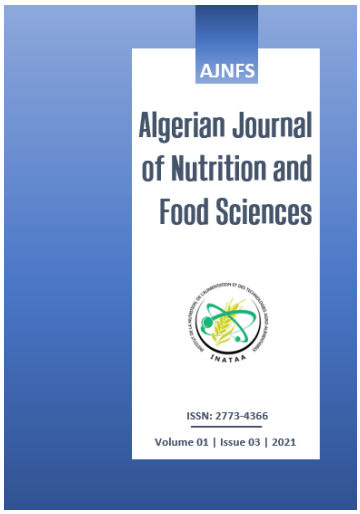


*Algerian Journal of*
*Nutrition and Food Sciences*
***(AJNFS)***

ISSN: 2773-4366

Journal homepage: fac.umc.edu.dz/inataa/revue/

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Published online: December 31, 2021.

To cite this article: Bouizar R., Mouzai A., Boughellout H. 2021. Impact of milk substitution by sweet whey on chocolate mousse physicochemical, microstructural and sensory properties. *Algerian Journal of Nutrition and Food Sciences*, 1(4), 17–24

To link to this article: https://fac.umc.edu.dz/inataa/revue/files/ajnfs0104003.pdf

**Algerian Journal of Nutrition and Food Sciences** (AJNFS) – Open Access – ISSN: 2773-4366
Volume 01, Issue 04, 2021: 17-24

*Original Article*

# Impact of milk substitution by sweet whey on chocolate mousse physicochemical, microstructural and sensory properties

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Received November 21, 2021 Accepted December 23, 2021 Available online December 31, 2021

***Abstract*** *Whey is a cheese industry co-product, its rejection as waste will cause environmental pollution if not treated. Whey proteins have a high nutritional value and excellent functional properties as solubility, ability to absorb and fix water, gelation, emulsifying and foaming properties. Rejecting whey is a huge economic loss. This study aimed whey valorisation rejected by cheese factories by its incorporation in dairy foams (chocolate mousse). In the first part, we performed liquid whey physicochemical characterization. In the second part, we proceeded to the whey incorporation in substitution of milk at rates 25, 50, 75 and 100%. Prepared chocolate mousse formulas presented fat content, total dry extract and protein rates respectively: (2.27 - 3.47 g/100g); (32.17 - 36.03%); (1.39 - 3.91 g/l); and expansion rates between 22.16 and 78.08%. The obtained chocolate mousses showed as organoleptic characteristic quite similar to those of the reference formula for foaming texture and flavour with a pronounced chocolate taste (no significant difference). The mousse formula prepared with 100% of whey was the most preferred.*

***Keywords*** *Whey, Valorisation, Chocolate mousse, Physicochemical characterization, Sensory evaluation*

***Résumé*** *Le lactosérum est un sous-produit de l'industrie fromagère, son rejet serait à l'origine de pollution s'il n'est pas traité. D'un point de vue physiologique, les protéines du lactosérum possèdent une haute valeur nutritionnelle, elles ont également d'excellentes propriétés fonctionnelles telles que la solubilité, la capacité à absorber et fixer l'eau, la gélification et les propriétés émulsifiantes et moussantes, son rejet constitue donc, une perte économique énorme. Cette étude vise à valoriser le lactosérum via une incorporation dans des formules de mousses laitières (mousse au chocolat) afin d'utiliser au mieux ces protéines, et réduire le caractère polluant de ce produit. Ce travail a été entamé par une caractérisation physico-chimique du lactosérum doux puis suivi par l'étude de l'impact de la substitution du lait par le lactosérum à différents taux (0, 25, 50, 75 et 100%) sur la qualité des mousses formulées. Les formules préparées ont présenté des taux de matières grasses, d'extrait sec total et de protéines de (2,27 - 3,47 g/100g) ; (32,17 - 36,03%) ; (1,39 - 3,91 g/l) respectivement. Les taux de foisonnement ont été de 22,16 à 78,08% pour les taux de substitution de 0, 25, 50, 75 et 100% respectivement. Les formules de mousses au chocolat ont présenté des caractéristiques organoleptiques assez proches de la formule industrielle par rapport à la texture, le caractère moussant et la saveur (aucune différence significative entre les formules et le témoin). La formule préparée à un taux d'incorporation de lactosérum de 100% a été préféré par la majorité du jury.*

***Mots clés*** *Lactosérum, Valorisation, Mousse au chocolat, Caractérisation physico-chimique, Propriétés organoleptiques*

## Introduction

Many food industries reject by-products into the environment. Thus, it constitutes a polluting agent due to their large quantity and high polluting potential. Among these, we were interested in the dairy industry, where cheese production rejects 4 to 12 kg of whey per kilogram of cheese produced (Gana and Touzi, 2001). Whey, a co-product in dairy industry, is undoubtedly a noble and rich material. Indeed, it has become an interesting source of active compounds and specific nutrients. It has incomparable properties, both nutritionally and techno-functionally, such as soluble proteins, lactose, water-soluble vitamins and mineral elements (Benaissa, 2018). In Algeria, the lack of development of whey is a serious problem due to the absence of strict regulations from the public authorities that can prevent the rejection of this product in nature. Since 2013, Algerian cheese production was estimated at 1,540 tons per year, which represents a lost of about 14 million litters of whey (FAO, 2017). At the Giplait-

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Numidia dairy, during the manufacture of pressed cheese type "Edam", 1800 litters of whey are produced each production (2 to 4 times per week). This important mass of nutrients is unfortunately treated as waste and thrown in the nature. That is about 216,000 litters per month and 2,592,000 litters per year. Several works have been carried out providing new knowledge on the valorisation of whey at Algerian universities. Recently, the main sector of whey growth has been probiotic drinks (Benabbou and Bentalab, 2016; Shukla *et al.*, 2013). Since 2017, many works are being carried out in Institute of nutrition and food technology (INATAA) to prepare different formulas of milk drinks, ricotta cheese and ice creams (Hachemi, 2018; Kafi, 2017; Djemaoui and Mamache, 2019). Despite the numerous studies carried out by Algerian universities, no development of this noble co-product has been carried out by milk processing units. The whey quantities rejected into nature are constantly increasing. The pollution caused by whey is in this case a significant threat for the environment (Hachemi, 2018). In this context, in collaboration with Giplait-Numidia factory we have engaged this study, which aimed to the valorisation of sweet whey in mousse chocolate. The effect of replacing milk with whey during the formulation of chocolate mousses and the impact of this substitution on the physicochemical, microstructural and sensory quality of chocolate mousses were studied.

This work is accomplished within the agreement signed between the Giplait-Numidia dairy and the team: Food Process Engineering, Biodiversity and Agro-environment of Food engineering laboratory (GENIAAL).

## Material and methods

### *Raw materials*

The following commercial ingredients were employed for the chocolate mousse production: liquid cream (Empreinte, Algeria), cocoa powder (Chocodada Cocoa, Algeria), unflavored gelatin powder (Queen, Egypt), sucrose (Cevital, Béjaia, Algeria), skimmed milk powder (Loya, Algeria), UHT skimmed milk (Numidia, Constantine, Algeria), Whey protein (Numidia, Constantine, Algeria).

### *Physical and chemical characterization of whey*

*pH*

The whey pH is measured according to AFNOR (1993) method. The electrode of the pH meter (Crison) with 0.01 units of precision is immersed in a beaker containing the whey sample and the pH value is displayed on the screen.

*Acidity*

The acidity was determined by measuring the lactic acid with 0.11 mol/l sodium hydroxide. The presence of phenolphthalein, as a colored indicator, indicates the limit of neutralization by change of color.

*Determination of density*

The method is carried out using a lacto-densitometer at 20 °C.

*Determination of total dry extract (TDE)*

The TDE was determined by drying 10 ml of whey with a RADWAG ® desiccator (MAC 110, max 110 g, reading accuracy: 1 mg).

*Determination of the fat content according to the GERBER method*

The fat content was determined according to the NF V04-210 standard (AFNOR, 1980). The principle of the method is based on the separation of the fat from the whey, in a butyrometer, after organic elements whey degradation, except for the fat, with concentrated sulphuric acid.

*Determination of protein content by the Bradford method (1976)*

The principle of this assay was based on the change in absorbance made at 595 nm manifested by the change in Coomassie blue color after basic amino acids binding (arginine, histidine, lysine) and amino acids hydrophobic residues present in the protein(s).

### *Formulation of chocolate mousse*

The formula used was proposed by Aragon-Allegro *et al.*, (2007) with some modifications. This recipe was designed for the manufacture of chocolate mousse. The formula was modified after several preliminary trials to make it successful. Milk was substituted by sweet whey at different rate (25%, 50%, 75% and 100%).

According to the formula, ingredients were weighed, mixed until the ingredients are completely dissolved and homogenized to form the mix, then heated to 80-85 °C in a water bath for 2 minutes. After ingredients homogenization, the emulsifying agent is added and mixed. The total mix was beaten with a mixer (Robuste, BRB300, 300W) at 14 °C in an ice bath, for air incorporation, until the mix volume doubled. Resulting products were transferred to plastic cups, closed with a metal lid, and stored at 4 ± 1 °C.

### *Characterization of chocolate mousses*

*Physico-chemical characterization*

Physico-chemical analyses were carried out on the chocolate mousse as the sweet whey: pH, protein content and fat content. The total dry extract (TDE) of the chocolate mousse is determined by drying in an oven set at 103 ± 2 °C of 1 g sample of the chocolate mousse until constant weight according to standard NF V04-282 (1985) (AFNOR, 1993).

*Determination of the expansion ratio*

The expansion ratio consisted to determine the air quantity present in the mix (Benezech *et al.*, 1994; El-Zeini *et al.*, 2016).

A beaker of 20 ml was filled with the mix and its weight was determined. The same beaker is filled with the mousse after expansion, and its weight was then determined. The expansion ratio was expressed according to the following formula:

$$ER\% = [\frac{(P_1 - P_2)}{P_2}] \times 100$$

ER : Expansion rate
P1: Weight of the mix
P2: Weight of the chocolate mousse

*Chocolate mousse microstructure*

This analysis was based on the use of an optical microscope. The mousse was spread between the slats and the lid and placed to observation under two microscopic magnification x14 and x10.

*Sensory characterization of the chocolate mousse*

Sensory evaluation has been defined as a method used to evoke, measure, analyze and interpret those responses to products as perceived through senses of sight, smell, touch, taste and hearing (Stone and Sidel, 2004). This study consists of giving the overall sensory profile of the mousse produced with a panel of tasters. This analysis describes the sensory characteristics of the mousse: color, appearance, taste and texture. The degustation panel was made up of 30 male and female subjects already introduced to sensory analysis and trained to evaluate food products. Several factors were taken into consideration prior to the evaluation in order to obtain the best performance from the subjects. We made sure that subjects do not suffer from any illness (flu, allergy....), they were advised to avoid the use of strong smelling products such as perfumes, and not to eat before the tasting for at least 30 minutes. The sensory analysis was divided into two tests; a descriptive test and a preference test. The samples to be analysed were presented in small 10 g jars. In the descriptive test, tasters were asked to rate the perceived intensity of a sensory characteristic (attribute) of each coded sample on a scale from 1 (low intensity) to 9 (high intensity). In the preference test, the tasters were asked to rank in order of preference the 5 samples presented according to their overall appreciation of taste, aroma, viscosity, and visual properties.

*Statistic analysis*

The scores for each sample were tabulated and analyzed using analysis of variance (ANOVA) using XLSTAT version 2009 statistical software (Tukey test) significance level 5%).

## Results and discussion

The mean values and standard deviations of the physicochemical parameters evaluated, for sweet whey and during storage of the different trials of chocolate mousse studied are shown in table 1 and table 2.

***Whey characteristics***

*pH and acidity*

The pH of whey is 6.6 ± 0.07, which is a value included in the pH range 5 and 7 as reported by Pega *et al.* (2018); Zernadji and Chebchoub (2018). The titratable acidity of whey is 12.5 ± 0.5 °D, and this value is quite low compared to Saulnier *et al.* (1996) results who noted that sweet whey has an acidity lower than 18 °D.

*Density*

The sweet whey density is 1021g/l. This value is lower than that noted by Furtado and Pombo (1978) who noted a density between 1025 and 1026g/l. This difference may be due to a lower dry matter content or a higher fat content.

*Total dry matter*

The total dry matter of the whey studied is 6.08 ±1.35%. It is comparable to the rate noted by Blaschek *et al.* (2007) (5.8%). This parameter presents an information on the milk composition initially used as well as on the manufacturing processes, issu of the sweet whey used. This rate shows the good quality of the milk used.

*Total protein content*

The whey total protein content is 6.79 g/l, ~~it~~ is lower than the value reported by Boudjema *et al.* (2009) of 13.5 g/l, but similar to that reported by Yadav *et al.* (2015) and Arora *et al.* (2013), ranged between 6 to 10 g/l. During milk coagulation, serum proteins remain intact and quantities of caseins are eliminated in the whey during draining.

*Fat content*

The whey fat content is 3.66 ± 1.15%, which is higher than the value of 1% given by Sottiez (1985). The main reason for this whey fat content is probably related to the whey separation processes, and also to the fact that a quantity of milk fat is lost in the whey (Fauquant *et al.*, 1985).

**Table 1.** Physico-chemical characteristics of the sweet whey

| Settings | Mean ± Standard deviation |
|---|---|
| T (°C) | 29.33 ± 0.57 |
| pH | 6.6 ± 0.07 |
| Density | 1021 ± 0 |
| Acidity (°D) | 12.5 ± 0.5 |
| Total dry matter (%) | 6.08 ± 1.35 |
| Proteins (g/l) | 2.79 ± 1.61 |
| Fat content (%) | 3.66 ± 1.15 |

**Table 2.** Physico-chemical characteristics of chocolate mousses

| Settings | Control (0%) | $M_1$ (25%) | $M_2$ (50%) | $M_3$ (75%) | $M_4$ (100%) |
|---|---|---|---|---|---|
| pH | 5.59 ± 0.53 | 5.63 ± 0.61 | 5.80 ± 0.51 | 5.81 ± 0.56 | 5.87 ± 0.57 |
| Total dry matter (%) | 34.64 ± 0.54 | 36.03 ± 0.33 | 32.93 ± 1.57 | 32.77 ± 1.69 | 32.17 ± 4.60 |
| Fat content (g/100) | 3.47 | 2.64 | 2.39 | 2.78 | 2.27 |
| Proteins (g/l) | 1.39 ± 1.04 | 2.59 ± 0.07 | 3.65 ± 1.76 | 3.91 ± 0.97 | 2.67 ± 0.67 |

### *Physicochemical characteristics of chocolate mousses*

*pH*

The chocolate mousse formulas have pH values between 5.59 ± 0.53 and 5.87 ± 0.57. The pH of the mousse formula increases with the increase of the whey incorporation rate. These results are comparable to those reported by Aragon-Alegro *et al.* (2007) (5.6-6.4).

*Total dry matter (TDM)*

The TDM content of formulas is situated between 32.17 and 36.03%. The TDM of the control formula is 34.64%.

*Fat content*

The fat content of the chocolate mousse formulas decreases from 3.47 g/100g for the 0% whey mousse to 2.27 g/100g for the 100% whey mousse. These results are slightly higher than those reported by Komatsu *et al.* (2012) who found 1.38 g/100g. The fat content in the whey used is lower compared to the fat content in the milk, which explains the decrease in fat content with increasing incorporation of whey in the formula. Generally, mousses quality is influenced by the fat content, which is a very important factor for the stability of the mousse and the amount of air incorporated during manufacture. It appears that higher fat content leads to a decrease in air retention. During expansion, air bubbles and fat droplets are coated and emulsified with milk proteins. If the fat content is high, some proteins will emulsify the fat and there will be less protein to stabilize the air bubbles. Thus, there will be less stable air bubbles in the high fat samples Weeraya *et al.* (2016).

### *Expansion rate of chocolate mousses*

The expansion rates of the manufactured chocolate mousse formulas are given in figure 1.

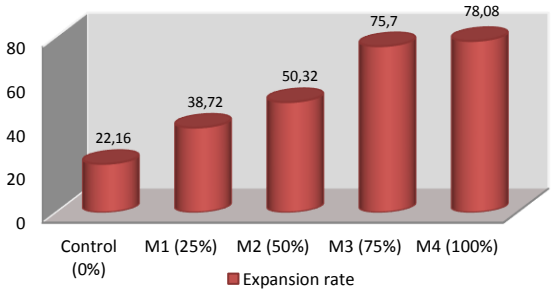


**Figure 1.** Expansion rate of the chocolate mousse

The expansion rate increases from 22.16% to 78.08% depending on the whey incorporation rate. It varies from 22.16% for the control sample with 0 % whey to 78.08% for the sample with 100% whey.

The increase of the expansion rate with the increase of the formulas whey substitution shows the excellent foaming properties of whey proteins. The expansion of dairy mousse is more important factor than other dairy products, it gives them a light and airy texture in the mouth.

### *Microstructure of chocolate mousses*

Figure 2 shows the results of the observation of the chocolate mousses produced under the enlargement 4 and 10 of the optical microscope.

The different optical microscopy images show a difference in the structure of the different chocolate mousse formulas with regard to the size, number and distribution of air bubbles.

These microscopy results illustrate the high foaming property of the whey. The size decrease and the number increase of air bubbles with the increase of whey content confirm the increase of expansion rate with the increase of the whey incorporation rate. The size decrease of air bubbles is responsible for the stability of mousse.

Results obtained by Kresic *et al.* (2006) showed that mousses formed with whey and treated at high pressure have a long stability. The results of Huffman *et al.* (2011) showed that the increase in the number of air bubbles is due in particular to the very interesting foaming properties of whey proteins.

### *Sensory characteristics of chocolate mousses*

The organoleptic qualities evaluated were color, appearance (density), flavor and texture.

*Hedonic analysis (Tukey test)*

The sensory analysis of the chocolate mousse formulas with whey incorporation rates of 0%, 25%, 50%, 75% and 100% by comparing them to a reference chocolate mousse of the "Soummam" brand, allowed to highlight the main characteristics of each mousse formula and also to show the preference of the jury who tasted the different formulas.

Table 3 shows the sensory profile, classification and overall sensory accessibility of the mousse products.

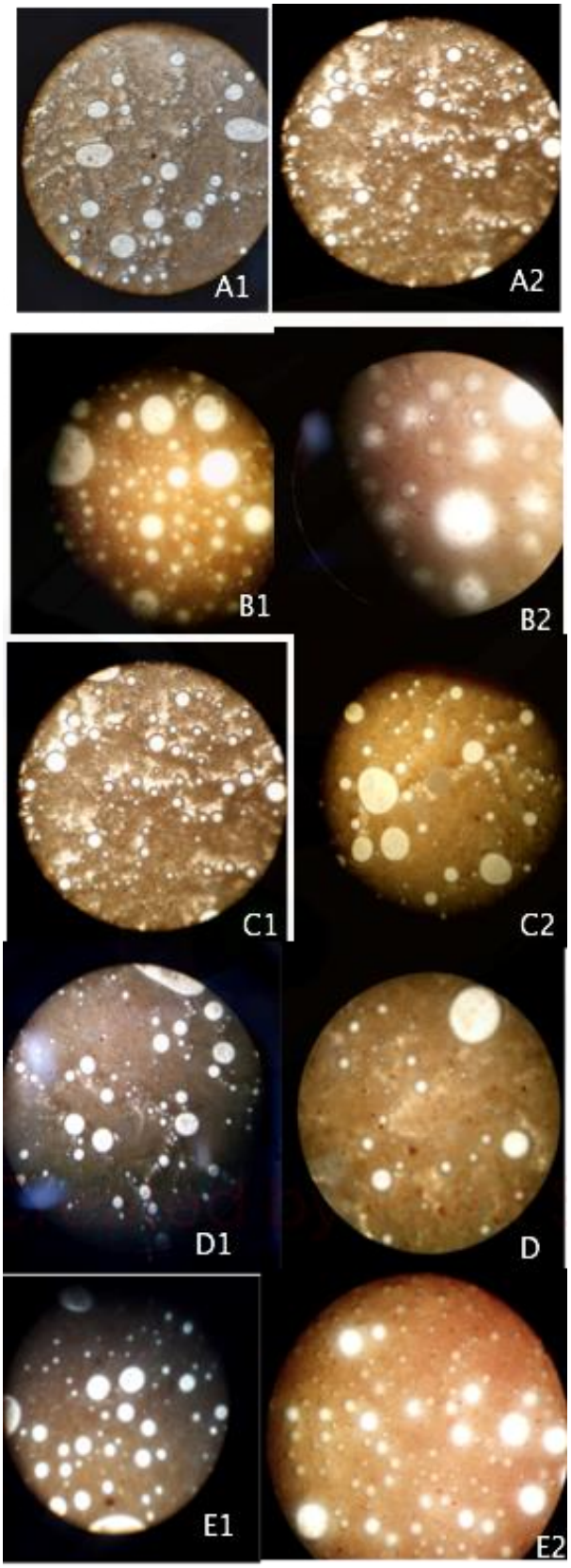


**Figure 2.** Optical photography of different chocolate mousse formulas
A1: Control (Enlargement 4); A2: Control (Enlargement 10); B1: 25% whey (enlargement 4); B2: 25% Whey (enlargement 10); C1: 50% whey (enlargement 4); C2: 50% Whey (enlargement 10); D1: 75% whey (enlargement 4); D2: 75% Whey (enlargement 10); E1: 100% whey (enlargement 4); E2: 100% Whey (enlargement 10)

**Table 3.** Hedonic analysis of different formulas of chocolate mousses

| | | | | | | |
|---|---|---|---|---|---|---|
| **Color** | | | | | | |
| Brown | 4,4c | 5,5bc | 5,3bc | 6,1bc | 7ab | 8,9a |
| **Density** | | | | | | |
| Light | 5.8ab | 5b | 5.4ab | 4.4b | 5.3b | 8.3a |
| Creamy | 4.3a | 4.1a | 5a | 4.8a | 4.3a | 4.5a |
| Thick | 5.3a | 5.7a | 5.7a | 4.9a | 5.3a | 5.3a |
| Liquid | 4a | 3.5a | 3.8a | 3.8a | 3.6a | 3.8a |
| Gel | 3.7a | 3.1a | 2.9a | 3.2a | 3a | 2a |
| Mousse | 5.1b | 5.7ab | 6ab | 6.7ab | 7.3ab | 8.4a |
| **Flavor** | | | | | | |
| Dairy Products | 3.6a | 4a | 5.7a | 4.2a | 4a | 5.7a |
| Dairy fat | 3.5a | 4.5a | 3.6a | 4.7a | 4.5a | 5a |
| Whey Aromas | 1.7a | 2.2a | 2.9a | 4a | 2.6a | 3.3a |
| Chocolate flavor/cacao | 6.7a | 5.6a | 5.6a | 5.5a | 5.9a | 7.2a |
| Rancid Aromas | 0.9a | 0.9a | 1a | 1.4a | 1.4a | 2.7a |
| Astringent | 1.3a | 1.6a | 1.2a | 2.3a | 1.8a | 1.5a |
| **Texture** | | | | | | |
| Mousse | 5.5a | 5.5a | 6.1ab | 6.2ab | 7.3ab | 8.4a |
| Density | 4.9a | 5.3a | 5.4a | 4.7a | 5.7a | 5.9a |
| Viscosity | 4.5a | 4.8a | 4.2a | 4.2a | 4.5a | 4.8a |
| Gel | 3.6a | 3.2a | 2.9a | 3.1a | 2.4a | 2.3a |
| Greasy feeling | 2.7a | 2.6a | 3.3a | 3.8a | 4.2a | 5a |
| well ventilated | 4.2b | 4.6b | 5ab | 5.2ab | 6.2ab | 7.9a |
| Homogeneous | 6.1ab | 6.1ab | 5.6ab | 5 b | 6ab | 8.5a |
| Sand blaster | 1.3a | 1.8a | 2.1a | 2.7a | 2.4a | 1.9a |
| Mouth coating | 4.7a | 4.8a | 5.1a | 4.6a | 5.3a | 6.6a |

a, b, c: different letters in the same row indicate a significant difference ($p < 0, 05$)

*Sensory profile of chocolate mousses*

This test highlights differences between the different chocolate mousse formulas. The attributes are divided into visual attributes, flavor attributes and texture attributes. The significance of the Anova test is shown at the 5% significance level.

- *Visual examination*: The 0% substitution formulas and the industrial mousse have a significant difference compared to the other formulas. For lightness, the comparable formulas are T at 0% substitution, M2 at 50%, M3 at 75% and M 4 at 100% substitution rate. They show no significant difference between them. However, formulas that show significant differences are M1 at 25% substitution and the industrial M5. The five formulas showed no significant difference for creaminess, mousse thickness, liquid appearance or gel appearance between them and the reference chocolate mousse (0%, 25%, 50%, 75% and 100%). For the moussey aspect no significant difference is noticed between the control and the different formulas, but a significant difference between the 0% whey control and the industrial mousse is noted. Figure 3 represents the visual attributes of different formulas.
- *Flavor*: No significant differences are observed between the formulas for the majority of the flavor attributes (dairy taste, dairy fat, whey aroma, ...). Figure 4 represents the sensory flavor profile of the mousses.
- *Texture*: For texture the results of the sensory profile are presented in Figure 5. According to these results we observe no significant difference between the formulas for the mousseing texture, density, viscosity, gel texture, greasy feel, sandy texture and mouth coating of the mousse. For the other attributes we observe that there is a significant difference between the Control (0%), M1 (25%) and M5 industrial mousse formulas for the aeration of the mousses. These two formulas have a lower expansion ratio than the other formulas 50%, 75% and 100%.

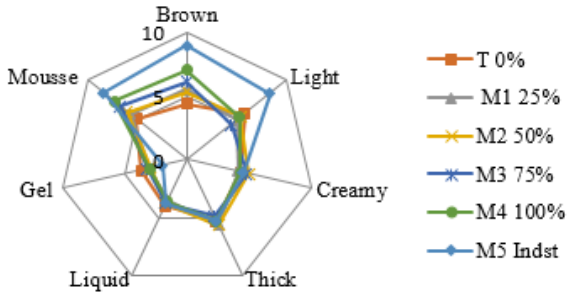


**Figure 3.** Visual profile of chocolate mousses

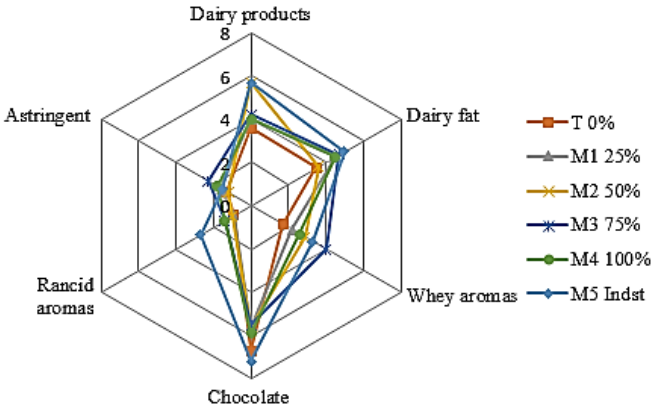


**Figure 4.** Flavour profile of chocolate mousses

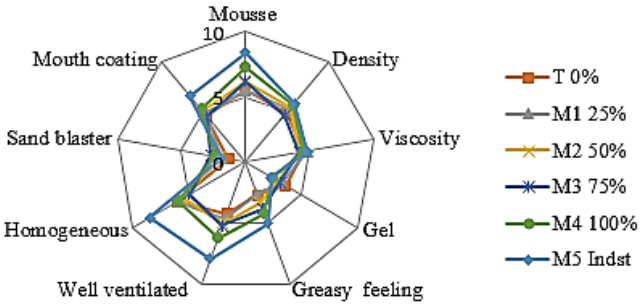


**Figure 5.** Texture profile of chocolate mousses

*Preference test*

The subjects prefer sample M4 (100% whey), M5 (industrial), M3 75%, M2 50%, M1 25% substitute and T 0%. 40% of the tasters prefer the 100% whey mousse because it taste good compared to the other whey mousses. While for the 33.33% of tasters who prefer the industrial mousse, their choice—was based on the homogeneous texture, the good aeration and stability of the mousse compared to the formulas. We can note that no taster mentioned an unpleasant taste due to the presence of whey in the formulas.

***Is the recovery of whey profitable?***

The incorporation of whey in the manufacture of chocolate mousses reduces the amount of milk used. The substitution of milk by whey allowed a gain of 180 DA (3L × 60 DA) (for the manufacture of 168 boxes of 30-35g of 100% whey chocolate mousse). According to (Cheryan, 1998), moreover, the polluting effect of whey will be reduced (for the same quantity of rejected whey (18000 l) it will be possible to produce 35.15 kg of chocolate mousse with 100% whey; 18000 × 65300 g of O2 /l, i.e. 1.175 × 109 g of O2 preserved).

## Conclusion

The aim of this work was to enhance the value of the sweet whey produced by Giplait-Numidia dairy, by incorporating it into chocolate mousse formulas and evaluating physicochemical, structural and sensory parameters of the proposed formulas. We started by determining the physico-chemical characterization of the whey produced by the Numidia dairy, which is derived from the manufacture of the uncooked pressed paste type "Edam".

Five chocolate mousses at different substitution rate are formulated. A sweet whey was used from the manufacture of pressed cheese type "Edam" which has a pH of 6.6 with a density of 1021 at 29.33 °C, an acidity of 12.5 °D and a total dry matter of 6.08 g/l.

The different chocolate mousse formulas had pH, fat, dry matter and protein values in the following ranges respectively: (5.89 - 5.87); (32.17 - 34.64%); (2.27 - 3.47 g/100g) and (1.39 - 3.91 g/l). The expansion ratio, which has a direct impact on texture and mousse formation, varied between 22.16% and 78.08%. For sensory characteristics, the formulas produced had a very appreciable organoleptic quality: for color, density, flavor and even texture, a significant difference for the homogeneity and aeration of the mousse compared to industrial mousse was observed. The mousse with 100% whey substitution was the most appreciated by the tasting panel with average organoleptic characteristics and a high expansion rate compared to the other formulas.

## References


AFNOR (Association Française de NORmalisation). 1993. Recueil de normes françaises. Contrôle de la qualité de produits Alimentaires: laits et produits laitiers. Analyses physico-chimiques. AFNOR-DGCCRF (4e Ed). Paris, 562 p.

AFNOR (Association Française de NORmalisation). 1986. Méthodes d'analyses du lait et les produits laitiers. Recueil des normes Françaises (2e Ed.), 580 p.

Aragon-Alegro, L.C., Alarcon-Alegro, J.H., Cardarelli, H.R., Chih-Chiu M., Isay-Saad, M.S. 2007. Potentially probiotic and synbiotic chocolate mousse. lwt-food science and technology. Science direct. University of Sao paulo. Www.elsevier.com/locate/lwt

Arora, S., Ashish, M., Shendurse, V.S., Balbir-Wadhwa, K., Ashish-Singh, K. 2013. Assessment of stability of binary sweetener blend (aspartame x acesulfame-k) during storage in whey lemon beverage. *Journal of food science and technology*, 50 (4), 770-76.

Benabbou, A., Bentalab, S.M. 2016. Valorisation du lacto-sérum liquide en l'incorporant dans la fabrication des crèmes glacées de type sorbet. Mémoire présenté à Faculté des Sciences de la Nature et de la Vie et Sciences de la Terre et de l'Univers pour l'obtention du diplôme de Master en Gestion de la Qualité en Industrie Agroalimentaire. Département d'Agronomie, 72 p.

Benaissa, M. 2018. Valorisation du lactosérum par les bactéries lactiques. Thèse de Doctorat en Sciences spécialité: Biotechnologie, option : Ecosystèmes Microbiens Complexes. Département de Biotechnologie, Faculté des Sciences de la Nature et de la Vie, Université d'Oran Ahmed Ben Bella.

Benezech, T., Maingnnat, J.F. 1994. Characterization of the rheological properties of Yoghurt. A review. *J. Food engineering*, 21, 447-472.

Blaschek, K.M., Wendorff, W.L., Rankin, S.A. 2007. Survey of salty and sweet whey composition from various cheese plants in Wisconsin. *Journal of Dairy Science*, 90(4), 2029-2034.

Boudjema, K., Fazouane-Naimi, F., et al. 2009. Optimisation et modèle de production d'acide lactique par streptococcus thermophilus sur lactosérum. *Sciences & technologie - C, Biotechnologies*, 80-90.

Bradford, M. 1976. A rapid and sensitive method for the quantification of microgram quantities of protein utilizing the principal of protein dye binding. *Analytical Biochemisty*, 72, 248-254.

Cheryan, M. 1998. Ultrafiltration and microfiltration handbook, thechnomic publishing, Company. Lancaster, Paris.

Djemaoui, S., Mamache, K. 2019. Impact de l'incorporation de lactosérum atomisé sur la qualité de crèmes glacées. Mémoire présenté pour l'obtention du diplôme de Master en Technologies Alimentaires. INATAA, Université Frères Mentouri Constantine 1, 95 p.

EL-Zeini-Mahmoud, H., Moneir-EL-abd, M., Mostafa, A.Z., Yasser EL-ghany, F.H. 2016. Effect of incorporating whey protein concentrate on chemical, rheological and textural Properties of ice cream. *Journal of Food Processing & Technology*, 7(2), 7.

FAO/ONU (Food and Agriculture Organization of the United Nation), 2017. http://www.fao.org/faostat/fr/#data/QP

Fauquant, J., Vieco, E., Brule, G., Maubois, J.L. 1985. Clarification des lactosérums doux par agrégation thermocalcique de la matière grasse résiduelle. *Le lait*, 65(647-648), 1-20.

Furtado, M.M., Pombo, A.W. 1978. Étude de quelques aspects de la fabrication des fromages brésiliens Prato et Minas. *Le Lait*, 58(578), 510-530.

Gana, S., Touzi, A. 2001. Valorisation du lactosérum par la production de levures lactiques avec les procédés de fermentation discontinue et continue. *Rev. Energ. Ren*, 1, 51-58.

Hachemi, N.EL. 2018. Valorisation du lactosérum : optimisation des conditions de préparation d'une boisson lactée non fermentée. Mémoire présenté pour l'obtention du diplôme de Master en Technologies Alimentaires, INATAA, Université Frères Mentouri Constantine1, 92 p.

Huffman, L.M., De barros-Ferreira, L. 2011. Whey-based ingredients dairy ingredients for food processing, Wiley-blackwell, pp. 179-198.

Komatsu, T.R., Buriti, F.C.A., Da Silva, R.C., Gioielli, L.A., Saad, S.M.I. 2012. Nutrition claims for functional guava mousses produced with milk fat substitution by inulin and/or whey protein concentrate based on heterogeneous food legislationiences. Lwt- food science and technology. University sao paulo ; brazil av. Prof. Lineu prestes, 580, b16,05508-000. DOI: 10.1016/j.lwt.2012.07.013

Kresic, G., Lelas, V., Herceg, Z., Rezek, A. 2006. Effects of high pressure on functionality of whey protein concentrate and whey protein isolate. *Le lait*, 86(4), 303-315.

Lawless, H.T., Heymann, H. 2010. Sensory evaluation of food (principals and practices). Food science text series. 2nd Ed. Springer http://www.springer.com/series/5999

Meilgaard, M.C., Carr, B.T., Civille, G.V. 1999. Sensory evaluation techniques. Food sciences & Technology. 3rd Ed., Crc press, New York, 400 p.

Pega, J., Denoya, G.I., Castells, M.L., Sarquis, S., Aranibar, G. F., Vaudagna, S.R., Nanni, M. 2018. Effect of high-pressure processing on quality and microbiological properties of a fermented beverage manufactured from sweet whey throughout refrigerated storage. *Food and Bioprocess Technology*, 11(6), 1101-1110.

Saulnier, F., Calco, M., Humbert, G., Linden, G. 1996. Composition minérale et organique de différents lactosérums acides industriels, analysée par électrophorèse capillaire. *Le Lait*, 76(5),423-432

Shukla, M., Jha, Y.K., Admassu, S. 2013. Development of probiotic beverage from whey and pineapple juice. *J Food Process Technol*, 4(2), 1-4.

Sottiez, P. 1985. Produits dérivés des fabrications fromagères. Laits et produits laitiers : vache, brebis, chevre/societe scientifique d'hygiene alimentaire; Francois M. Luquet, coordonnateur, assiste de Yvette Bonjean-Linczowski; Prefaces de J. Keilling, R. De wilde, Technique et documentation, Lavoisier : APRIA, Paris, co1985.

Stone, H., Sidel, J.L. 2004. Introduction to sensory evaluation. Sensory evaluation practices, (3rd ed.), Academic press, San Diego, 1-19.

Weeraya, C., Panita, N., Rossarin, T. 2016. Effect of fat content on characteristics of ice cream fortified with calcium and vitamin D3. Rossarin tansawat, 254 phayathai rd, Pathumwan, bangkok 10330, thailand.132p.

Yadav, J., Shankar, S., Song, Y., Sridhar, P., Kumar, L., Tyagi, R.D., *et al.* 2015. Cheese whey: a potential resource to transform into bioprotein, functional/nutritional Proteins and bioactive peptides. *Biotechnology advances*, 33(6), 756-774.

Zemel, M.B. 2004. Role of calcium and dairy products in energy partitioning and weight management. *American Journal of Clinical Nutrition*, 79, 907se912s.

Zernadji, W., Chebchoub, F. 2018. Essai de la fabrication d'une boisson fermentée à base de jus de la fraise et de lactosérum. Mémoire de fin d'études en vue de l'obtention du diplôme de Master en Biologie : Technologie Agroalimentaire et Contrôle de Qualité, Département Microbiologie Appliquée et Sciences Alimentaires. Faculté des Sciences de la Nature et de la Vie, Université de Jijel.

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