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# INCORPORATION OF MILK PROTEIN CONCENTRATE (MPC) AND WHEY PROTEIN CONCENTRATE (WPC) IN THE BLEND OF LOW FAT ICE CREAM

**El-Nemr, T.; M. El-Ghannam and N. Diab**
**Department of Dairy Science and Technology, Faculty of Agriculture (shatby), Alexandria University , Alexandria , Egypt**

## ABSTRACT

Study was carried out to utilize the available novel dairy products as a non-fat-dry milk substitutes in manufacturing of low fat ice cream, as well as to fortify the product with such high biological value nutrients.

Non-fat-dry milk (NFDM) was used as a source of milk solids-not-fat in the manufacturing of control and three sources of milk solids were used as NFDM substitutes; milk protein concentrate 70% protein (MPC70), whey protein concentrate 80% protein (WPC80) and whey protein concentrate 30% protein (WPC30). NFDM was substituted by 25, 50, 75 and 100% of each source. Each trial contained 3% milkfat, 15% sucrose, 0.25% gelatin and 11.5% MSNF and 29.5% total solids. Viscosity, pH, and whipping time were determined in the mix while overrun, melting down and organoleptic properties were determined in the finished manufactured ice cream.

Data revealed that substitution has no effect on pH values; it ranged between 6.5 and 6.6 for all treatments. Substitution of NFDM by MPC70 and WPC80 led to gradual increscent in viscosity, while Substitution by WPC30 has no effect.

Control sample had the longest whipping time (10min.) comparing with all other treatments where the increasing of substitution ratios led to a slight decrease in whipping time. Samples contained WPC30 showed closer whipping time (9-8min.) to the control.

Overrun was greatly influenced by substitution treatments. Control sample achieved 48.1% overrun. MPC70-containing samples gained higher overrun than control but in a descending trend and at 100% substitution, overrun become lower than the control. On the other hand, WPC80-containing samples had the highest overrun values in an ascending trend positively with the substitution ratio and at 100% substitution it was (89.5%) nearly the duplicate of control. Samples contain WPC30 had an opposite trend despite all overrun values were lower than the control.

Melted amount of control sample was 50.5%. Samples contained MPC70 showed a drastic decrease in melting down (45.5-15.6%) with the increasing of substitution ratio. Samples contained WPC80 showed the same trend but the values were (66.3-38.6%)**.** Samples containing WPC30 showed reverse trend where the amount of melted samples was increased (42.6-56.3%).

It can be concluded that the MPC70 has an advantage of slow down the melting of ice cream.WPC80 has the same particularity but with a lesser extent. In accordance WPC30 has an adverse characteristic. It can also report that using of high ratios of the studied substitutes, particularly WPC30, associated with negative effects on the organoleptic properties of ice cream. On the other hand, MPC70 and WPC80 was more match than WPC30 for use as NFDM substitutes hence they can be used conveniently with ratios up to 50% substitution without causing adverse effects on the ice cream properties.

**Keywords**: low fat ice cream, substitution, milk protein concentrate, whey protein concentrate,physical property,

# INTRODUCTION

The authentic relation between food and health come to be superior concern of modern dairy industry. Augment customer wariness about his health make food processing companies pay attention to the nutritional substances getting in the formulation of food. In particular nutrients having high biological value such as milk proteins become more interesting.

Both whey proteins concentrate (WPC) and milk protein concentrate (MPC) are excellent sources of high quality protein. Whey protein concentrate (WPC) containing 35% protein is commonly used in ice cream processing as SNF replacer aiming at low cost advantage (Kelley, 1986). Whey protein concentrate (WPC) has been included in ice cream mix formulations for its contribution to favorable sensory and textural qualities (Tu¨lay *et al* 2006 ;Tirumalesha and Jayaprakasha, 1998; and Hofi et al., 1993).

The water-binding capacity of WPC is influenced by protein concentration, mineral content, and the extent of heating during manufacture (Morr, 1989 ;Sienkiewicz and Riedel, 1990). Whey protein concentrates can also be utilized for their emulsifying properties. Proteins interact at the oil/water interface during homogenization to stabilize the fat emulsion. During freezing, proteins function to control destabilization of fat (Goff, 1997; and Mangino, 1992).Increased amounts of whey proteins at the oil/water interface lower surface tension and slightly increase mix viscosity that produces a drier ice cream and enhances partial coalescence in the freezer (Goff *et al.,*1989). The tremendous foaming properties of whey proteins allow fine dispersion of air cells (Zayas, 1997), which will lower the ice crystal size in ice cream (Flores and Goff, 1999).

The amount of whey solids that may be used in ice cream is limited due to lactose crystallization and flavor. Currently, actual requirements allow 25% substitution of whey solids for SNF in frozen dairy products. Considerable studies have been conducted by incorporating types of whey products such as whey powders (Coder and Pansons. 1979), whey (Naidu, et al. 1986 and Haque, & T. Ji. 2003), hydrolyzed whey, (Martinez and Speckman.1988), UF whey concentrate (Gregory, 1985), and whey protein concentrates (Parsons, *et al* .1985) into ice cream .

Increasing levels of milk solids nonfat (MSNF) in ice cream can benefit texture and flavor. The use of traditional MSNF sources is limited at higher levels due to off-flavors and increased lactose content which increases the occurrence of sandiness in the ice cream (Kilara, 1993). Alvarez,(2005) reported that milk protein concentrates (MPC) are relatively new dairy product ingredients that have not yet been studied as an alternative MSNF source in full-fat ice cream formulations. Milk protein concentrates are manufactured by ultrafiltration and diafiltration of milk, followed by a 2-stage drying process of evaporation and spray drying. The product is high in protein, and low in lactose. Milk protein concentrates maintain the original casein: whey ratio of milk (Novak, 1992). These properties give MPC the potential to serve as an alternative source of MSNF, without some of the drawbacks of traditional sources or alternatives studied previously. Before using MPC to replace all or part of the NFDM as a source of MSNF in ice cream, MPC functionality needed. Patel, (2006) reported that it is hypothesized that ice cream enriched with protein can be produced by adding WPC or MPC. Whey protein concentrates or MPC could be used by ice cream manufacturers to produce acceptable quality ice cream that is higher in protein than traditional one.

The present study was carried out to evaluate to what extent the utilization of MPC or WPC can be successfully replaced the usual sources of MSNF (liquid milk and NFDM) in the ice cream blend.

## MATERIALS AND METHODS

**Ingredients of ice cream mix:**

Sources of milk solids-not-fat

| Product | Protein% | Lactose% | Ash% | Moisture% | Fat% | Origin |
|---|---|---|---|---|---|---|
| NFDM | 37.50 | 51.00 | 6.25 | 4.00 | 1.25 | France |
| MPC(7٠%) | 70.80 | 16.70 | 7.20 | 4.00 | 1.30 | (Alapro 4100 Newzeland |
| WPC(30%) | 30.40 | 55.00 | 6.60 | 4.00 | 4.00 | (Fondolac 30) Germany |
| WPC(80%) | 81.7 | 7.80 | 1.55 | 4.00 | 4.95 | Agri-Mark,Inc. USA |

NFDM = Non-fat-dry milk; MPC = Milk protein concentrate; WPC = Whey protein concentrate.

Fresh centrifugal separated cow cream 40 % fat and 5.1% SNF was used.

Pure crystalline sucrose was obtained from the local market.

Edible gelatin (pellets) was obtained from the local market.

Vanilla flavor (powder) obtained from the local market was used.

**Blends of ice cream mix (2Kg for each) were prepared as follows:**

Control blend: 240g NFDM; 300g sucrose; 150g Cream; 5g gelatin and 1305 g of water.

Substitution blends: NFDM was substituted by MPC 70%; WPC 30% and WPC 80% at a rate of 25%, 50%, 75%, and 100%.The other components of the blend still without change.

| Fat % | Sucrose % | Gelatin % | MSNF % | Total solids % |
|---|---|---|---|---|
| 3.0 | 15.0 | 0.25 | 11.5 | 29.75 |

**Processing steps of ice cream:**

| Steps | Temperature |
|---|---|
| Mixing the dry matter (sucrose with NFDM or MPC or WPC) | Room temp. |
| Dissolve the mix in the water | 50°C |
| Addition of cream | 50°C |
| Addition of dissolved gelatin(dissolved in a minimum amount of water) | 50°C |
| Heat treatment | 75°C / 15 min. |
| Cooling down to room temperature | Room temp. |
| Addition of vanilla | Room temp. |
| Aging | 4°C |
| Whipping | -5°C |
| Packaging in polystyrene cups of 100ml capacity | -5°C |
| Hardening and storing | -20°C |

Ice cream mix was frozen in a freezer (in metall waren fabrik Ansbach , Germany ).

NFDM, MPC and WPC were analyzed for fat by Mojonnier method (Atherton and Newlander, 1977); protein by the Kjeldahl method (991.20; AOAC, 2002); moisture by drying method (method 15.10C described in Standard Methods for the examination of Dairy Products, Bradley, 1993); ash according to the method 945.46; described in AOAC, 2002. Lactose content was determined according to method described in AOAC, 2002 .

Ice cream mix was analyzed for the pH using Fisher Scientific pH meter (USA ).Viscosity was measured at 20°C by using Hoeppler falling ball viscometer ( Germany ).The apparent viscosity was calculated according the manual supplied with the apparatus. Overrun was calculated according to the equation described by Arbuckle 1986; overrun = weight of mix – weight of ice cream / weight of ice cream. Overrun expressed as percentage.

Meltdown was determined as described by Olson, *et al* (2003) as follows: Samples in the cups were obtained from the hardening room, then the material of cups was removed by cutter and the obtained ice cream block was placed on a 2.33/cm² mesh which placed on a funnel stand on a beaker. The mesh, funnel and beaker were weighed before and after placing the ice cream block. The sample was left to melt for 15 minutes at ambient temperature (20± 2°C).The unmelted portion was then removed with spatula and discarded and the mesh, funnel and beaker which containing the melted portion were reweighed(Fig 1). Meltdown was calculated by dividing the weight of the melted portion by the weight of ice cream block and expressed as percentage.

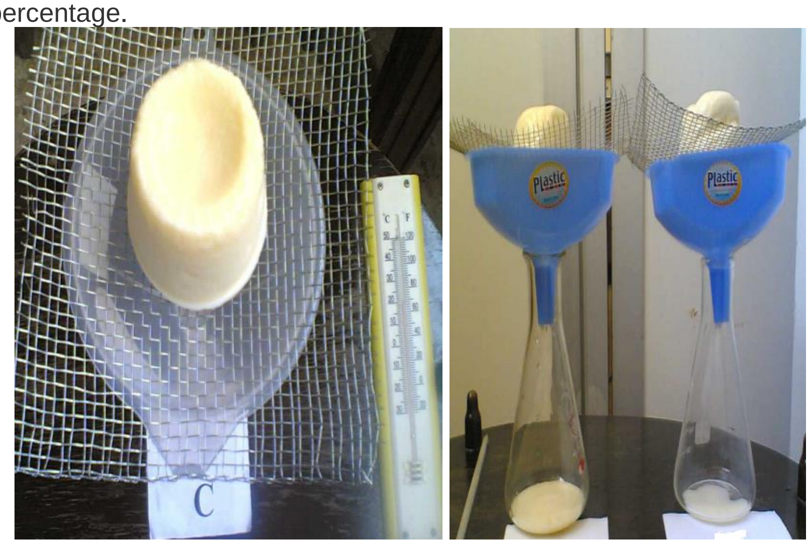


**Fig.1 Procedure of meltdown determination as described by Olson, *et al* (2003)**

Organoleptic properties were evaluated by expert staff members on randomly coded ice cream samples according to ice cream score card given by Bodytfelt *et al*, (1988) (flavor 10; body & texture 5; color & appearance 5; melting quality 5; total 25).

## RESULTS AND DISCUSSION

Changes in pH, viscosity and whipping time of ice cream mix due to substitution of NFDM by MPC and WPC have been shown in table 1 and figures 2,3and4

The values of pH were constant at 6.5 for control sample and all substitution ratios of WPC80, WPC30 and 25% substitution of MPC, while it was slightly raised to be 6.6 for 50, 75 and 100% substitution ratios of MPC (table1 & figure 3).This result emphasized that the sources of MSNF with different ratios of protein, lactose and ash content which have been used have no significant effect on the pH value of ice cream mix. This is due probably to intensified buffering effect of increasing protein content of the mix. Arbuckle,1986 reported that pH of ice cream mix constrained within a narrow range of 5.8 to 6.5.These results are agreed with those obtained by Abd El-Rahman *et al*., 1997; and Baer *et al.,* 1997)

**Table (1) Effect of substitution of milk solids-not-fat (MSNF) by milk protein concentrate (MPC 70%) and whey protein concentrates (WPC 80% or 30%) on the pH, viscosity and whipping time of low fat ice cream mix**

| Sample No. | Substitution of MSNF % | pH | Viscosity (cp) | Whipping time (min.) |
|---|---|---|---|---|
| **MPC (70%)** | | | | |
| Control | 0 | 6.5 | 16.6 | 10 |
| 1 | 25 | 6.5 | 26.1 | 8 |
| 2 | 50 | 6.6 | 26.9 | 7 |
| 3 | 75 | 6.6 | 32.6 | 7 |
| 4 | 100 | 6.6 | 34.0 | 6 |
| **WPC (80)** | | | | |
| Control | 0 | 6.5 | 16.6 | 10 |
| 1 | 25 | 6.5 | 17.9 | 7 |
| 2 | 50 | 6.5 | 20.1 | 7 |
| 3 | 75 | 6.5 | 21.9 | 6 |
| 4 | 100 | 6.5 | 22.3 | 6 |
| **WPC (30)** | | | | |
| Control | 0 | 6.5 | 16.6 | 10 |
| 1 | 25 | 6.5 | 17.0 | 9 |
| 2 | 50 | 6.5 | 16.0 | 9 |
| 3 | 75 | 6.5 | 15.5 | 9 |
| 4 | 100 | 6.5 | 16.0 | 8 |

Control sample had a viscosity value of 16.6cp (table1 & figure3).Substitution of NFDM by MPC70 and WPC80 led to gradual explicit increscent in viscosity, while Substitution by WPC30 has no effect. Viscosity at 25% substitution by MPC70 was 26.1cp and gradually increased to be 34cp at 100% substitution. The same trend has been occurred but with a lesser extent in substitution by WPC80 where viscosity values increased from 17.9cp at 25% to be 22.3cp at 100% substitution.

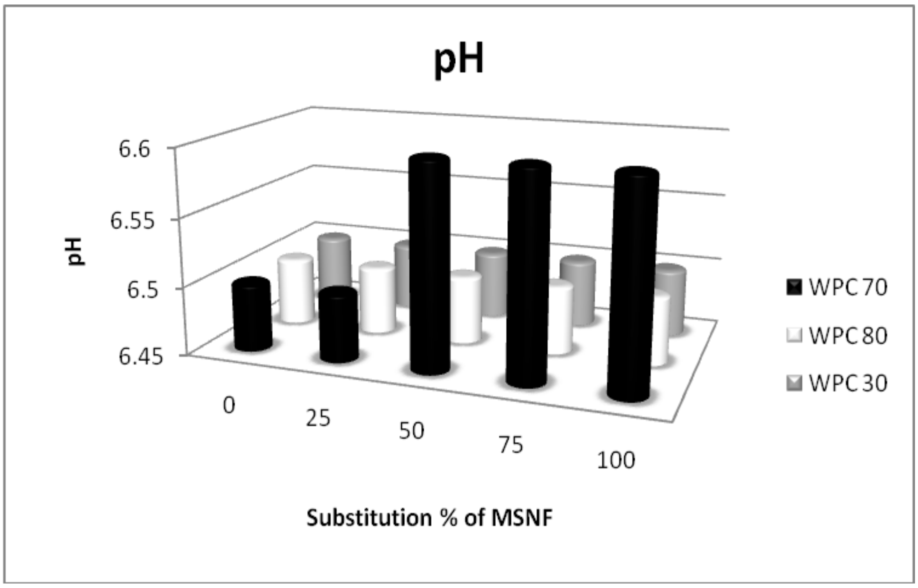


**Figure (2) Effect of substitution of milk solids-not-fat (MSNF) by milk protein concentrate (MPC 70%) and whey protein concentrates (WPC 80% or 30%) on the pH of low fat ice cream mix**

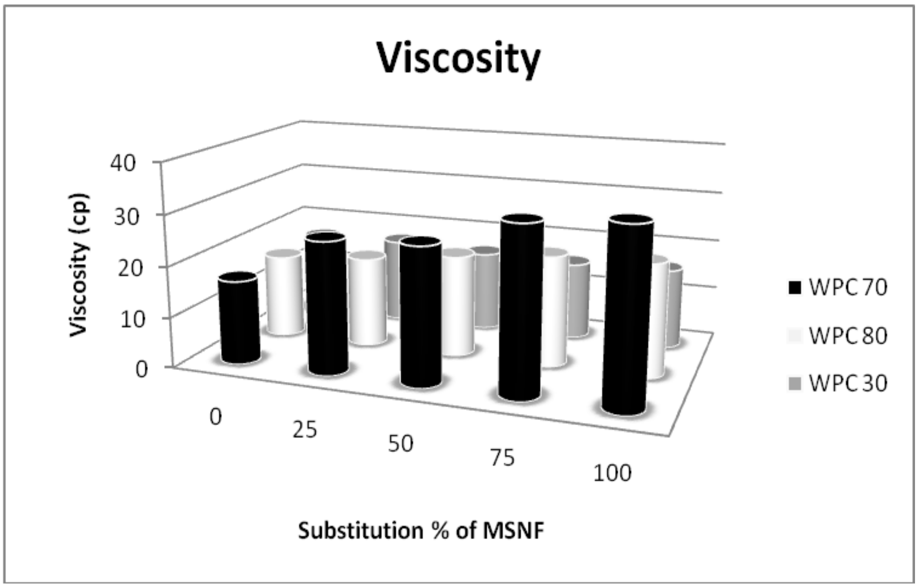


**Figure (3) Effect of substitution of milk solids-not-fat (MSNF) by milk protein concentrate (MPC 70%) and whey protein concentrates (WPC 80% or 30%) on the viscosity of low fat ice cream mix**

The results reflect the action of colloidal state of protein on the fluidity of the mix which become more viscous as the substitution ratio increased. In particular, MPC-contained mixes showed the highest values of viscosity. MPC contains the same ratio of casein: whey proteins of normal milk (4:1).Hence, the large size and amount of casein micelles in the medium led to a heavy body, higher viscosity comparing to the control or WPC-containing mixes. In addition, the higher viscosities of MPC mixes comparing with those of WPC mixes can be related to the increased voluminosity of the dispersed particles described by the Eilers equation (Walstra *et al.,* 1999). DeCastro Morel (1999) reported that MPC of higher protein content generally had longer hydration time comparing with MPC of lower protein content because of the presence of a case-hardened shell surrounding the spry-dried particles. On the other hand, WPC30-containing mixes had viscosity values (15.5 – 17.0cp) tightly closed to that of control sample (16.6cp) which contains NFDM.These results can be understood depending on the composition of WPC30 which is very similar to the composition of NFDM (see materials and methods).

Control sample had the longest whipping time (10min.) comparing with all other treatments (table1 & figure 4).As the substitution ratio increased, a slight decreasing tendency has been shown in mixes containing MPC70 (8-6 min.) and WPC80 (7-6min.).Samples contained WPC30 showed closer whipping time (9-8min.) to the control. It can be noticed that as the viscosity of a mix was higher as the whipping time was shorter. This finding is consistent with that found by Baer, *et al* (1997) ;Goff, et al (1989) ; Alvarez *et al* (2005) and Patel, *et al*.(2006)

Changes in overrun and meltdown of ice cream due to substitution of NFDM by MPC and WPC have been shown in table 2 and figures 5 and 6

Overrun was greatly influenced by substitution treatments (table2 & figure5).Control sample achieved 48.1% overrun. MPC-containing samples gained higher overrun than control with the substitution ratios of 25, 50 and 75% in a descending trend (57.9-53.2%) and at 100% substitution, overrun become lower (38.7%) than that of the control. On the other hand, WPC80-containing samples had the highest overrun values in an ascending trend. As the substitution ratio increased, overrun values were also increased and at 100% substitution it was nearly the duplicate (89.5%) of control.

Samples contain WPC30 had an opposite trend. All overrun values were lower than the value of control. With the increasing of substitution ratio (25-100%), overrun was decreased (41.7-32.0%).

The obtained values of overrun for all types of substitutes can be explained on the ground of the physical colloidal state of casein and whey proteins. The higher ratio of casein in MPC70 may facilitate the initial stabilization of newly formed air bubbles within the viscous body of the mix. Therefore, throughout whipping process an acceptable moderate ratio of overrun (57.9-53.2%) for samples of 25-75% substitution were accomplished. At 100% substitution the mix, probably, become so heavy that it might not retain the adequate air volume, consequently overrun was declined to be (38.7%) which is lower than that of control. Novak 1992 reported that MPC increase the formation of air bubbles during freezing.Damodaran,1996 stated that MPC should be slightly more denatured and the greater degree of unfolding may cause the proteins in MPC to absorb on the air/serum interface faster than proteins from UF retentates or NFDM. This may allow a greater amount of air to be incorporated in the mix.

The highest values of overrun in samples containWPC80 could be returned to the excessive ability of whey proteins to form foam. Phillips et al., 1994 reported that denatured proteins have been found to have better foaming properties, attributed to increased hydrophobicity, and greater interfacial contact.

The lowest values of overrun in WPC30-containing samples may due to the great lactose content of WPC30 which suppress the whipping ability of the mix, consequently lower the overrun.

**Table (2) Effect of substitution of milk solids-not-fat (MSNF) by milk protein concentrate (MPC 70%) and whey protein concentrates (WPC 80% or 30%) on the Overrun and Meltdown of low fat ice cream**

| SampleNo. | Substitution of MSNF % | Overrun% | Meltdown% |
|---|---|---|---|
| **MPC (70%)** | | | |
| Control | 0 | 48.1 | 50.5 |
| 1 | 25 | 57.9 | 45.5 |
| 2 | 50 | 57.2 | 35.2 |
| 3 | 75 | 53.2 | 26.4 |
| 4 | 100 | 38.7 | 15.6 |
| **WPC (80)** | | | |
| Control | 0 | 48.1 | 50.5 |
| 1 | 25 | 71.6 | 66.3 |
| 2 | 50 | 75.8 | 57.0 |
| 3 | 75 | 79.9 | 43.7 |
| 4 | 100 | 89.5 | 38.6 |
| **WPC (30)** | | | |
| Control | 0 | 48.1 | 50.5 |
| 1 | 25 | 41.7 | 42.6 |
| 2 | 50 | 37.7 | 44.6 |
| 3 | 75 | 35.2 | 55.0 |
| 4 | 100 | 32.0 | 56.3 |

Values of meltdown have been shown in table 2 & figure 6. Melting down of samples was tested by setting the samples for 15 min.at room temperature.50.5% of control sample was melted. Samples contained MPC70 showed a drastic decrease in the melted amounts (45.5-15.6%) as the substitution ratio of MPC was increased. All values were lower than the control. At 100% substitution, the melted amount was 15.6% which reflects very high resistance of ice cream against melting. Samples contained WPC80 showed the same trend but the values (66.3-38.6%) were 150-200% of those obtained for MPC70. Samples containing WPC30 showed reverse trend where the amount of melted samples was increased (42.6-56.3%) with increasing the substitution ratio. The values were distributed around the control value.

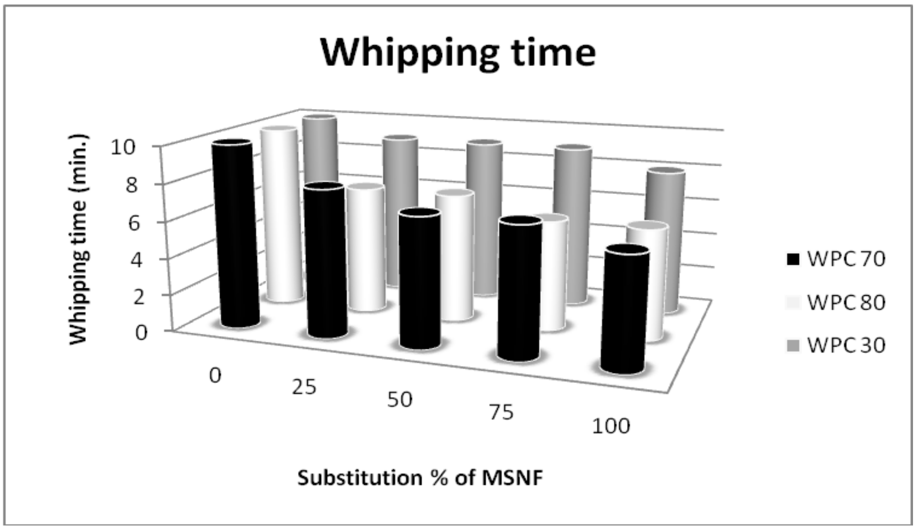


Figure (4) Effect of substitution of milk solids-not-fat (MSNF) by milk protein concentrate (MPC 70%) and whey protein concentrates (WPC 80% or 30%) on the whipping time of low fat ice cream mix

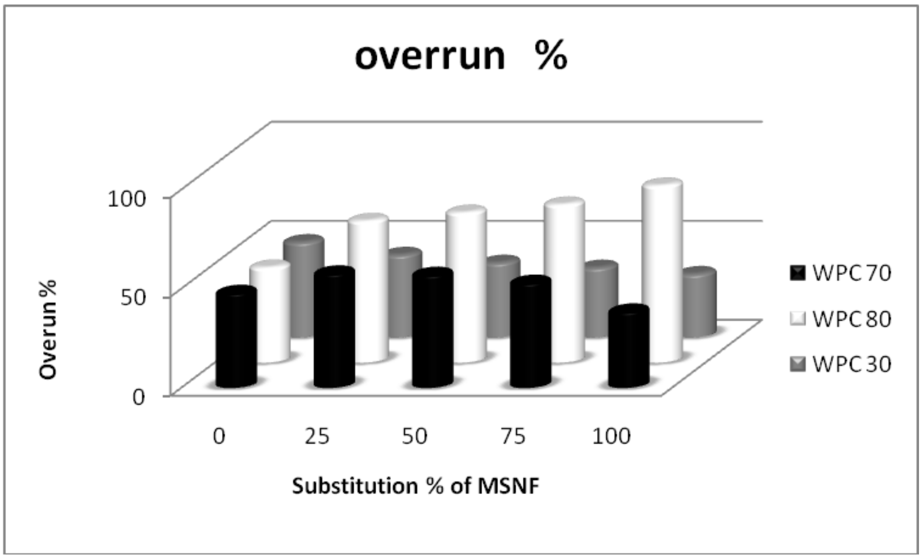


Figure (5) Effect of substitution of milk solids-not-fat (MSNF) by milk protein concentrate (MPC 70%) and whey protein concentrates (WPC 80% or 30%) on the Overrun of low fat ice cream

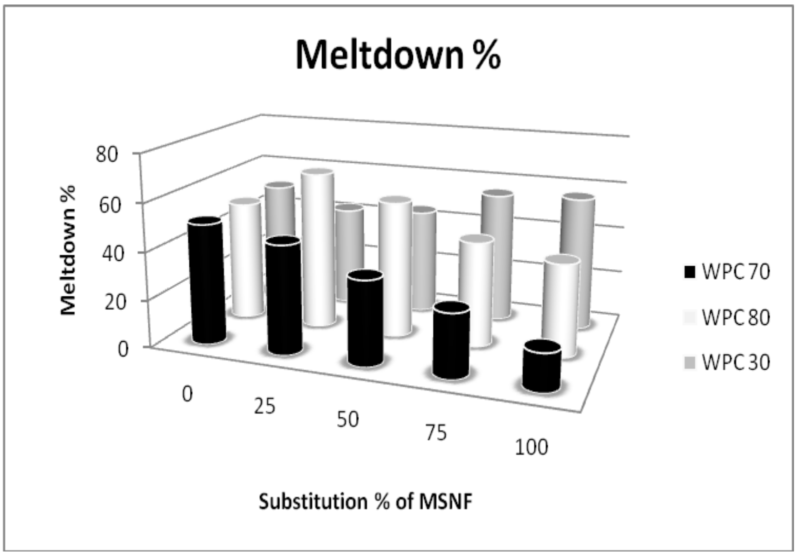


**Figure (6) Effect of substitution of milk solids-not-fat (MSNF) by milk protein concentrate (MPC 70%) and whey protein concentrates (WPC 80% or 30%) on the Meltdown of low fat ice cream**

It can be concluded from the above data that the MPC70 has an advantage of slow down the melting of ice cream.WPC80 has the same particularity but with a lesser extent. In accordance WPC30 has an adverse characteristic since it enhances the melting down of ice cream. It can be also observed that MPC70 has higher water absorbing capacity (swelling) than WPC80 due to its higher content of casein. On the other hand, WPC30 has a poor water absorbing capacity that led to fast melting down. A matter of course, its higher content of lactose and lower content of protein was the primary reason causes rapid melting of ice cream. This finding is consistent with that found by Flores, and Goff. (1999) and Alvarez, (2005)

Organoleptic properties (color, appearance, flavor, body and texture) are distinctive characteristics on which the producers take the decision whether a product accreditized and released to distribution and marketing or not. On the other hand, most –if not all- food products which have wide distribution and popularity are greatly depending on the acceptance of the consumers for their organoleptic properties. Frozen dairy products particularly ice cream products are highly organoleptic-dependent because the consumer consider it as a refreshing and enjoying food rather than essential food.

Table 3 show the evaluation of the organoleptic properties of ice cream prepared for this study. Out of 25 points total score, the control sample got the highest points (22.5) followed by samples contained MPC70 (21.5-19.5), WPC80 (21-16.5) and finally WPC30 (21-14.5). With the three types of substitutes, total score followed a descending order with the increase of substitution ratios.

**Table (3) Effect of substitution of milk solids-not-fat (MSNF) by milk protein concentrate (MPC 70%) and whey protein concentrates (WPC 80% or 30%) on the organoleptic properties of low fat ice cream**

| Sample No. | Substitution of MSNF % | Organoleptic properties | | | | |
|---|---|---|---|---|---|---|
| | | Flavor (10) | Body & texture(5) | Color & appearance (5) | Melting quality(5) | Total (25) |
| **MPC (70%)** | | | | | | |
| Control | 0 | 9.5 | 4.0 | 4.5 | 4.5 | 22.5 |
| 1 | 25 | 9.5 | 3.5 | 4.5 | 4.0 | 21.5 |
| 2 | 50 | 9.5 | 3.5 | 4.5 | 4.0 | 21.5 |
| 3 | 75 | 9.5 | 3.0 | 4.0 | 3.0 | 19.5 |
| 4 | 100 | 9.5 | 3.0 | 4.0 | 3.0 | 19.5 |
| **WPC (80)** | | | | | | |
| Control | 0 | 9.5 | 4.0 | 4.5 | 4.5 | 22.5 |
| 1 | 25 | 9.5 | 3.5 | 4.0 | 4.0 | 21.0 |
| 2 | 50 | 9.0 | 3.5 | 4.0 | 3.5 | 20.0 |
| 3 | 75 | 8.0 | 3.5 | 3.5 | 3.5 | 18.5 |
| 4 | 100 | 7.0 | 3.0 | 3.5 | 3.0 | 16.5 |
| **WPC (30)** | | | | | | |
| Control | 0 | 9.5 | 4.0 | 4.5 | 4.5 | 22.5 |
| 1 | 25 | 9.0 | 4.0 | 4.0 | 4.0 | 21.0 |
| 2 | 50 | 8.5 | 3.5 | 4.0 | 3.0 | 19.0 |
| 3 | 75 | 7.0 | 3.0 | 3.0 | 3.0 | 16.0 |
| 4 | 100 | 6.0 | 3.0 | 3.0 | 2.5 | 14.5 |

Flavor of control, MPC70- containing samples and WPC80- containing sample of 25% substitution gained the highest flavor score(9.5/10), while the sample contained 100% WPC30 had the lowest one (6/10). Samples of higher substitution ratios (75,100%) of WPC80 and WPC30 left an unpleasant feeling in the mouth after tasting.

Body and texture score was also decreased with increasing the substitution ratios in all treatments. Control sample had the highest score (4/5) followed by samples contained 25, 50% substitution with MPC70, WPC80 and WPC30 (3.5/5).

Color and appearance of control, 25 and 50% substitution by MPC70 had the highest score (4.5/5) followed by 75, 100% and 25, 50% substitution by MPC70 and WPC80, WPC30 respectively (4/5).

The highest score of melting quality was that of control (4.5/5) followed by 25, 50% substitution with MPC70 and 25% substitution by WPC80 or WPC30. The lowest melting quality was that of the sample contained 100% WPC30.

The above detailed discussion showed that using of high ratios of the studied substitutes, particularly WPC30, associated with negative effects on the ice cream properties. On the other hand, either MPC70 or WPC80 was more match than WPC30 for use as NFDM substitutes hence they can be used conveniently with ratios up to 50% substitution without causing adverse effects on the ice cream properties.

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## ادماج مركزات بروتين اللبن والشرش فى مخلوط المثلوج الدهنى المنخفض الدهن

**طارق النمر ، محمود الغنام و نهى دياب**
**قسم علوم وتكنولوجيا الالبان ، كلية الزراعة بالشاطبى ، جامعة الاسكندرية ، مصر**

اجريت تلك الدراسة بغرض امكانية استبدال الجوامد اللبنية اللادهنية فى تصنيع الايس كريم المنخفض الدهن ببدائل مبتكرة ذات قيمة حيوية عالية. ولقد استخدم اللبن المجفف المنزوع الدسم كمصدر للجوامد اللبنية اللادهنية فى المخلوط المرجعى بالاضافة لاستخدام مركزات بروتين اللبن المجففة المحتوية على ٧٠ % بروتين وكذلك مركزات بروتين الشرش المحتوية على ٣٠ و ٨٠ % بروتين . وكانت نسبة الاستبدال للجوامداللبنية اللادهنية لكل مصدر ٢٥ و٥٠ و٧٥ و ١٠٠ %. ولقد احتوى المخلوط لكل محاولة على دهن اللبن بنسبة ٣% , سكر بنسبة ١٥%,جيلاتين بنسبة٠,٢٥ %, جوامد صلبة لبنية لادهنية بنسبة١١,٥ % وبلغت بهذا الجوامد الصلبة الكلية ٢٩,٥%.ولقد قدرت اللزوجة ورقم الحموضةpH ووقت الخفق فى المخلوط المعد بينما قدرت نسبة الريع والانصهار والخواص الحسية فى المنتج النهائى للمثلوج اللبنى.

ولقد اوضحت النتائج ان الاستبدالات ليس لها تأثير على رقم الحموضةpH حيث تراوح بين ٥.٦ – ٦,٦ لكل المعاملات. استبدال الجوامداللبنية اللادهنية بمركزات بروتين اللبن المجففة المحتوية على ٧٠ % بروتين وكذلك مركزات بروتين الشرش المحتوية على ٨٠ % بروتين أدت الى الزيادة التدريجية فى اللزوجة بينما الاستبدال بمركزات بروتين الشرش المحتوية على ٣٠ % بروتين لم يكن لها تأثير. عينة المخلوط المرجعية كانت الاطول بزمن الخفق ( ١٠ دقائق ) مقارنة بكل المعاملات حيث أدت زيادة نسب الاستبدالات الى انقاص زمن الخفق . فى حين أن عينة المخلوط المحتوى على مركزات بروتين الشرش المحتوية على ٣٠ % بروتين أظهرت اسراعا بزمن الخفق( ٨-٩ دقائق) مقارنة بالعينات المرجعية

نسبة الريع تأثرت بصورة كبيرة بالاستبدالات داخل المعاملات فكانت نسبة الريع بالعينات المرجعية٤٨,١% فى حين أن عينة المخلوط المحتوى على مركزات بروتين اللبن المحتوية على ٧٠ % بروتين أكسبتها زيادة فى نسبة الريع مقارنة بالعينات المرجعية واظهرت العكس فى معاملات الاستبدال بنسبة ١٠٠% حيث قلت نسبة الريع عن العينة المرجعية.ومن جهة أخرى عينة المخلوط المحتوى على مركزات بروتين الشرش المحتوية على ٨٠ % بروتين كانت اعلى فى نسب الريع بنسب متزايدة مع زيادة نسب الاستبدال وكانت حال الاستبدال بنسبة ١٠٠% (٨٩,٥%) بينما عينة المخلوط المحتوى على مركزات بروتين الشرش المحتوية على ٣٠ % بروتين أظهرت اتجاها معاكسا على الرغم من أن كل قيم نسب الريع كانت أقل من العينات المرجعية.

الكميات المنصهرة من العينة المرجعية بلغت ٥٠,٥% فى حين عينة المخلوط المحتوى على مركزات بروتين اللبن المحتوية على ٧٠ % بروتين أظهرت انخفاضا حاد فى الانصهار(45.5-15.6%) بزيادة نسبة الاستبدالات. و أظهرت عينة المخلوط المحتوى على مركزات بروتين الشرش المحتوية على ٨٠ % بروتين نفس الاتجاه بقيم تراوحت بين (٣٨,٦-٦٦,٣ ) بينما عينة المخلوط المحتوى على مركزات بروتين الشرش المحتوية على ٣٠ % بروتين أظهرت اتجاها معاكسا حيث بلغت الكميات المنصهرة (42.6-56.3%)

ويمكن ان تخلص استنتاجات النتائج الى أن مركزات بروتين اللبن المحتوية على ٧٠ % بروتين تتميز بابطاء انصهار المثلوج يليه مركزات بروتين الشرش المحتوية على ٨٠ % بروتين فى حين أن مركزات بروتين الشرش المحتوية على ٣٠ % بروتين أظهرت اتجاها معاكسا تجاه مع كل نسب الاستبدال وكذلك الخواص الحسية. ومن جهة أخرى توصى النتائج ان افضل نسبة استبدال بمركزات بروتين اللبن المحتوية على ٧٠ % بروتين يليها مركزات بروتين الشرش المحتوية على ٨٠ % بروتين كانت ٥٠% دون أن تسبب اية اتجاهات مغايرة تؤثر على الخواص العامة للمثلوج.