Influence of Sugars, Modified Starches, and Hydrocolloids Additions on the Rheological Properties of Raspberry Cream Filling

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Abstract

Pichler A., Pozderović A., Pavlović J. (2012): **Influence of sugars, modified starches, and hydrocolloids additions on the rheological properties of raspberry cream filling**. Czech J. Food Sci., **30**: 227–235.

The influence of the addition of sugars, sucrose, fructose, and trehalose, modified starches, and hydrocolloids on the rheological properties of raspberry cream fillings prepared with the addition of sucrose (27%), combination of sucrose (17%) and fructose (10%), and combination of sucrose (25.4%) and trehalose (1.6%) was observed. Modified starches, tapioca modified starch (1%) or waxy maize modified starch (1%), hydrocolloids, karaya (0.05%), or guar (0.05%) were added into the cream fillings too. The rheological properties (shear stress and shear rate at different temperatures) were measured by rotational viscometer. The consistency coefficient and flow index were calculated from the measured data. The results showed that waxy maize modified starch or guar gum additions into raspberry cream fillings had a greater impact on the cream filling consistency than tapioca modified starch or gum karaya. All raspberry cream fillings were Non-Newtonian stationary fluids at the measured temperatures except cream fillings S (with sucrose) and SF (with sucrose and fructose) with guar gum at a low temperature. These cream fillings were non-stationary rheopectic fluids at 0°C. The above mentioned sugars added influence the rheological properties of the cream fillings in different ways.

Keywords: raspberry cream fillings; rheological properties; sugars; modified starches; hydrocolloids

The rheological properties of food are important quality factor of the products such as fruit purees, and play an important role in the processing of these materials. Raspberry fruit belongs to the *Rosaceae* family. The red fruits have been frequently used by the food industry. The products manufactured of them such as juices, nectars, ice creams and jellies, contain the fruit pulp as the basic raw material. The rheological behaviour and flow properties of fruit pulps have a significant role in food industry as they govern the product development, design, and evaluation of the process equipment (Ahmed *et al.* 2005; Nindo *et al.* 2007).

Fruit cream fillings are used as components in fruit toppings, doughnuts, pies, cakes, and other products. Flow properties are among the major quality attributes for consumers' acceptance of the fillings (Hill *et al.* 1995). The processing of fruit fillings uses starch as the base, mixed with fruit puree, water, and gum followed by heating and cooling operations (Pratt *et al.* 1986).

The gum, as hydrocolloid, may modify the flow properties of the food products, gives the most viscous fluids, and is more sensitive to changes in the solid contents (Christianson *et al.* 1981; Sudhakar *et al.* 1992, 1996; Wei *et al.* 2001; Sopade *et*

Supported by the Ministry of Science, Education and Sports of the Republic of Croatia, Project "Improvement of production processes of food".

al. 2008). Hydrocolloids have functional properties in stabilising the insoluble particles, thickening, improving the consistency, and can be widely used (Marrs 1996; Buffo *et al.* 2001). Their caloric value is quite low, making them useful particularly in the development of diet foods (Mendonca *et al.* 2001).

Starch is widely used in food industry as thickening agent or stabiliser, and to provide control of moisture and water mobility, improve the overall product quality, reduce cost, and/or facilitate the processing (Shi & BeMiller 2002; Funami *et al.* 2005). Tapioca starch has unique functional properties due to its granule swelling ability and rheological properties (Atichokudomchai *et al.* 2004). The properties of native starch are not optimal in many applications. In order to obtain the required functional properties, starch is subjected to chemical, physical, and enzymatic modifications. Chemically modified starches are considered as food additives and have a broad range of application as thickening, texturing, bulking, stabilising, and gelling agents (Fortuna 1995; Golachowski 1998; Tomasik 2000). Chemical modification of starch can be replaced by the utilisation of its interactions with hydrocolloids that may stabilise its properties (Korus *et al.* 2004).

Sugars are important ingredients in many food products containing starch, they affect properties such as gelatinisation, retrogradation, and staling. It is important to realise the interactions between sugars and starch to achieve the required properties and product stability. Many mechanisms have been proposed to explain this phenomenon: starch-sugar interaction (Hansen *et al.* 1989; Lim *et al.* 1992), the formation of starch-sugar inclusion complexes (Tomasik *et al.* 1995), the increase in free volume resulting in a less plasticising effect of the starch-sugar solvent (Levine & Slade 1989). From various studies, it is obvious that sugars significantly influence the thermal properties of starch, the effect depending on the sugar used, starch origin, and storage conditions.

The aim of this research was to investigate the effects of various sugars, trehalose, fructose and sucrose, modified starches, tapioca and waxy maize, as well as hydrocolloids, karaya and guar gum, at different temperatures on the rheological properties of raspberry cream fillings.

MATERIAL AND METHODS

Material. Raspberries were bought at a local market and were kept at –20°C before use. Tapioca modified starch (commercial named Textra, moisture content 15.0%) and waxy maize modified starch (commercial named Frigex W, moisture content 15.0%) were obtained from the National Starch & Chemical (North Humberside, UK). Hydrocolloids, karaya gum (KG), and guar gum (GG) were the products of Sigma-Aldrich Chemie (Steinheim, Germany). The other ingredients used were: sucrose, fructose, and trehalose (Merck KGaA, Darmstadt, Germany).

Preparation of raspberry cream fillings. Raw materials for the cream fillings preparation were raspberry puree, sugar, modified starch, and hydrocolloid. Raspberry cream fillings were prepared from basic raspberry (cv. Wilamet) purees. The cream fillings were prepared by heating the raw material at 85°C and adding the examined additives until 35% of dry matter was achieved (15 min). Then they were put into sterile bottles (200 ml) and pasteurised at 80°C for 15 minutes. Fifteen different cream fillings were obtained. Three different cream fillings were made only with the addition of sugars: 27% of sucrose; 17% of sucrose and 10% of fructose; 25.4% of sucrose and 1.6% of trehalose. Four raspberry cream fillings were prepared with the addition of 27% sucrose and with the addition of 1% tapioca modified starch (TMS), 1% waxy maize modified starch (WMMS), 0.05% karaya gum (KG) or 0.05% guar gum (GG). Next four cream fillings were prepared by replacement of part of sucrose with fructose. These samples were prepared with the addition of 17% of sucrose, 10% of fructose and 1% TMS, 1% WMMS, 0.05% KG or 0.05% GG. The last four cream fillings were prepared by replacement part of sucrose with trehalose. These samples were prepared with the addition of 25.4% sucrose, 1.6% trehalose and 1% TMS, 1% WMMS, 0.05% KG or 0.05% GG.

Rheological measurements. Rheological evaluations of the examined pastes was carried out on a computer controlled rotational viscometer (Model DV-III + Digital Rheometer; Brookfield Engineering Laboratories, Middleboro, USA) using spindle SC4-27.

The pastes examined were placed in a viscometer and subjected to a programmed shear rate linearly increasing from 0–200 rpm and linearly decreasing from 200–0 rpm at temperatures of 0, 20, and 40°C. All samples were done in triplicate.

The power-law model was used to describe the flow behaviour of the pastes:

$t = k\,\gamma^n$

where:
t – shear stress (Pa)
k – consistency coefficient (Pas^n)
γ – shear rate (s^{-1})
n – flow behaviour index

Logaritmic plots of shear stress vs. shear rate were used to calculate the consistency coefficient and flow behaviour index.

Apparent viscosity, μ (Pas) at 100 s^{-1} was evaluated using the equation:

$\mu = k\,\gamma^{\,n-1}$

Statistical analyses. The experimental data were analysed by the analysis of variance (ANOVA) and Fisher's least significant difference (LSD) with the significance defined at $P < 0.05$. All statistical analyses were carried out using the software program STATISTICA 8 (StatSoft, Inc., Tulsa, USA).

RESULTS AND DISCUSSION

The research data on the influence of the addition of sugars, modified starches, and hydrocolloids on rheological properties of raspberry cream fillings are shown in Tables 1–3 and Figures 1–6. The results in Tables 1–3 are shown for temperatures of 0, 20, and 40°C, while the results in Figures 1–6 are presented for temperatures of 0°C and 20°C, since the results at 40°C are not significantly different from those at 20°C. The only observed difference between the results at 20°C and 40°C was the decrease in consistency.

All the cream fillings examined were prepared with the addition of sugars, modified starches, and hydrocolloids into basic raspberry puree. The addition of all the examined sugars at the investigated temperatures caused an increase in the paste consistency (Tables 1–3, Figures 1–3). Krokida *et al.* (2001) performed a study comparing the available

Table 1. Power-law parameters of raspberry cream fillings with addition of different combination of sugars, modified starches and hydrocolloids at 0°C

Sample	n	k (Pas^n)	μ (at 100 s^{-1}) (Pas)	R^2
Raspberry puree	0.307^{a} ± 0.019	7.898^{a} ± 0.451	0.325^{a} ± 0.011	0.908 ± 0.043
S 27%	$0.441^{b,e}$ ± 0.065	16.802^{b} ± 5.296	1.246^{b} ± 0.023	0.998 ± 0.001
S 17% + F 10%	$0.424^{c,d,e}$ ± 0.025	$23.921^{c,e}$ ± 2.271	1.677^{c} ± 0.038	0.992 ± 0.011
S 25.4% + T 1.6%	$0.366^{a,d}$ ± 0.028	$25.503^{d,e}$ ± 4.099	1.363^{d} ± 0.039	0.994 ± 0.006
Raspberry puree	0.307^{a} ± 0019	7.898^{a} ± 0.451	0.325^{a} ± 0.011	0.908 ± 0.043
S 27% + TMS 1%	$0.339^{a,e}$ ± 0035	8.642^{a} ± 0.847	0.412^{a} ± 0.031	0.994 ± 0.001
S 27% + WMMS 1%	$0.407^{b,f}$ ± 0.027	28.702^{b} ± 4.041	1.857^{b} ± 0.028	0.988 ± 0.004
S 17% + F 10% + TMS 1%	$0.387^{c,f}$ ± 0.035	12.914^{a} ± 1.764	0.767^{c} ± 0.108	0.995 ± 0.005
S 17% + F 10% + WMMS 1%	0.329^{a} ± 0.019	$22.538^{c,f}$ ± 2.553	$1.021^{d,g}$ ± 0.024	0.993 ± 0.001
S 25.4% + T 1.6% + TMS 1%	$0.380^{d,e,f}$ ± 0.028	$19.267^{d,f}$ ± 3.762	$1.098^{e,g}$ ± 0.085	0.991 ± 0.011
S 25.4% + T 1.6% + WMMS 1%	0.332^{a} ± 0.016	37.254^{e} ± 5.876	1.711^{f} ± 0.148	0.989 ± 0.002
Raspberry puree	$0.307^{b,h,i}$ ± 0.019	7.898^{a} ± 0.451	0.325^{a} ± 0.011	0.908 ± 0.043
S 27% + KG 0.05%	$0.317^{c,i,j}$ ± 0.046	$13.151^{a,g}$ ± 3.724	0.554^{a} ± 0.049	0.934 ± 0.018
S 27% + GG 0.05%	$0.374^{d,j,k,l}$ ± 0.031	$17.294^{b,g,h}$ ± 2.098	$0.962^{b,f,i}$ ± 0.024	0.982 ± 0.007
S 27% + F 10% + KG 0.05%	$0.259^{e,h}$ ± 0.019	$17.595^{c,g,i}$ ± 1.369	0.581^{a} ± 0.006	0.972 ± 0.012
S 27% + F 10% + GG 0.05%	0.175^{a} ± 0.007	46.793^{d} ± 1.336	$1.301^{c,g,h}$ ± 0.409	0.897 ± 0.007
S 25.4% + T 1.6% + KG 0.05%	$0.323^{f,i,k}$ ± 0.049	32.661^{e} ± 8.381	$1.415^{d,h,i}$ ± 0.026	0.993 ± 0.006
S 25.4% + T 1.6% + GG 0.05%	$0.351^{g,i,l}$ ± 0.032	$21.176^{f,h,i}$ ± 3.188	$1.057^{e,f,g}$ ± 0.008	0.995 ± 0.002

S – sucrose; F – fructose; T – trehalose; TMS – tapioca modified starch; WMMS – waxy maize modified starch; KG – karaya gum; GG – guar gum; power-law parameters: n – flow behaviour index; k – consistency coefficient; μ – apparent viscosity; R^2 – coefficient of determination; values are means ± SD of triplicate; $^{a-l}$values in the same column with different superscripts significantly different ($P < 0.05$)

Table 2. Power-law parameters of raspberry cream fillings with addition of different combination of sugars, modified starches and hydrocolloids at 20°C

Sample	n	k (Pas^n)	μ (at 100 s^{-1}) (Pas)	R^2
Raspberry puree	0.266^a ± 0.029	6.178^a ± 0.341	0.211^a ± 0.032	0.952 ± 0.021
S 27%	0.432^b ± 0.005	8.829^b ± 0.155	0.646^b ± 0.003	0.997 ± 0.001
S 17% + F 10%	0.394^{c,e} ± 0.006	12.402^{c,e} ± 0.483	0.761^{c,e} ± 0.008	0.995 ± 0.001
S 25.4% + T 1.6%	0.396^{d,e} ± 0.016	12.140^{d,e} ± 0.837	0.749^{d,e} ± 0.003	0.995 ± 0.002
Raspberry puree	0.266^a ± 0.029	6.178^a ± 0.341	0.211^a ± 0.032	0.952 ± 0.021
S 27% + TMS 1%	0.326^{b,h} ± 0.023	5.740^a ± 0.189	0.458^{b,h} ± 0.329	0.987 ± 0.002
S 27% + WMMS 1%	0.372^{c,i} ± 0.005	17.183^b ± 0.206	0.954^{c,j} ± 0.014	0.989 ± 0.005
S 17% + F 10% + TMS 1%	0.327^{d,h} ± 0.009	10.212^c ± 0.683	0.460^{d,h} ± 0.032	0.984 ± 0.008
S 17% + F 10% + WMMS 1%	0.318^{e,h} ± 0.008	13.474^{d,g} ± 0.709	0.581^{e,h,i} ± 0.009	0.993 ± 0.001
S 25.4% + T 1.6% + TMS 1%	0.363^{f,i} ± 0.015	13.131^{e,g} ± 1.050	0.698^{f,i} ± 0.009	0.994 ± 0.002
S 25.4% + T 1.6% + WMMS 1%	0.329^{g,h} ± 0.009	20.613^f ± 1.117	0.940^{g,j} ± 0.008	0.990 ± 0.001
Raspberry puree	0.266^{b,h} ± 0.029	6.178^a ± 0.341	0.211^a ± 0.032	0.952 ± 0.021
S 27% + KG 0.05%	0.277^{c,h,i} ± 0.019	7.722^{a,g} ± 0.440	0.276^{a,g} ± 0.019	0.982 ± 0.013
S 27% + GG 0.05%	0.301^{d,i} ± 0.014	8.767^{b,g,h} ± 0.483	0.351^{b,g} ± 0.003	0.992 ± 0.001
S 27% + F 10% + KG 0.05%	0.248^{e,h} ± 0.021	10.357^{c,h} ± 1.139	0.323^{c,g} ± 0.009	0.979 ± 0.017
S 27% + F 10% + GG 0.05%	0.192^a ± 0.006	29.638^d ± 0.657	0.716^{d,h} ± 0.006	0.909 ± 0.016
S 25.4% +T 1.6% + KG 0.05%	0.341^{f,j} ± 0.008	14.712^{e,i} ± 0.557	0.707^{e,h} ± 0.008	0.991 ± 0.001
S 25.4% +T 1.6% + GG 0.05%	0.340^{g,j} ± 0.007	16.439^{f,i} ± 2.226	0.787^{f,h} ± 0.116	0.994 ± 0.004

S – sucrose; F – fructose; T – trehalose; TMS – tapioca modified starch; WMMS – waxy maize modified starch; KG – karaya gum; GG – guar gum; Power-law parameters: n – flow behaviour index; k – consistency coefficient; μ – apparent viscosity; R^2 – coefficient of determination; values are means ± SD of triplicate; $^{a–j}$values in the same column with different superscripts are significantly different ($P < 0.05$)

literature data on fruit pulps, including guava, raspberry, pineapple, apricot, apple, mango, tamarind, and black currant and found that all these fruit pulps showed shear-thinning behaviour. Besides, a reduction was noticed in the values of the rheological parameters with increasing temperature. Cream fillings consistencies of SF (sucrose and fructose) and ST (sucrose and trehalose) samples

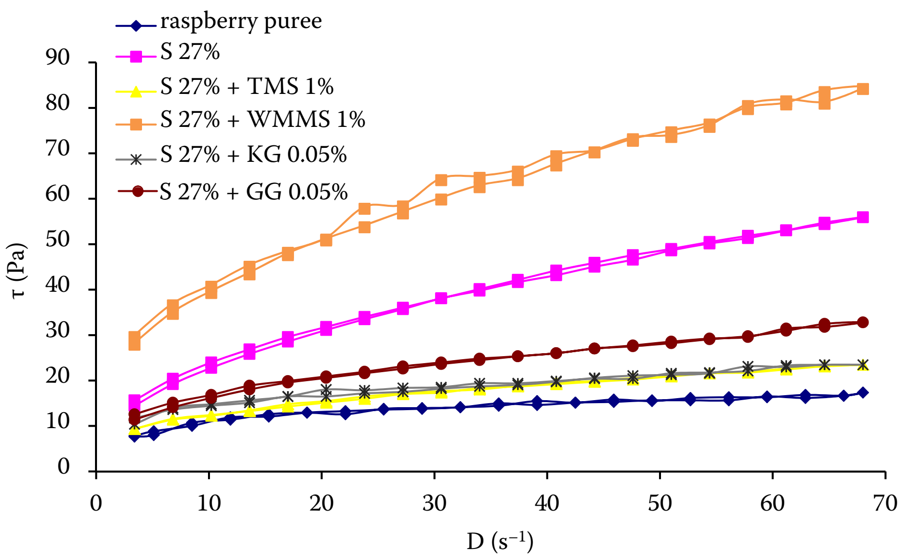

Figure 1. Influence of S (27%) – TMS (1%) – WMMS (1%) – KG (0.05%) and GG (0.05%) addition on rheological parameters of raspberry cream fillings at 20°C

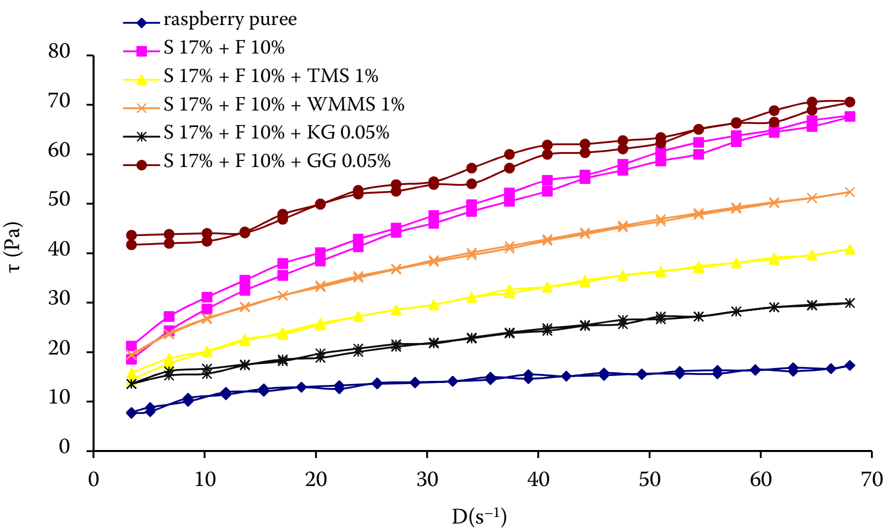

Figure 2. Influence of S (17%) – F (10%) – TMS (1%) – WMMS (1%) – KG (0.05%) and GG (0.05%) addition on rheological parameters of raspberry cream fillings at 20°C

were greater than that of S (sucrose), while no significant difference was observed between SF and ST. Similar results were reported for commercial fruit fillings by Wei *et al.* (2001). The results also showed that the consistency of cream fillings with all additives examined was greater than that of the basic puree. The basic puree and cream fillings with the additives examined at 20°C and 40°C were Non-Newtonian, pseudoplastic fluids (n < 1), while at 0°C they were not.

Table 3. Power-law parameters of raspberry cream fillings with addition of different combination of sugars – modified starches and hydrocolloids at 40°C

Sample	n	k (Pas^n)	μ (at 100 s^{-1}) (Pas)	R^2
Raspberry puree	0.401^{b} ± 0.007	1.971^{a} ± 0.155	0.125^{a} ± 0.013	0.919 ± 0.037
S 27%	0.378^{c} ± 0.004	6.619^{b} ± 0.179	0.378^{b} ± 0.005	0.993 ± 0.001
S 17% + F 10%	0.351^{a} ± 0.003	8.666^{c} ± 0.237	$0.436^{c,e}$ ± 0.007	0.989 ± 0.001
S 25.4% + T 1.6%	0.341^{a} ± 0.009	9.278^{d} ± 0.401	$0.445^{d,e}$ ± 0.009	0.987 ± 0.005
Raspberry puree	0.401^{b} ± 0.007	1.971^{a} ± 0.155	0.125^{a} ± 0.013	0.919 ± 0.037
S 27% + TMS 1%	0.292^{c} ± 0.018	4.672^{b} ± 0.293	0.179^{b} ± 0.008	0.996 ± 0.001
S 27% + WMMS 1%	$0.351^{d,i}$ ± 0.009	11.354^{c} ± 0.374	$0.571^{c,h}$ ± 0.014	0.995 ± 0.003
S 17% + F 10% + TMS 1%	0.257^{a} ± 0.009	9.904^{d} ± 0.683	0.324^{d} ± 0.023	0.984 ± 0.006
S 17% + F 10% + WMMS 1%	$0.326^{e,h}$ ± 0.007	$8.032^{e,h}$ ± 0.353	0.361^{e} ± 0.005	0.996 ± 0.001
S 25.4% + T 1.6% + TMS 1%	$0.356^{f,i}$ ± 0.013	$8.515^{f,h}$ ± 0.465	0.437^{f} ± 0.006	0.988 ± 0.003
S 25.4% + T 1.6% + WMMS 1%	$0.324^{g,h}$ ± 0.004	13.058^{g} ± 0.373	$0.579^{g,h}$ ± 0.006	0.993 ± 0.001
Raspberry puree	0.401^{b} ± 0.007	1.971^{a} ± 0.155	0.125^{a} ± 0.013	0.919 ± 0.037
S 27% + KG 0.05%	$0.327^{c,h}$ ± 0.019	3.878^{b} ± 0.332	0.175^{b} ± 0.002	0.992 ± 0.001
S 27% + GG 0.05%	$0.275^{d,g}$ ± 0.006	6.679^{c} ± 0.312	0.237^{c} ± 0.005	0.983 ± 0.003
S 27% + F 10% + KG 0.05%	0.243^{a} ± 0.019	$8.483^{d,h}$ ± 0.562	0.259^{d} ± 0.007	0.951 ± 0.211
S 27% + F 10% + GG 0.05%	0.231^{a} ± 0.009	16.405^{e} ± 0.498	0.475^{e} ± 0.006	0.943 ± 0.018
S 25.4% + T 1.6% + KG 0.05%	$0.288^{e,g}$ ± 0.007	11.505^{f} ± 0.499	0.433^{f} ± 0.003	0.978 ± 0.005
S 25.4% + T 1.6% + GG 0.05%	0.329^{f-h} ± 0.008	9.214^{g-h} ± 0.485	0.419^{g} ± 0.006	0.994 ± 0.001

S – sucrose; F – fructose; T – trehalose; TMS – tapioca modified starch; WMMS – waxy maize modified starch; KG – karaya gum; GG – guar gum; Power-law parameters: n – flow behaviour index; k – consistency coefficient; μ – apparent viscosity; R^2 – coefficient of determination; values are means ± SD of triplicate; $^{a-i}$values in the same column with different superscripts are significantly different (P < 0.05)

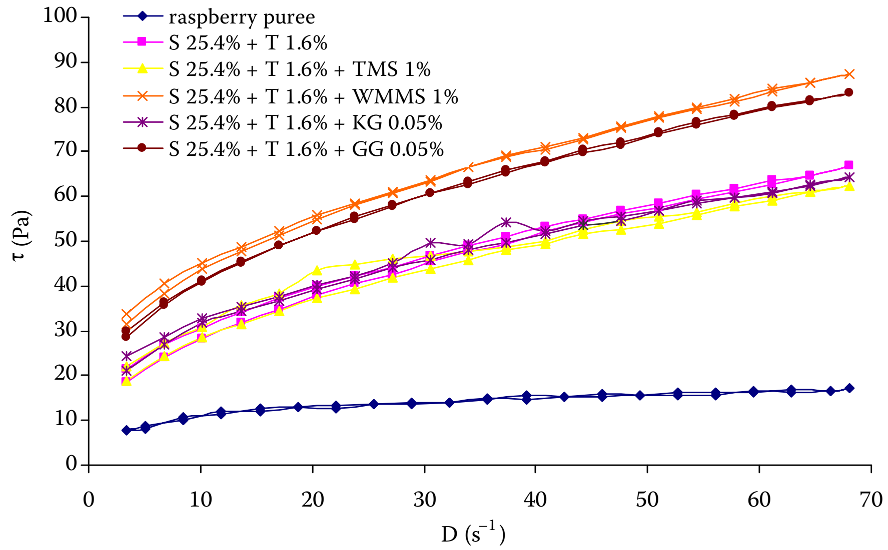

Figure 3. Influence of S (25.4%) – T (1.6%) – TMS (1%) – WMMS (1%) – KG (0.05%) and GG (0.05%) addition on rheological parameters of raspberry cream fillings at 20°C

The addition of waxy maize starch, (Tables 1–3, Figure 1), into paste S significantly increased its consistency at all three temperatures, while the addition of tapioca modified starch and karaya gum caused a decrease of the parameter mentioned. The addition of guar gum did not influence cream filling consistency which was not significantly different from that of the cream filling with only sucrose addition.

The data in Tables 1–3 and Figure 2 show that guar gum addition into SF cream filling at all of the three temperatures caused a higher increase in consistency. The consistency of cream filling with the addition of the other ingredients decreased or was not significantly different from that of SF paste. Waxy maize starch and guar additions significantly increased the consistency of ST cream fillings at 20°C while tapioca starch and karaya addition did not. The temperature drop caused cream filling consistency to increase differently for all additives. The increase the consistency of ST cream filling with the addition of guar or karaya was in a smaller extent than in the case of other additives; at 0°C, those samples had a lower consistency than ST cream filling. Álvarez *et al.* (2006) found such temperature effect on rheological properties of different jams. Similar results were obtained in this study in raspberry cream filling with different additives. The greatest decrease of consistency revealed by ST cream filling with tapioca starch; its consistency was lower than that of ST cream filling at 40°C. From the above mentioned, it was seen that the examined sugars had different impacts on the consistency of raspberry cream fillings with the addition of the starches and hydrocolloids mentioned.

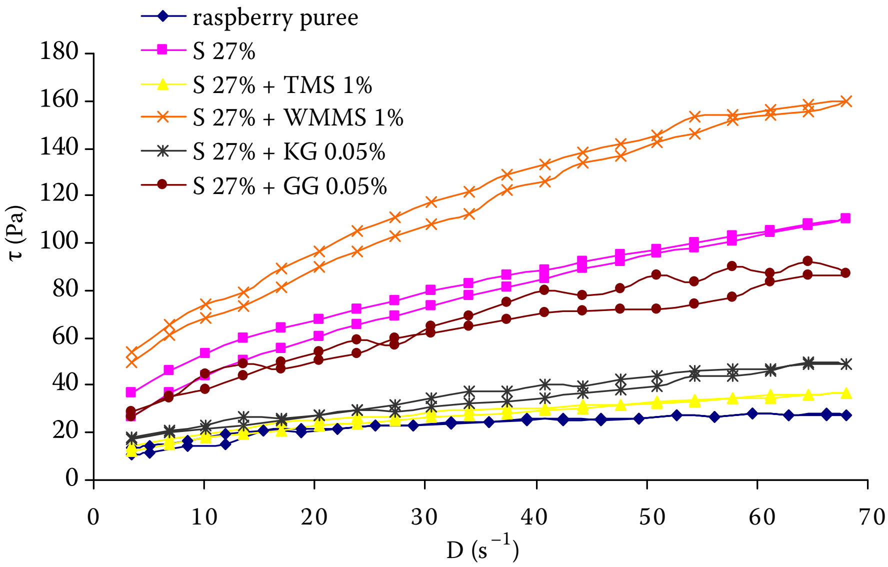

Figure 4. Influence of S (27%) – TMS (1%) – WMMS (1%) – KG (0.05%) and GG (0.05%) addition on rheological parameters of raspberry cream fillings at 0°C

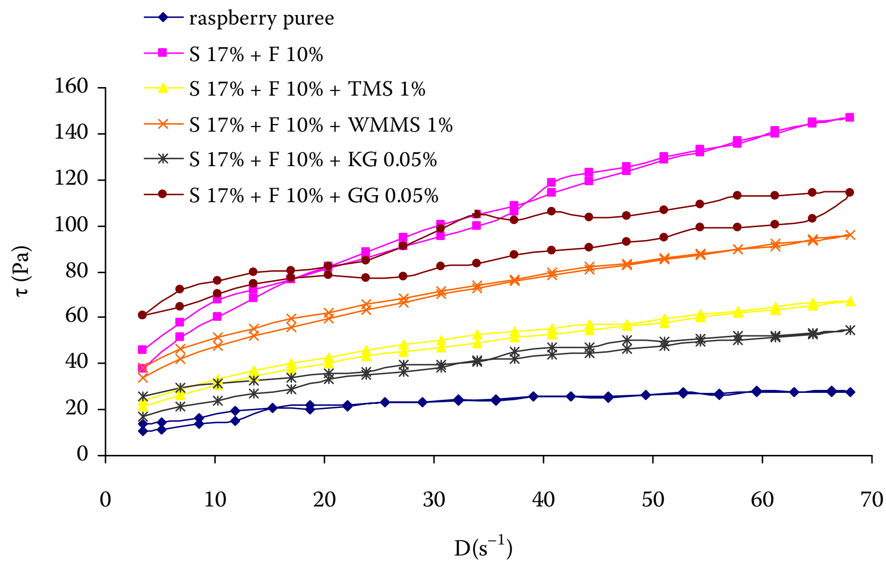

Figure 5. Influence of S (17%) – F (10%) – TMS (1%) – WMMS (1%) – KG (0.05%) and GG (0.05%) addition on rheological parameters of raspberry cream fillings at 0°C

Temperature had a different influence on consistency with the examined additives (Figures 1–6, Tables 1–3). The increase of temperature from 20°C to 40°C caused a decrease of the cream fillings consistency but the cream fillings remained Non-Newtonian, stationary fluids. On the contrary, the decrease of temperature from 20°C to 0°C caused an increase of cream fillings consistency; all cream fillings were stationary, pseudoplastic fluids except S and SF with guar gum. Cream fillings S and SF with guar gum were nonstationary, rheopectic fluids at 0°C (Figures 4 and 5).

At all temperatures, waxy maize starch addition caused a higher cream filling consistency than tapioca starch addition. Waxy maize starch in cream fillings S, SF, and ST caused an increase of consistency, with the exception of SF at 20°C. The samples with the addition of tapioca starch had opposite effect.

The consistency of the cream filling with the addition of guar was higher than cream filling consistency with the addition of karaya in all samples except ST at 0°C and 40°C. Guar addition into cream fillings S, SF, and ST had different effects on consistency. This ingredient in cream filling S did not significantly change the consistency at any of the three temperatures while in SF cream filling it significantly increased the consistency at the above mentioned temperatures and in ST cream filling, it increased the consistency at 20°C, decreased it at 0°C, and did not have any significant influence at 40°C. Karaya addition into S and SF cream fillings decreased the consistency at all three temperatures, however, in ST cream filling the same ingredient increased it.

The data in the given tables and figures showed that from the examined modified starches and hydrocolloids added into cream fillings S, SF, and ST,

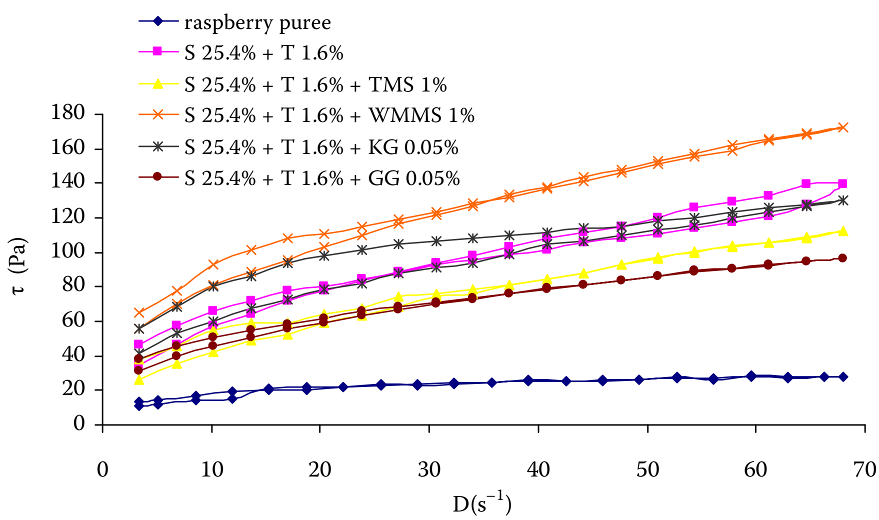

Figure 6. Influence of S (25.4%) – T (1.6%) – TMS (1%) – WMMS (1%) – KG (0.05%) and GG (0.05%) addition on rheological parameters of raspberry cream fillings at 0°C

the a higher impact on the cream filling consistency was revealed by waxy maize modified starch and guar gum compared to tapioca modified starch and karaya gum.

The results of other Power-law parameters of raspberry cream fillings with the addition of different combinations of sugars, modified starches, and hydrocolloids showed the same tendency as consistency.

CONCLUSION

The addition of all the examined sugars into raspberry cream fillings increased the cream fillings consistency. The added sugars had different effects on the increase of consistency. Cream fillings SF and ST had a higher consistency than S cream filling. The replacement of part of sucrose with fructose or trehalose resulted in increased consistency.

The modified starches and hydrocolloids, examined in this paper, had different impacts on the consistency of S, SF, and ST cream fillings. The influence of the analysed starches and hydrocolloids depended on the examined sugars portions in the cream fillings. The cnsistency of S cream filling increased with waxy maize modified starch addition and decreased with tapioca modified starch, karaya, and guar gum additions. The cream filling consistency of SF increased with guar addition and decreased or was not significantly different on the addition of tapioca starch, karaya, or waxy maize modified starch. The cream filling consistency of ST significantly increased with waxy maize modified starch and guar additions while it slightly increased with tapioca modified starch and karaya at room temperature. The temperature had different impacts on the paste consistency with the examined additives.

All cream fillings were Non-Newtonian stationary fluids at 0, 20, and 40°C except cream fillings S and SF with guar gum at 0°C. These cream fillings were non-stationary rheopectic fluids at 0°C.

Waxy maize modified starch or guar gum additions into raspberry cream fillings had a greater impact on the cream filling consistency than tapioca modified starch or gum karaya.

Acknowledgement. We would like to thank National Starch & Chemical (Liverpool, UK) for tapioca and waxy maize modified starches for preparing the raspberry cream fillings.

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Received for publication December 7, 2009
Accepted after corrections May 18, 2011

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