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Organogels as novel ingredients for low saturated fat ice creams

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ABSTRACT

The aim of this work was to evaluate the use of sunflower oil organogels made with phytosterols and γ-oryzanol as milk cream substitutes in artisanal ice creams. Fat amount (4 and 8 g/100 g) and type (milk cream, sunflower oil, and organogels containing two levels of gelators) were considered as factors. The higher fat amount significantly decreased density (1.08 ± 0.01 g/mL *vs* 1.10 ± 0.01 g/mL) and soluble solid content (27.2 ± 0.3 °Bx *vs* 30.1 ± 0.3 °Bx) of mixes, as well as ice cream overrun (31.1 ± 0.6% *vs* 37.3 ± 0.6%) and melting rate (2.5 ± 0.1 g/min *vs* 2.9 ± 0.1 g/min). The use of organogels with the highest gelator concentration yielded ice creams with quality characteristics comparable to those of the samples containing milk cream, and even better overrun (42.4 ± 0.8% *vs* 37.1 ± 0.8%) and melting starting time (20 ± 1 min *vs* 16 ± 1 min). Thus, the application of organogels in artisanal ice creams is a successful approach in order to obtain "low saturated fat" products (saturated fat < 0.9 g/100 g) "with added plant sterols and stanols" intended for people who want to lower their blood cholesterol level.

1. Introduction

High amounts of trans and saturated fatty acids in the diet represent a major concern since these compounds are known to be atherogenic, contributing to the build-up of cholesterol and other substances in artery walls (Marangoni & Garti, 2011). A consumption of saturated fat lower than 10% of the daily energy is recommended by dietary guidelines of governing bodies worldwide, while an increasing consumption of mono and polyunsaturated fatty acids from vegetable (and vegetable oil) sources is suggested (EFSA, 2017; Stortz, Zetzl, Barbut, Cattaruzza, & Marangoni, 2012; WHO, 2015).

Unfortunately, the mouthfeel and textural properties of many foods including ice cream, chocolate, and meat products are due to saturated fats, thus, their replacement with unsaturated oils is a considerable technical challenge (Stortz et al., 2012). In particular, the physical properties of fat play a significant role in ice cream mix behaviour during freezing and in formation of the final structure. The two factors of interest are the proportion of liquid fat present in the fatty phase at the time of entry into the freezer and the way in which the fat crystallizes (Berger, 1990), both affected by the proportion of saturated fatty acids.

A novel strategy to reduce the amount of saturated fats in food products relies in the ability to structure liquid oil and make it behave like a solid crystalline fat, without causing significant changes in the chemical composition. A major approach is to incorporate specific components (named "gelators") that, by various mechanisms, are able to alter the oil physical properties so that the rheological behaviour resembles that of fats. These novel oil-based materials are usually called "organogels" or "oleogels", being gels where the liquid phase is oil and not water as in a hydrogel (Marangoni & Garti, 2011). One of the most interesting organogelling strategies for food applications is based on the use of a plant sterol (i.e., β-sitosterol) and a plant sterol ester (i.e., γ-oryzanol) as gelators. The building blocks of this gel are self-assembled tubules and the onset of assembly is strongly dependent on gelator concentration. The kinetic of the aggregation depends considerably on the details of the system, such as the sitosterol-oryzanol ratio, the type of sterol, the cooling temperature, the quiescent or stirring conditions, etc. At least 2–4 g/100 g total sterols are needed to form a gel at 5 °C. The optimal composition of the gelator mixture in terms of maximal organogel firmness is a 1:1 M ratio of sitosterol and oryzanol, that is a 40:60 wt ratio. With increasing temperatures, the progressive dissolution of sitosterol and oryzanol tubules leads to the gel melting (Bot & Flöter, 2011).

Apart from the good structuring properties, phytosterol-based organogels are particularly interesting because phytosterol intake by

Abbreviation list: ANOVA, analysis of variance; A_t/A_0, ratio between ice cream sample area at different times of melting referred to the area at the initial time; K, consistency coefficient; LSD, Least Significant Difference test; MC, milk cream; MC4, ice cream sample made with 4 g/100 g milk cream; MC8, ice cream sample made with 8 g/100 g milk cream; MSNF, milk solids not fat; n, flow behaviour index; OG, organogel; OG_12, organogel with 12 g/100 g gelators; OG_8, organogel with 8 g/100 g gelators; OG4_12, ice cream sample made with 4 g/100g organogel containing 12 g/100 g gelators; OG4_8, ice cream sample made with 4 g/100 g organogel containing 8 g/100 g gelators; OG8_12, ice cream sample made with 8 g/100 g organogel containing 12 g/100 g gelators; OG8_8, ice cream sample made with 8 g/100 g organogel containing 8 g/100 g gelators; R_t/R_0, ratio between ice cream sample height and width at different times of melting referred to the ratio at the initial time; SO, sunflower oil; SO4, ice cream sample made with 4 g/100 g sunflower oil; SO8, ice cream sample made with 8 g/100 g sunflower oil

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foods is associated with a significant LDL-cholesterol lowering. For the recommended intake of 2 g/day, a 9% lowering of LDL-cholesterol is expected (Demonty et al., 2009).

Notwithstanding the high interest in food-grade organogels meant by the packed literature in this field, few papers deal with oleogel applications in real food systems (Aguirre-Mandujano, Lobato-Calleros, Garcia, & Vernon-Carter, 2009; Calligaris, Manzocco, Valoppi, & Nicoli, 2013; Goldstein & Seetharaman, 2011; Manzocco, Anese, Calligaris, Quarta, & Nicoli, 2012; Stortz et al., 2012). Only Zulim-Botega, Marangoni, Smith, and Goff (2013a,b) studied the application of oleogels in ice cream. In particular, performances of rice bran wax, candelilla wax, or carnauba wax oleogels in ice creams formulated with 10 or 15 g/100 g fat were evaluated. They demonstrated the potentials of rice bran wax oleogels to develop fat structure in ice cream with high fat concentration (15 g/100 g), in the presence of glycerol monooleate as emulsifier.

The aim of this work was to study the possibility of producing healthier artisanal ice creams by substituting milk cream with phytosterol organogel systems based on sunflower oil. In particular, a cold-pressed sunflower oil was used, in order to reduce the amount of saturated fatty acids brought in the final product and to enrich the ice cream in antioxidant compounds (i.e., α- and β-tocopherol). Quality features of ice creams were studied as a function of the amount (4 and 8 g/100 g) and type of fat used (milk cream, sunflower oil, and organogels containing two different levels of gelators), as well as of their interaction.

2. Materials and methods

2.1. Organogel preparation

In organogel (OG) preparation the following ingredients were used: cold-pressed sunflower oil kindly supplied by Il frutteto Incantato di Montefiore (Recanati, Italy), γ-orizanol (Sochim International, Cornaredo, Italy), and phytosterol complex concentrate 95% (Sochim International). The cold-pressed sunflower oil had a saturated fatty acid level of 10.2%, and a α- and β-tocopherol content of 540 mg/kg and 25 mg/kg, respectively. The phytosterol concentrate contained β-sitosterol (51.62 g/100 g), campesterol (21.85 g/100 g), stigmasterol (21.23 g/100 g), brassicasterol (1.13 g/100 g), β-sitostanol (0.81 g/100 g), campestanol (0.49 g/100 g), and other sterols and stanols (2.87 g/100 g).

Two levels of gelators were considered in OG production: 8 g/100 g (OG_8) or 12 g/100 g (OG_12) on oil basis. Gelators consisted of a phytosterol concentrate and γ-orizanol mixture in 40:60 wt ratio.

Sunflower oil was warmed up to 70 °C in a thermostatic bath; then the given amount of gelators was added under continuous stirring. The stirring phase lasted for 35 min, until the total dissolution of gelators in the oil. Then, the hot mixture of oil and gelators was added to ice cream mix during pasteurization as described in §2.3. Since the application of a heating-cooling temperature cycle causes the gelator tubules to dissolve and reform (Bot et al., 2011), the cooling phase necessary to the formation of the OG was not carried out because the addition of the lipid phase to the ice cream mix during heating would have dissolved the gel in any case. The typical tubules of this kind of OG were supposed to form during cooling of the ice cream mix, as already demonstrated for oil in water (o/w) emulsions: the initial creation of the emulsion can be done more or less independently from a later formation of the OG network in the lipid phase (Duffy et al., 2009).

2.2. Ice cream formulations

Experimental ice creams were formulated as reported in Table 1, varying the amount of fat (4 or 8 g/100 g) and keeping constant the quantity of added sugars (14.9 g/100 g) and total solids (30.6 ± 0.3 g/100 g). Fresh pasteurized skim milk (Centrale del Latte di Milano, Milan, Italy) and pasteurized milk cream (Centrale del Latte di Milano, Milan, Italy) were purchased from a local supermarket, while all the powder ingredients were kindly supplied by Comprital S.p.A. (Settala, Italy). Pasteurized milk cream contained 35.0 g/100 mL fat, 68% of which were saturated fatty acids.

Experimental samples were identified by a code consisting of two letters and two numbers: the letters refer to the type of fat used (MC, milk cream; OG, organogel; SO, sunflower oil), the first number to the amount of fat in the formulation (4 or 8 g/100 g), and the second number to the percentage of gelators used for oil structuring (8 or 12 g/100 g on oil basis).

2.3. Ice cream production

Ice cream mixes were prepared as reported by Rossi, Alamprese, Casiraghi, and Pompei (1999), by using a Pastomaster 60 Tronic and a Labotronic 20–30 batch freezer (Carpigiani S.r.l, Anzola Emilia, Italy). Briefly, liquid ingredients were heated up to 50 °C before the addition of solid ingredients. SO and OG, when present, were added to milk during heating just before the solid ingredient addition. The mix (15 kg) was then pasteurised at 85 °C for about 1 min and aged at 4 °C for 24 h. Mix freezing was carried out in 3 L batches, measuring ice cream extrusion time using a chronometer. Immediately after extrusion, ice cream temperature was evaluated by a thermometer inserted in the centre of the product. After packaging, ice cream samples were stored for 24 h at −30 °C and then conditioned

Table 1
Formulation and composition of ice cream samples produced in order to study the effect of fat amount and type.

	MC4	MC8	SO4	SO8	OG4_8	OG8_8	OG4_12	OG8_12
Ingredients (g/100 g)								
Fresh skim milk	67.9	60.3	75.2	75.2	75.2	75.2	75.2	75.2
Fresh milk cream	11.2	22.8	–	–	–	–	–	–
Sunflower oil	–	–	3.9	7.9	–	–	–	–
Organogel 8 g/100 g gelators	–	–	–	–	3.9	7.9	–	–
Organogel 12 g/100 g gelators	–	–	–	–	–	–	3.9	7.9
Skim milk powder	5.4	1.4	5.4	1.4	5.4	1.4	5.4	1.4
Sucrose	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Dextrose	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Whey proteins	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Stabilizers & Emulsifiers	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Composition (g/100 g)								
Fat	4.0	8.0	4.0	8.0	4.0	8.0	4.0	8.0
of which saturated	2.7	5.5	0.5	0.9	0.5	0.9	0.5	0.9
Added sugars	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9
MSNF	11.2	7.8	11.2	7.7	11.2	7.7	11.2	7.7
Total solids	30.4	31.0	30.3	30.8	30.3	30.8	30.3	30.8

MSNF, milk solids not fat; MC, milk cream; SO, sunflower oil; OG, organogel.

for 24 h at −16 °C before analyses. Two technological replicates were carried out for each formulation.

2.4. Ice cream mix analyses

Ice creams mixes were characterized in terms of viscosity, density and soluble solids as reported by Moriano and Alamprese (2017). In particular, viscosity was evaluated in duplicate at 4 °C by means of flow curves performed by a Physica MCR 300 rheometer (Anton Paar, Graz, Austria) equipped with a cone-plate geometry (CP50-1), ranging shear rate from 20 to 500 s^{-1}. Results are expressed as the average of two technological replicates in terms of apparent viscosity (mPa s) at 290 s^{-1}. This value of shear rate was chosen because it represents an average pipe wall shear rate during fluid food pumping (Alamprese, Pompei, & Guatelli, 2001). Moreover, consistency coefficient (K; mPa s^n) and flow behaviour index (n; dimensionless) were calculated by fitting flow curves with the power law equation (Steffe, 1996).

2.5. Ice cream analyses

Analyses of ice cream quality characteristics were carried out as reported in Alamprese, Foschino, Rossi, Pompei, and Savani (2002), and in Moriano and Alamprese (2017). Overrun is reported as the percentage of mix volume increase during freezing, measured on ten 230 mL samples for each production. Firmness was determined by an Instron Universal Testing Machine (Mod. 4301, Instron Ltd., High Wycombe, UK) performing penetration tests on 50 mL samples. A stainless steel cylindrical probe (8 mm diameter) connected to a 100 N load cell was used, penetrating ice cream samples for 18 mm, using a crosshead speed of 50 mm/min. Results, expressed as the maximum load (N) opposed by ice cream to a 15 mm penetration, are the average of at least ten measurements for each production. Melting behaviour, reported as melting starting time and melting rate, was evaluated at 20 °C on 230 mL ice cream samples, recording the weight of melted ice cream (g) as a function of time (up to 90 min). Results are the average of three replicates for each production. During melting tests, pictures of the samples were taken every 15 min and elaborated by a purposely developed image analysis method (Image Pro Plus 7.0; Media Cybernetics Inc., Rockville, MD, USA). The following shape retention indexes were calculated: R_t/R_0, ratio between sample height and width at different times (0, 15, 30, 45, 60, 75, 90 min) referred to the ratio at the initial time (0 min); A_t/A_0, ratio between the area at each time referred to the area at the initial time. Ice cream colour was measured using a reflectance colorimeter Chroma Meter II (Konica-Minolta, Tokyo, Japan), with standard illuminant C. CIE L*a*b* indexes are reported as the average of nine determinations, carried out on three 230 mL samples of each production.

2.6. Statistical analysis

Two-way analysis of variance (ANOVA) was applied to the analytical data in order to study the effects of the two considered factors: amount of fat (4 g/100 g and 8 g/100 g) and type of fat (MC, SO, OG_8, and OG_12). The interaction term (fat amount × fat type) was also considered in ANOVA; it has not been reported in result tables, but commented in the text only when significant ($p < 0.05$). The Least Significant Difference (LSD) test at $p < 0.05$ was used to evaluate significant differences among the averages (Statgraphics Plus 5.1, Statistical Graphics Corp., Herndon, VA, USA).

3. Results and discussion

3.1. Ice cream mix properties

Results of ice cream mix characteristics and LSD test after two-way ANOVA are shown in Table 2. Formulations with higher amount of fat showed significantly ($p < 0.05$) decreased mix density and soluble solid content, due to the lower density of fat with respect to the serum phase and the lower level of milk solids not fat (MSNF; Table 1). On the contrary, the type of fat did not affect mix density and soluble solid content, with the exception of OG_12 that led to a significantly ($p < 0.05$) higher Brix degree value, probably ascribable to gelators.

Rheological behaviour of ice cream mixes was mainly affected by fat type rather than amount. In particular, the use of SO or OG_8 significantly ($p < 0.05$) decreased the apparent viscosity and the consistency coefficient of the mixes with respect to samples containing MC or OG_12. This result is related to the higher amount of saturated fatty acids in MC, yielding higher proportions of crystallized fat at 4 °C with respect to those of samples containing SO or OG_8. OG_12 showed a higher structuring effect with respect to OG_8, resulting in an apparent viscosity of ice cream mixes not significantly ($p > 0.05$) different from that of samples made with MC. This result revealed that an OG network was actually created in the ice cream mix containing OG_12, increasing the apparent viscosity of the system. The higher amount of gelators needed to structure sunflower oil in the ice cream emulsion is in agreement with previous findings by Sawalha et al. (2012), who reported that in the emulsion, the water molecules bind to the β-sitosterol molecules, forming monohydrate crystals that hinder the formation of the tubules thus resulting in a weaker emulsion-gel.

Sunflower oil is a Newtonian fluid, thus its flow behaviour index (n) is equal to 1. Rheology of sunflower oil affected the rheological behaviour of ice cream mixes containing this type of fat (structured or not). Indeed, ice cream mixes SO, OG_8, and OG_12 showed significantly ($p < 0.05$) higher values of n with respect to samples produced with MC. As it is shown in Fig. 1, the behaviour of mixes containing OG with 12 g/100 g gelators (OG4_12 and OG8_12) was more similar to those produced with MC rather than to samples made with SO or OG_8, in agreement with the higher structuring ability of the higher gelator concentration.

Table 2
Results of ice cream mix properties (mean ± standard error values of two technological replicates) as a function of the two experimental factors studied: fat amount and type.

Factors	Density (g/mL)	Soluble solids (°Bx)	Apparent viscosity (mPa s)	K (mPa s^n)	n (−)
Fat amount (g/100 g)					
4	1.10 ± 0.01^{b}	30.1 ± 0.3b	29.9 ± 0.5a	78±3a	0.831 ± 0.005a
8	1.08 ± 0.01^{a}	27.2 ± 0.3a	29.5 ± 0.5a	74±3a	0.848 ± 0.004b
Fat type					
MC	1.08 ± 0.01^{a}	28.5 ± 0.4a	32.2 ± 0.7b	102±4c	0.799 ± 0.006a
SO	1.09 ± 0.01^{a}	28.0 ± 0.4a	27.6 ± 0.7a	66±4a	0.848 ± 0.007b
OG_8	1.09 ± 0.01^{a}	28.0 ± 0.4a	27.1 ± 0.7a	60±4a	0.862 ± 0.007b
OG_12	1.09 ± 0.01^{a}	30.2 ± 0.4b	31.9 ± 0.7b	76±3b	0.850 ± 0.005b

MC, milk cream; SO, sunflower oil; OG_8, sunflower oil-based organogel with 8 g/100 g gelators; OG_12, sunflower oil-based organogel with 12 g/100 g gelators; K, consistency index; n, flow behavior index.
[a-c] within the same factor, results with different superscript letters in the same column are significantly different ($p < 0.05$) on the basis of two-way ANOVA followed by the Least Significant Difference test.

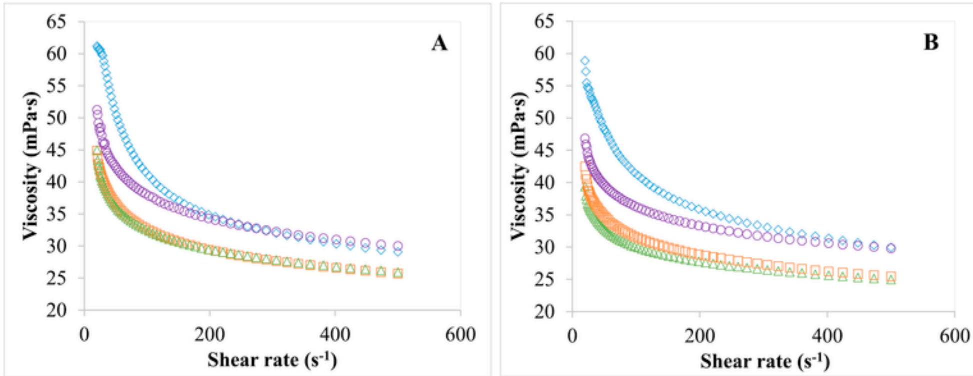

Fig. 1. Flow curves (mean of two technological replicates) of ice cream mixes produced with milk cream (MC; ◊), sunflower oil (SO; □), organogel with 8 g/100 g gelators (OG_8; Δ) and organogel with 12 g/100 g gelators (OG_12; ○), containing 4 g/100 g fat (A) and 8 g/100 g fat (B). Standard deviation values ranged from 0.9 to 6.8 mPa s.

3.2. Quality characteristics of ice creams

No significant ($p > 0.05$) differences were measured in extrusion time and temperature of ice cream samples as a function of fat amount or type. All ice cream mixes were extruded in 7.8 ± 0.2 min, reaching a temperature of −7.9 ± 0.4 °C. On the contrary, both the considered factors significantly ($p < 0.05$) affected quality characteristics of ice creams in terms of overrun and melting behavior (Table 3). As already observed in previous works (Alamprese et al., 2002; Roland, Philips, & Boor, 1999; Zulim-Botega, Marangoni, Smith, & Goff, 2013b), a higher amount of fat accounted for a lower overrun and melting rate. This can be related to the corresponding lower level of MSNF in the ice creams (Table 1), bringing in the product less proteins and consequently modifying whipping properties of mix and melting behavior of the final product (Goff, 1997). As regards the type of fat, SO and OG_8 worsened the ice cream overrun with respect to MC, while the use of OG_12 resulted in an overrun even higher than that of the ice cream containing MC. Moreover, in comparison with MC samples, ice creams made with OG_12 showed a significantly ($p < 0.05$) higher melting starting time and a similar melting rate. Thus, it can be concluded that the use of OG_12 accounted for an improvement in ice cream quality characteristics with respect to the use of non-structured SO. This can be related to the higher ratio of solid:liquid fat attained during mix ageing, since, as reported by Goff (1997), a partially crystalline emulsion is needed for partial fat coalescence in the whipping and freezing steps, leading to air bubble stabilization and, as a consequence, to higher overrun and melting resistance. Similar results were obtained by Zulim-Botega et al. (2013b), who demonstrated that the use of a rice bran wax oleogel instead of high oleic sunflower oil improves overrun and melting rate of ice cream.

The fat amount effect on ice cream firmness was not in agreement with previous papers reporting a higher softness with the increasing of fat content (Alamprese et al., 2002; Roland et al., 1999). However, it has to be highlighted that the formulation balancing is very important to this aspect. In this work, mix total solids have been kept constant, meaning that in recipes with a low amount of fat there was a higher content of MSNF (Table 1) including also lactose and minerals. According to the Raoult's law, a higher molar fraction of low molecular weight solutes accounts for a higher freezing point depression effect (LeBail & Goff, 2008). This means that at a given temperature ice creams with higher MSNF concentration (corresponding in this research to the samples with lower amount of fat) will have a higher amount of unfrozen water, thus justifying the lower ice cream firmness.

The interaction term fat amount × type was also significant ($p < 0.05$). Actually, looking at each fat type separately (Table 4), the increase in fat amount always yielded firmer ice creams, with the exception of the samples containing SO. In this case, it is likely that the lower amount of solid fat at the temperature of analysis (−16 °C) caused the lower ice cream firmness.

All the ice cream samples showed a good shape retention during melting (Fig. 2). However, the significantly ($p < 0.05$) highest R_t/R_0

Table 3
Results of quality characteristics of ice cream samples (mean ± standard error values of two technological replicates) as a function of the two experimental factors studied: fat amount and type.

Factors	Overrun (%)	Firmness (N)	Melting behaviour	
			t_s (min)	rate (g/min)
Fat amount (g/100g)				
4	37.3 ± 0.6^b	12.7 ± 0.7^a	18±1^a	2.9 ± 0.1^b
8	31.1 ± 0.6^a	15.4 ± 0.7^b	19±1^a	2.5 ± 0.1^a
Fat type				
MC	37.1 ± 0.8^b	14±1^a	16±1^a	2.28 ± 0.09^a
SO	27.5 ± 0.8^a	13±1^a	20±1^b	2.83 ± 0.09^b
OG_8	29.9 ± 0.8^a	14±1^a	18±1^{ab}	2.98 ± 0.09^b
OG_12	42.4 ± 0.8^c	15±1^a	20±1^b	2.67 ± 0.09^{ab}

MC, milk cream; SO, sunflower oil; OG_8, sunflower oil-based organogel with 8 g/100 g gelators; OG_12, sunflower oil-based organogel with 12 g/100 g gelators; t_s, starting time.
[a-b] within the same factor, results with different superscript letters in the same column are significantly different ($p < 0.05$) on the basis of two-way ANOVA followed by the Least Significant Difference test.

Table 4
Firmness (mean ± standard error values of two technological replicates) of ice cream samples produced with different fat amount and type.

Sample	Fat amount (g/100 g)	Type of fat	Firmness (N)
MC4	4	MC	13 ± 1
MC8	8	MC	15 ± 1
SO4	4	SO	14 ± 2
SO8	8	SO	11 ± 2
OG4_8	4	OG_8	12 ± 1
OG8_8	8	OG_8	16 ± 1
OG4_12	4	OG_12	11 ± 1
OG8_12	8	OG_12	18 ± 1

MC, milk cream; SO, sunflower oil; OG_8, sunflower oil-based organogel with 8 g/100 g gelators; OG_12, sunflower oil-based organogel with 12 g/100 g gelators. See Table 1 for ice cream sample formulations.

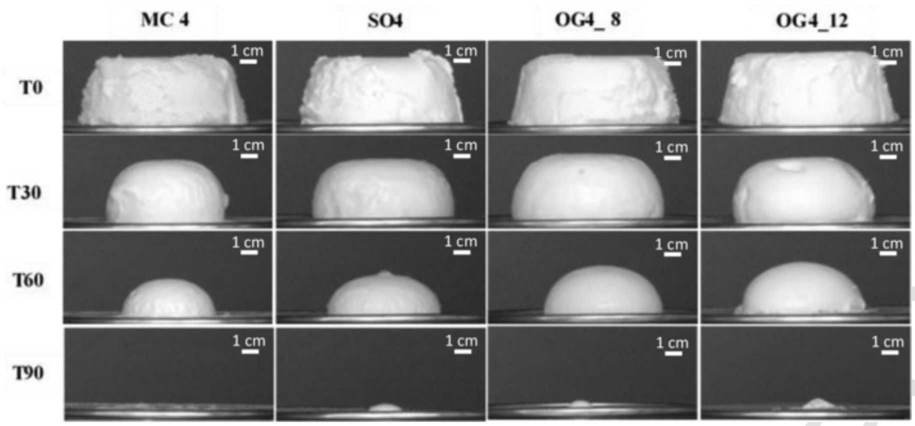

Fig. 2. Examples of pictures taken during melting test of ice creams containing 4 g/100 g fat, produced with milk cream (MC4), sunflower oil (SO4), organogel with 8 g/100 g gelators (OG4_8), and organogel with 12 g/100 g gelators (OG4_12). The pictures are taken at the beginning of the test (T0) and after 30 (T30), 60 (T60), and 90 (T90) minutes.

values were obtained with the use of OG_12, confirming the good performance of this type of fat in comparison with SO and even MC, the latter resulting in ice creams with significantly ($p < 0.05$) lower R_t/R_0 values (Fig. 3A and B). The higher fat amount accounted for significantly ($p < 0.05$) higher A_t/A_0 indexes (Fig. 3C and D), in agreement with the lower melting rate of these samples (Table 3).

Color of ice cream samples was measured in order to highlight possible effects of the different fat types and amounts used. In all samples, L* values ranged from 93.0 to 95.3, a* from −3.9 to −2.9, and b* from 5.3 to 6.4. No significant ($p > 0.05$) differences were observed. Thus it can be concluded that the different color of MC with respect to SO and OG did not modify visual appearance of ice creams.

4. Conclusions

In conclusion, the application of organogels in artisanal ice creams as milk cream substitutes is a successful approach in order to obtain healthier products. In particular, ice creams produced with OG

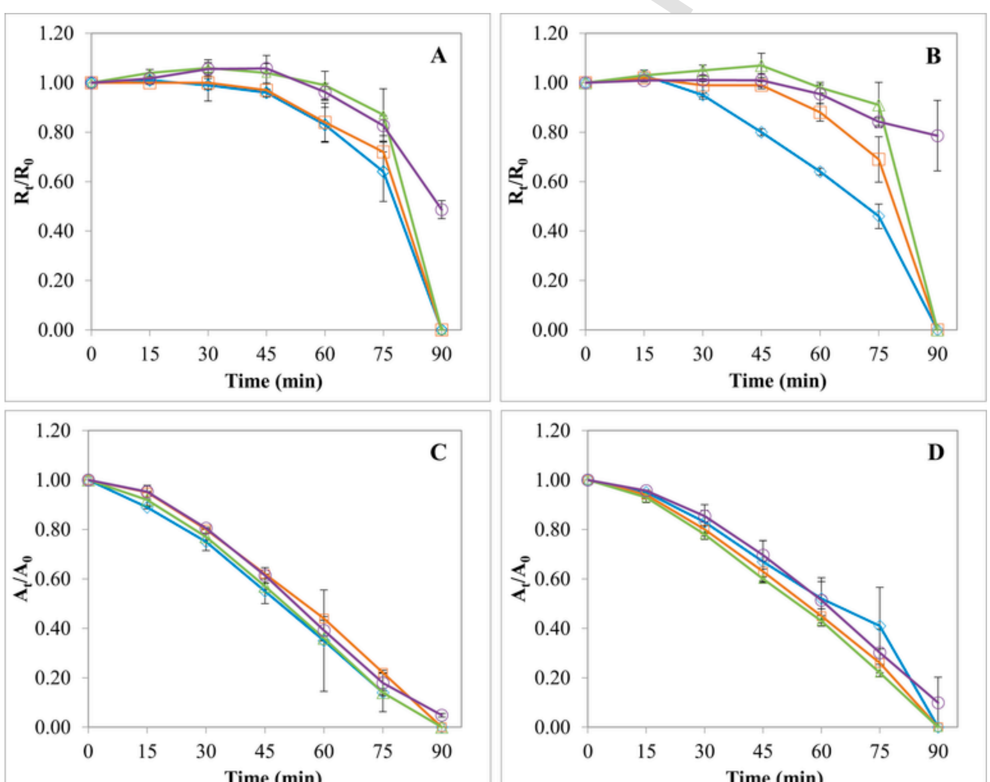

Fig. 3. Shape retention indexes (R_t/R_0 and A_t/A_0) as a function of melting time of ice creams produced with milk cream (MC; ◊), sunflower oil (SO; □), organogel with 8 g/100 g gelators (OG_8; Δ) and organogel with 12 g/100 g gelators (OG_12; ○), containing 4 g/100 g fat (A, C) and 8 g/100 g fat (B, D). Error bars represent standard deviation values of two technological replicates. R_t/R_0, ratio between ice cream sample height and width at different times of melting referred to the ratio at the initial time; A_t/A_0, ratio between ice cream sample area at different times of melting referred to the area at the initial time.

containing 12 g/100 g gelators showed similar or even better quality characteristics with respect to samples made with MC.

Ice creams produced with 4 or 8 g/100 g OG contained 0.48 g/100 g and 0.86 g/100 g saturated fats, respectively, representing about 3 and 5% of the total energy content of the products. Thus, in agreement with Regulation (EC) No 1924/2006, they can be claimed as “low saturated fat” ice creams. Actually, the Regulation states that the claim can be used if the sum of saturated fatty acids and *trans*-fatty acids in the product does not exceed 1.5 g/100 g for solids and does not provide more than 10% of energy. In MC samples, saturated fatty acids ranged from 2.74 to 5.47 g/100 g as a function of the fat amount.

Moreover, because of the presence of phytosterols and phytostanols, the label of ice creams containing OG shall contain the words “with added plant sterols and plant stanols”, the amount of phytosterols and phytostanols used as ingredients, and a statement that the product is intended for people who want to lower their blood cholesterol level (Commission Regulation (EC) No 608/2004). Considering an average ice cream serving portion of 150 g, the developed products does not exceed the limit about the consumption of no more than 3 g/day of added plant sterols/stanols stated by the European legislation.

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