	14	28	56
I	$7.70^{c} \pm 1.23$	$9.96^{b} \pm 1.04$	$10.59^{ab} \pm 0.89$	$11.26^{ab} \pm 1.04$	$11.86^{a} \pm 1.83$
Ip	$5.65^{c} \pm 1.25$	$7.47^{b} \pm 1.29$	$7.54^{b} \pm 0.79$	$8.87^{a} \pm 1.00$	$9.78^{a} \pm 0.95$
E	$8.88^{c} \pm 1.42$	$10.21^{b} \pm 1.24$	$10.95^{b} \pm 1.30$	$11.52^{ab} \pm 1.50$	$12.50^{a} \pm 1.23$
Ep	$6.22^{c} \pm 0.39$	$8.48^{b} \pm 0.34$	$9.85^{a} \pm 0.37$	$9.66^{a} \pm 0.48$	$8.84^{b} \pm 0.90$
W	$12.16^{c} \pm 1.28$	$13.06^{c} \pm 1.21$	$12.54^{c} \pm 0.68$	$14.24^{b} \pm 1.58$	$16.48^{a} \pm 0.68$
Wp	$9.27^{b} \pm 0.50$	$9.05^{b} \pm 1.18$	$11.80^{a} \pm 1.38$	$11.44^{a} \pm 0.54$	$12.41^{a} \pm 0.76$

Data are presented as means ± standard deviation; Means in the same row with different superscripts are significantly different, $P \leq 0.05$; For explanation I–Wp see Table 1

10 line scales, each with the positive descriptor at the far right end of the line and the negative descriptor at the left end. They examined spreadability (0 – unspreadable, 10 – easy to spread), smoothness (0 – undetectable, 10 –smooth), meltability in mouth (0 – not complete, 10 – rapid), margarine flavour (0 – undetectable, 10 – strongly detectable), general acceptance (0 – bad, 10 – very good).

Statistical analysis. Hardness, adhesiveness, cohesiveness, apparent viscosity and pH measurements were completed in three independent tests. Each analysis was performed in triplicate. All data including the sensory evaluation were analysed by the Statistical Analysis System (SAS Enterprise Guide 3.0.3.414) using the ANOVA procedure for the analysis of variance and Student-Newman-Keuls *t*-test for ranking the means.

RESULTS AND DISCUSSION

Of all the analysed characteristics of instrumental texture, hardness slightly increased during the first weeks of storage (Table 3) this increase, however, was not significant ($P \leq 0.05$).

The analysis of apparent viscosity allowed obtaining data which characterised the changes in the samples during storage (Table 2). Apparent viscosity increased during storage both in the samples with the emulsifiers and in the inulin pastes. Rheological properties of the analysed samples changed significantly ($P \leq 0.05$) after one week of storage. Most samples achieved rheological stability after two weeks of storage. Further storage did not have any significant influence on the apparent viscosity in most samples. The presence of inulin had most likely a considerable influence on the rheological parameters during the first weeks of storage. The increase in apparent viscosity values was probably caused by the conformational changes of the inulin chains (Chiavaro *et al.* 2007).

Hardness was highly correlated with apparent viscosity, especially in the case of the samples designed for spreading like butters, margarines, or spreads (Glibowski *et al.* 2008), however, evidently the apparently apparent viscosity characterises sensi-

Table 3. Hardness (N) changes in inulin pastes and inulin-oil emulsions as an effect of storage at 8°C

Sample	Storage time (days)				
	1	7	14	28	56
I	$3.03^{a} \pm 0.26$	$3.72^{a} \pm 0.26$	$3.77^{a} \pm 0.22$	$3.63^{a} \pm 0.38$	$3.56^{a} \pm 0.30$
Ip	$2.73^{a} \pm 0.51$	$3.35^{a} \pm 0.43$	$3.38^{a} \pm 0.41$	$3.21^{a} \pm 0.55$	$3.36^{a} \pm 0.56$
E	$3.67^{a} \pm 0.54$	$4.17^{a} \pm 0.63$	$4.19^{a} \pm 0.43$	$3.85^{a} \pm 0.61$	$4.02^{a} \pm 0.77$
Ep	$2.38^{a} \pm 0.10$	$2.98^{a} \pm 0.40$	$2.80^{a} \pm 0.33$	$2.98^{a} \pm 0.50$	$2.75^{a} \pm 0.12$
W	$3.21^{a} \pm 0.05$	$3.45^{a} \pm 0.06$	$3.41^{a} \pm 0.18$	$3.47^{a} \pm 0.22$	$3.31^{a} \pm 0.12$
Wp	$2.87^{a} \pm 0.20$	$2.97^{a} \pm 0.50$	$3.19^{a} \pm 0.59$	$2.75^{a} \pm 0.29$	$3.22^{a} \pm 0.57$

Data are presented as means ± standard deviation; Means in the same row with the same superscripts are not significantly different, $P \leq 0.05$; For explanation I–Wp see Table 1

Table 4. Adhesiveness (N·s) changes in inulin pastes and inulin-oil emulsions as an effect of storage at 8°C

Sample	Storage time (days)				
	1	7	14	28	56
I	−13.57^{a} ± 1.66	−15.34^{a} ± 1.61	−14.38^{a} ± 0.63	−12.16^{a} ± 2.26	−14.49^{a} ± 3.15
Ip	−13.81^{a} ± 2.18	−16.48^{a} ± 5.47	−13.78^{a} ± 3.61	−10.03^{a} ± 4.93	−14.36^{a} ± 1.93
E	−11.33^{a} ± 2.75	−13.03^{a} ± 1.48	−12.72^{a} ± 2.81	−11.58^{a} ± 1.90	−13.70^{a} ± 1.37
Ep	−8.31^{a} ± 0.13	−9.14^{a} ± 0.80	−10.17^{a} ± 1.44	−10.20^{a} ± 1.38	−11.15^{a} ± 0.73
W	−19.63^{a} ± 3.78	−18.49^{a} ± 5.54	−16.56^{a} ± 1.93	−12.33^{a} ± 2.76	−14.47^{a} ± 7.49
Wp	−11.36^{a} ± 4.25	−16.89^{a} ± 3.39	−12.21^{a} ± 1.10	−11.30^{a} ± 2.24	−9.92^{a} ± 6.34

Data are presented as means ± standard deviation; Means in the same row with the same superscripts are not significantly different, $P \leq 0.05$; For explanation I–Wp see Table 1

bility better than do the hardness measurements by demonstrating the differences in rheological properties. The hardness results resemble those obtained in the texture analysis of the Table spreads with 20% fat content (Glibowski *et al.* 2008).

Storage time did not have any significant influence on adhesiveness and cohesiveness (Tables 4 and 5). The analysed samples exhibited adhesiveness comparable to that of the samples of butter or margarines with 60–80% fat content (Glibowski *et al.* 2008). The high values of adhesiveness probably resulted from the structure of the samples. Inulin forms particle gels (Franck 2002) and the presence of little crystals of inulin in the analysed samples required a greater amount of work to overcome the attractive forces between the sample and the instrument probe surface. Although solid fat also has a crystalline structure, fat crystals have much lower hardness. The values of cohesiveness of the analysed samples were higher than that for butter and lower than those for most spreads and margarines (Glibowski *et al.* 2008). As in the case of adhesiveness, the higher values of cohesiveness probably resulted from the sample structure.

In most samples, a slight decrease in pH value during storage was observed (Table 6). Only in the samples with WPI emulsifier the increase in pH values was considerable. This was the result of microbiological growth as Table 7 confirms. In the samples without oil (I and Ip) and Ep samples, the total counts of microorganisms were very low or not detectable during the whole storage (Table 7). In the samples with PGPR without chemical preservation (E), the growth of microorganisms was more intense but still low. The presence of KS evidently affected the microbiological stability, especially in the samples with a WPI used as emulsifier. In W samples, either total count of microorganisms or yeast count was high and increased according to the storage time. Yeasts counts in inulin pastes and inulin-oil emulsions were lower than 10 (CFU/g) in almost all samples. The samples with WPI as emulsifier without chemical preservation had < 10, 1.53×10^{4}, 7.24×10^{5}, 1.00×10^{6}, and

Table 5. Cohesiveness changes in inulin pastes and inulin-oil emulsions as an effect of storage at 8°C

Sample	Storage time (days)				
	1	7	14	28	56
I	0.296^{a} ± 0.025	0.261^{a} ± 0.038	0.241^{a} ± 0.034	0.210^{a} ± 0.024	0.259^{a} ± 0.095
Ip	0.332^{a} ± 0.086	0.317^{a} ± 0.069	0.266^{a} ± 0.045	0.199^{a} ± 0.086	0.271^{a} ± 0.014
E	0.225^{a} ± 0.008	0.235^{a} ± 0.033	0.225^{a} ± 0.044	0.220^{a} ± 0.017	0.262^{a} ± 0.089
Ep	0.247^{a} ± 0.022	0.236^{a} ± 0.008	0.269^{a} ± 0.004	0.248^{a} ± 0.073	0.302^{a} ± 0.040
W	0.227^{a} ± 0.036	0.216^{a} ± 0.029	0.201^{a} ± 0.052	0.175^{a} ± 0.021	0.197^{a} ± 0.046
Wp	0.371^{a} ± 0.041	0.291^{a} ± 0.178	0.324^{a} ± 0.027	0.361^{a} ± 0.046	0.305^{a} ± 0.120

Data are presented as means ± standard deviation. Means in the same row with the same superscripts are not significantly different, $P \leq 0.05$; For explanation I–Wp see Table 1

Table 6. pH changes in inulin pastes and inulin-oil emulsions as an effect of storage at 8°C

Sample	Storage time (days)				
	1	7	14	28	56
I	$6.93^{a} \pm 0.12$	$6.95^{a} \pm 0.12$	$6.88^{a} \pm 0.12$	$6.78^{a} \pm 0.07$	$6.85^{a} \pm 0.09$
Ip	$6.89^{a} \pm 0.04$	$6.85^{a} \pm 0.02$	$6.82^{a} \pm 0.08$	$6.73^{b} \pm 0.04$	$6.69^{b} \pm 0.02$
E	$7.00^{a} \pm 0.07$	$6.95^{a} \pm 0.07$	$7.03^{a} \pm 0.07$	$6.94^{a} \pm 0.07$	$6.96^{a} \pm 0.07$
Ep	$7.08^{a} \pm 0.02$	$7.01^{ab} \pm 0.03$	$6.97^{ab} \pm 0.07$	$6.85^{ab} \pm 0.16$	$6.78^{b} \pm 0.14$
W	$6.93^{a} \pm 0.10$	$6.95^{a} \pm 0.02$	$6.90^{a} \pm 0.00$	$6.87^{a} \pm 0.14$	$6.26^{b} \pm 0.03$
Wp	$6.94^{a} \pm 0.04$	$6.85^{a} \pm 0.10$	$6.95^{a} \pm 0.05$	$6.83^{a} \pm 0.11$	$6.47^{b} \pm 0.07$

Data are presented as means ± standard deviation. Means in the same row with different superscripts are significantly different, $P \leq 0.05$; For explanation I–Wp see Table 1

1.85×10^{6} CFU/g after 1, 7, 14, 28, and 56 days of storage at 8°C, respectively.

The presence of WPI, which is almost a pure protein, clearly stimulated the growth of microorganisms because in the emulsions analysed, protein was the most available component for degradation with a majority of microflora (Piatkiewicz 2000). Evidently, the use of protein emulsifier utterly needs chemical preservation. The presence of *Salmonella* sp., *Listeria* sp., *Escherichia coli*, *Staphylococcus aureus*, moulds, or lipolytic bacteria was not detected in any sample. The absence of foodborne pathogenic and fecal bacteria in the examined samples is in agreement with the microbiological requirements of the Commission Regulation (EC) No. 2073/2005 for foodstuffs (2005) and confirms the safety of these model products for consumers' health.

The last part of the study was the sensory evaluation of the spreads containing inulin (Table 8). It is necessary to emphasise that the analysed samples were obtained by mixing commercial spreads and margarine with 20% inulin gel, therefore only small differences may be expected in comparison with the spreads manufactured on the basis of individual ingredients. The presence of inulin did not significantly ($P \leq 0.05$) affect spreadability. Notable deterioration was observed in the smoothness and meltability in mouth, the presence of inulin aggregates being the reason for this deterioration. Inulin gel is a three dimensional network of inulin aggregates which are constructed from inulin crystals (Bot *et al.* 2004). The presence of inulin aggregates in the analysed samples caused a floury taste in the mouth which negatively affected the analysed features. The fats present in butter, margarine, or spreads mostly have melting temperatures below the temperature of the mouth cavity temperature (Rousseau & Marangoni 1998). The solubility temperature of the amorphous forms of commercial high performance inulin with the degree of polymerisation ≥ 23 is much higher than 36.6°C, thus the crystal forms of inulin present in the analysed samples are more difficult to dissolve (Kim *et al.* 2001; Bot *et al.* 2004; Ronkart *et al.* 2009). The presence of inulin in the analysed samples caused a small but statistically insignificant ($P \leq 0.05$) decrease

Table 7. Total count of microorganisms (cfu/g) in inulin pastes and inulin-oil emulsions as an effect of storage at 8°C

Sample	Storage time (days)				
	1	7	14	28	56
I	< 10	< 10	< 10	< 10	< 10
Ip	< 10	< 10	< 10	0.50 × 10	< 10
E	< 10	< 10	1.00 × 10	0.50 × 10	3.33 × 10
Ep	< 10	1.00 × 10	< 10	< 10	< 10
W	1.90 × 10	1.96×10^{4}	2.30×10^{6}	8.43×10^{6}	2.2×10^{10}
Wp	6.19 × 10	0.50 × 10	< 10	5.24 × 10	2.62×10^{2}

For explanation I–Wp see Table 1

Table 8. Sensory evaluation of the commercial margarine and spreads, and inulin spreads produced in this study

Samples	Inulin (%)	Fat (%)	Spreadability	Smoothness	Meltability in mouth	Margarine flavour	General acceptance
A	0.0	80.0	8.91^{a}	9.11^{a}	7.27^{a}	4.28^{bcd}	7.30^{a}
B	0.0	40.0	8.39^{a}	8.84^{a}	6.83^{a}	5.90^{ab}	7.48^{a}
C	0.0	25.0	8.57^{a}	7.88^{b}	5.19^{ab}	7.10^{a}	5.63^{b}
2A1I	6.7	53.3	7.86^{a}	0.94^{c}	3.74^{bc}	3.70^{cd}	1.35^{cd}
2B1I	6.7	26.6	8.14^{a}	1.34^{c}	3.42^{bc}	4.35^{bcd}	1.59^{cd}
2C1I	6.7	16.7	8.54^{a}	1.58^{c}	2.56^{c}	5.76^{ab}	2.22^{c}
1A1I	10.0	40.0	7.52^{a}	0.82^{c}	2.97^{bc}	2.70^{d}	0.72^{d}
1B1I	10.0	20.0	8.35^{a}	1.02^{c}	2.18^{c}	4.37^{bcd}	1.36^{cd}
1C1I	10.0	12.5	8.33^{a}	1.62^{c}	2.00^{c}	5.09^{abc}	1.82^{cd}

$^{a–d}$means in the same column with different superscripts are significantly different, $P \leq 0.05$

in margarine flavour. General acceptance of the spreads with inulin was significantly ($P \leq 0.05$) lower than of the commercial products.

The presence of inulin may be justified and accepted despite the deterioration of sensory feeling. Inulin has a high nutritional value and its addition to spreads causes them to rate among functional foods. Prohealthy effect of a food product may change the consumers' attitude even if its sensory value is less attractive than the common one.

CONCLUSIONS

The analysed samples reached rheological stability one-two weeks after their production. The application of protein emulsifiers may have an effect on intensive growth of microorganisms, therefore it is necessary to apply chemical preservatives in such products. For this reason, it seems more practical to apply non-protein emulsifiers like e.g. PGPR. The shelf-life of low-fat chemically preserved products based on inulin can be established for two months. Chemical preservation of the products with non-protein emulsifiers is not necessary. The presence of inulin in the spreads did not significantly affect spreadability but considerable deterioration was noted in the smoothness and meltability in the mouth. The main reason for this was the presence of inulin aggregates constructed from the inulin crystals. Although general acceptance of the spreads with inulin was significantly lower than that of the commercial products, a strong prohealthy effect of inulin may justify the deterioration of the sensory characteristics.

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Received for publication September 1, 2009
Accepted after corrections August 7, 2010

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