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Influence of combined emulsifier on physical characteristics of fat filling

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Summary

The influence of mixture of two separate emulsifiers and a new generation of emulsifier 2 in 1, which nowadays has a tendency to replace these two, on the rheological and textural properties and sensory quality of fat filling was investigated. Emulsifiers were added in concentrations of 0.3, 0.45 and 0.75%, and calculated on the total mass of raw materials. The addition of emulsifiers in concentrations of 0.3 and 0.45% had a significant influence on the textural and rheological parameters of fat filling. These results showed that is not necessary to add a maximum amount of an emulsifier in order to achieve optimal spreadibility and hardness, which is certainly justified from an economic point of view. The addition of emulsifier 2 in 1 caused starchy taste and migration of fat to the surface of fat filling. The sample with 0.45%, which was a combination of two emulsifiers, had the best sensory quality and spreadability characteristics.

Keywords: fat filling, emulsifiers, physical properties

Introduction

Confectionary fillings contain 30 – 40% of fat, which is the continuous phase of these products. Fat plays an important role in physical properties of fillings and fat characteristics determine sensory quality of final products (Lidefelt, 2002). Fat is the holder of taste and odour, regulates consistency of fillings, affects speed of melting in the mouth and flavour release. The compatibility and connectivity between filling and shell are dependent on fat, thereby preventing fat blooming and undesirable softening (Pedersen, 2001). Lots of fat fillings used in confectionery contain hydrogenated fats (Kristott, 2003). Partial hydrogenation converts some unsaturated fatty acids with cis configuration into the trans configuration (Wilkinson, 2003). Several studies on the negative impact of a high fatty acid diet on human health have been published. Therefore, it is recommended that trans fatty acid consumption be as low as possible (Wilkinson, 2003; Khosla and Hayes, 1996).

The other ingredients of confectionery fillings are sugar, milk powders, cocoa products, and often some kinds of nuts (Lidefelt, 2002). Multiphase food products are susceptible to phase separation, which is very undesirable from the technological aspect. Emulsifiers keep such systems in a quasi-homogeneous state for a long time. Also, they regulate the viscosity of fat fillings and affect crystallization and polymorphic transformation of fat phase. So the use of the proper emulsifier or the mixture of emulsifiers has the crucial importance on the formation of the appropriate characteristics of the final product (Whitehurs, 2004). It is often the case that in confectionary the combination of two emulsifiers in a formulation results in a longer lasting and more uniform product (Hasenhuettl, 2008). Nowadays the 2 in 1 emulsifiers are available, which are alternative to the combined use of two emulsifiers.

The aim of this research was to determine the influence of the addition of emulsifiers (two emulsifiers which are in a widespread use in the confectionery industry, and "2 in 1" emulsifier that nowadays has a tendency to replace these two) on the textural, rheological and sensory characteristics of fat filling, which contains fat with low trans fatty acid content.

Materials and methods

Materials

In the this experiment, for fat filling preparation, vegetable fat DELIAIR^{TM}04 with the content of trans fatty acids < 1% (AarhusKarlshamn, Sweden) was used. Emulsifiers added in different samples were: Emulsifier GRINDSTED ® PGPR 90 - polyglycerol esters of polycondensed fatty acids

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from castor oil (hereinafter PGPR 90) (Danesco, Malaysia); emulsifier GRINDSTED ® CITREM LR 10 EXTRA KOSHER – citric acid esters of monoglycerides from refined edible sunflower oil (hereinafter CITREM LR 10) (Danisco, Germany), and emulsifier GRINDSTED ® CITREM LR 2 in 1 KOSHER – citric acid esters of mono - glycerides from refined edible sunflower oil (hereinafter CITREM 2 IN 1) (Danisco, Germany).

Samples preparation

Fat filling (sugar - 30.5%, fat DELIAIR^{TM} 04 - 41.3%, dextrose - 15.2%, cocoa powder - 9.1%, milk powder - 3.1%, emulsifier - 0.8%) was prepared in a triple roller mill in "Jaffa" factory from Crvenka, Serbia. In experimental work we used samples of fat filling with the addition of different emulsifiers in different concentrations (Table 1).

Textural measurement

Textural properties were determined by the Texture Analyser TA. XT Plus (Stable Micro Systems, Surrey, U.K.). To define the hardness and the work of shearing of fat fillings, Margarine Spreadability method – MAR4_SR.PRJ was used. The accessories included TTC Spreadability Rig (HDP/SR) using 5 kg load cell and Heavy Duty Platform (HDP/90). Each sample was placed into the cone sample holder which was put in the base holder, and a 45-degree cone probe was used to penetrate the samples. Measurements were performed at 20° C with the test speed of 3mm/s. Calibration (Control Probe) before sample analysis was performed, which ensures that at each measurement the start position of cone probe is at the same distance from the sample holder. During the analysis, the rise of force to a maximum penetration depth was followed. Values of this force present hardness at a specific penetration depth. The size of the area under the curve dependence F (force) of t (time) presents work of shearing.

Rheological measurements

Rheological properties of fat filling samples were determined by the rotational rheometer Rheo Stress 600 (Haake, Karslruhe, Germany) according to O.I.C.C method using a concentric cylinder system (sensor Z20 DIN) (IOCC 2000). Flow curves (shear stress, τ (Pa) versus shear rate, γ (1/s)) were recorded at 40 °C. Shear rate was increased linearly from 0 to 60 1/s for 240 s, then it was held on a maximum shear rate (60 1/s) for 240s, and afterwards shear rate was decreased linearly from 60 to 0 1/s for 240 s.

Sensory evaluation

Fat filling samples were evaluated by 8 trained panelists recruited from staff members of the Faculty of Technology, University of Novi Sad, Serbia, selected on the basis of their interests and availability. The panellists used 5 – point scale to rate the intensity of sensory attributes (ISO 4121:1987). Evaluated attributes were surface appearance (5 – characteristic, no white spots, 1 – white fat spots on surface), hardness (5 – appropriate, soft, 1 - hard), adhesiveness (5 – appropriate, 1- very sticky), flavour (5 – extremely good, characteristic, 1 – extremely bed), taste (5 – extremely good, characteristic, 1 – extremely bed) (ISO 5492:1992). Samples were served in white plastic cups labelled with three - digit codes, and water and bread were used for cleaning the mouth between samples.

Statistical analysis

Data obtained in textural and sensory analysis were subjected to the analysis of variance (ANOVA), and the Duncan's test was used as a post-hoc mean separation technique for treatments. Differences among the data were determined at a significance level at 0.05. The data analysis was completed using STATISTICA 10.0 (Statsoft, Tulsa, OK).

Table 1. Share of emulsifiers in fat filling samples

Sample	PGPR 90 (%)	CITREM LR 10 (%)	CITREM 2 in 1 (%)
Sample 0	/	/	/
Sample 1	0.1	0.2	/
Sample 2	0.15	0.3	/
Sample 3	0.25	0.5	/
Sample 4	/	/	0.3
Sample 5	/	/	0.45
Sample 6	/	/	0.75

Results and discussion

Textural measurement

Values of textural parameters of fat filling samples with different type of emulsifiers in different concentrations are given in Table 2.

Values of hardness and work of shearing for samples with the addition of the combination of two emulsifiers, which are commonly used in the manufacture of this type of filling, are statistically significant lower ($p<0.05$) when compared to the sample 0 (control sample). This means that the addition of the combination of these two emulsifiers in all concentration significantly affects the improvement of fat filling spreadability. Emulsifier 2 in 1 also has statistically significant influence on the decrease of hardness and work of shearing of fat fillings at concentration of 0.3 and 0.45%. However, at a concentration level of 0.75%, emulsifier 2 in 1 did not significantly reduce hardness of fat filling. These results show that it is not necessary to add a large amount of emulsifier in order to achieve optimal spreadability and hardness of fat filling, which is certainly justified from an economic point of view.

Rheological measurement

Rheological properties are very important not only during processing, but alsofor the quality of the final product. The influence of emulsifiers at a concentration of 0.3, 0.45 and 0.75% on the rheological characteristics of fat filling is shown in Figure 1, Figure 2 and Figure 3 respectively.

In all cases, addition of emulsifiers regardless of type and concentration diminished viscosity of fat filling compared with control sample, i.e. the sample without emulsifier. This result indicates that emulsifiers decreased the energy required for destroying the system. The addition of lower concentrations (0.3 and 0.45%) of tested emulsifiers (Fig. 1 and 2) has clearly influenced the viscosity reduction of fat filling. The results also show that the combination of two emulsifiers has the same influence on the viscosity reduction of fat filling as emulsifier 2 in 1. The sample of fat filling with the addition of emulsifier 2 in 1 in concentration of 0.75% (sample 6), has a higher viscosity when compared with samples which contain the same concentration of the combination of emulsifiers, and with samples containing the lower concentrations of emulsifier 2 in 1. This also indicates that is not necessary to add a large amount of emulsifier in order to achieve the optimal viscosity of fat filling.

Sensory analysis

Results of the sensory analysis of fat filling samples are given in Table 3. The sample without emulsifier and samples with low concentrations (0.3 and 0.45%) of combination PGPR 90, and CITREM LR 10 have similar sensory characteristics. These results indicate that the amount of low concentrations of these emulsifiers has not statistically significant effect on the sensory quality of fat filling ($p>0.05$). A slight deterioration of sensory characteristics, primarily in the appearance due to the extraction of fat on the surface, was observed in the sample with the highest concentration of these two emulsifiers (sample 3).

The increase in the amount of emulsifiers regardless of type and concentration causes fat separation. Scores for hardness and adhesiveness increased with the increase in the amount of emulsifiers, except for the sample with the highest concentration of emulsifier 2 in 1. The addition of emulsifier 2 in 1 has statistically significant influence on the sensory characteristics of fat filling. The panelists indicate that the taste becomes starchy, and there was a separation of fat on the surface, at all concentrations of this emulsifier. These changes are particularly pronounced in the sample with the highest concentration of emulsifier 2 in 1 (sample 6). The samples with this emulsifier have better aeration properties than samples with the combination of two emulsifiers, and the control sample. The best sensory characteristics have been observed in samples with lower concentrations of the combination of two emulsifiers (sample 1 and sample 2).

Table 2. Textural parameters of fat filling samples

Sample	Hardness (g)	Work of shearing (g sec)
Sample 0	$527.88 \pm 0.96^{a,f}$	478.79 ± 1.10^{a}
Sample 1	490.66 ± 0.89^{b}	424.59 ± 0.63^{b}
Sample 2	489.22 ± 0.76^{b}	442.59 ± 1.21^{c}
Sample 3	469.76 ± 0.84^{c}	421.26 ± 1.26^{d}
Sample 4	497.28 ± 1.05^{d}	450.52 ± 0.92^{e}
Sample 5	463.44 ± 1.21^{e}	437.75 ± 1.06^{f}
Sample 6	522.37 ± 0.73^{f}	465.28 ± 1.05^{g}

[a-f] Values of the same column with the same superscript are not statistically different ($p>0.05$)

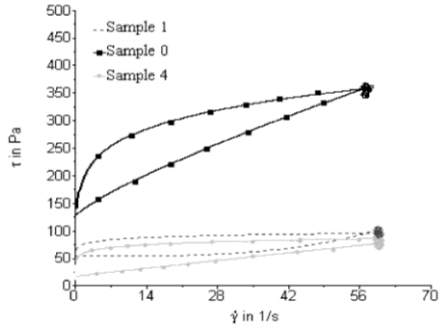

Fig 1. Flow curves of fat fillings for control sample and samples with 0.3% emulsifiers

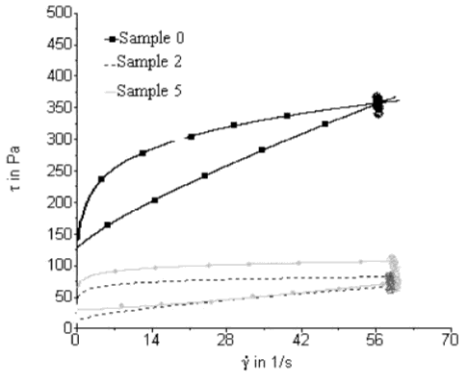

Fig 2. Flow curves of fat fillings for control sample and samples with 0.45% emulsifiers

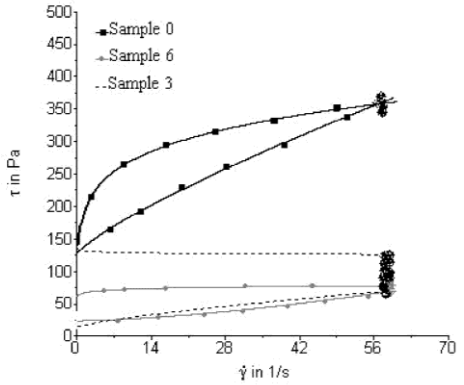

Fig 3. Flow curves of fat fillings for control sample and samples with 0.75% emulsifiers

Conclusions

The results showed that the addition of combination of emulsifiers PGPR 90 and CITREM LR 10, and lower concentrations of emulsifier 2 in 1 decrease work of shearing and hardness, which directly indicates improvement of spreadability of fat filling. The addition of emulsifiers in concentrations of 0.3 and 0.45% generally leads to decreasing of tixotropic loop area which indicates the better homogeneity of the system. The sample with the highest concentration of emulsifier 2 in 1 (0.75%) has greater viscosity than the sample with the same concentration of the combination two emulsifiers. Increase in the concentration of emulsifiers to the maximum led to the extraction of fat onto the surface, which is especially expressed in emulsifier 2 in 1. Scores for sensory quality were better for samples with lower concentrations of the combination of two emulsifiers (sample 1 and sample 2). The addition of emulsifier 2 in 1 caused starchy taste and decreased total sensory quality of the fat filling. The best sensory quality and spreadability characteristics showed sample 2 (sample with 0.45% of combination of emulsifiers PGPR 90 and CITREM LR 10).

Table 3. Sensory characteristics of fat filling samples

Sample	Appearance	Hardness	Adhesiveness	Flavor	Taste
Sample 0	4.75 ± 0.46^{a}	$3.25 \pm 0.88^{a,c}$	3.25 ± 0.50^{a}	3.25 ± 0.56^{a}	3.50 ± 0.53^{a}
Sample 1	4.62 ± 0.51^{a}	3.63 ± 0.74^{a}	3.50 ± 0.58^{a}	3.25 ± 0.46^{a}	3.50 ± 0.58^{a}
Sample 2	4.85 ± 0.35^{a}	$4.00 \pm 0.53^{a,b}$	3.75 ± 0.50^{a}	3.62 ± 0.74^{a}	3.50 ± 0.46^{a}
Sample 3	4.25 ± 0.88^{b}	4.50 ± 0.58^{b}	3.25 ± 0.46^{a}	$3.0 \pm 0.00^{a,b}$	$3.25 \pm 0.46^{a,b}$
Sample 4	3.50 ± 0.53^{c}	3.62 ± 0.58^{a}	3.25 ± 0.70^{a}	2.25 ± 0.70^{b}	$2.75 \pm 0.64^{a,b}$
Sample 5	3.25 ± 0.46^{c}	$3.75 \pm 0.88^{a,b}$	3.00 ± 0.53^{a}	2.25 ± 0.46^{b}	$2.50 \pm 0.75^{b,c}$
Sample 6	1.75 ± 0.70^{d}	2.50 ± 0.58^{c}	2.25 ± 0.46^{b}	2.13 ± 0.36^{b}	$1.75 \pm 0.71^{b,c}$

[a-d] Values of the same column with the same superscript are not statistically different ($p>0.05$)

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