ORIGINAL ARTICLES

Study of the emulsifying properties of whey proteins in crude and modified environments

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ABSTRACT

The study of physicochemical and biochemical variability of the environment on the emulsifying properties of whey proteins and modified crude, we can implement two main parts, the first part is the characterization phase of the emulsion which are oil sweet almond, crude and modified whey (delactozed whey, deproteinized and demineralized) and the second part focused in the study of the emulsifying properties of whey proteins modified crude (delactozed whey, deproteinized and demineralized). Changing crude whey is performed by three different techniques; an organic by the job of a lactic thermophilic strain that aims to produce delactozed whey, the other two are physical techniques, the first is named thermalcoagulation used to generate deproteinized whey, and the second is called the ion-exchange chromatography (cation exchange resin) whose goal is to produce demineralized whey. The results show that the physicochemical parameters of sweet almond oil are suitable for the emulsification, the values of physicochemical parameters of crude soft whey are higher than those found in whey including crude acid: proteins, lactose, density and viscosity. For against those obtained in the modified whey is variable depending on the nature of the techniques applied, in addition we record the values of interfacial tension lower for demineralized whey compared with modified serum .Emulsion stability of O / W type of whey prepared with crude and modified whey depends on the physicochemical environment, biochemical of whey used and the presence or absence of sodium caseinate as a stabilizing agent.

Key words: crude whey, modified whey, sweet almond oil, thermalcoagulation, cationic ion exchange resin, thermophilic lactic strain, environment, emulsion, stability, proteins.

Introduction

The dairy industry is one of the agro-food, which is responsible for the production of large quantities of whey harmful to the environment. Whey is an industrial waste cheese; its fermentable organic matter is the enabling factor of the biological pollution of freshwater ecosystems. The amount of whey in Algeria and as in other countries of the world represents about 85% of milk processed into cheese, whey is however an interesting product for its proteins rich in essential amino acids (lysine and tryptophan), lactose, minerals and the presence of many B vitamins such as thiamine and riboflavin (Fao, 1995).

The emulsions are the basis for a wide range of products manufactured both in the food (milk, cream, mayonnaise, butter etc.), in pharmacy, agrochemical or in cosmetology and consist of at least two immiscible liquids, one being dispersed in the other form of droplets, in the simplest case the two liquids are oil and water, the liquid which is not called phase is then dispersed continues.

However, the formulation of products now includes emulsion texturizing agent’s mixed, specific use and whose composition is the result of empirical observations and expertise of specialists in mixtures, it becomes imperative to understand the behavior of molecules in mixtures by studying their interactions with each other and with not-proteins or proteins components naturally present in raw materials.

The emulsions are inherently unstable systems that can destabilize next several mechanisms reversible or not. Among these mechanisms, the two largest are creaming (or sedimentation following the relative densities of two liquids) and coalescence, creaming is the migration droplets upwards under the effect of gravity which is due to the different densities of the two phases, dispersed and continuous; sedimentation phenomenon is the same but in this case, the droplets migrate downwards; coalescence is the fusion of two droplets to form a larger one. The different phenomena of destabilization result in changes to both the size and number of droplets in the emulsion and by changes in the microscopic appearance of the emulsions. It is thus observed from a state perfectly uniform dispersion in a complete separation of the two phases; these phenomena induce changes in the physical structure of emulsions and they may affect the properties of the emulsion.
The study of emulsion stability is therefore essential to understand the parameters to obtain systems that meet the stability criteria defined a priori; different methods have been proposed to follow the destabilization of emulsion including conductivity measurements of turbidity or ultrasonic techniques (Novales et al., 2009). Knowledge of primary structures and three-dimensional six major milk proteins and whey (casein \(\alpha_1\), \(\alpha_2\), \(\kappa\) and \(\beta\), \(\beta\)-lactoglobulin and \(\alpha\)-lactalbulin) was used to connect these structures and physicochemical behavior and predict functional the properties of an ingredient in a product determined according to the preparation conditions. Whey proteins are increasingly used as ingredients in many of texture or intermediate products ready for consumption. Several works were undertaken on the functional behavior and individual caseinates and whey proteins concentrates in aqueous solution and many journals have already established an inventory of the properties of hydration, and surface texture (Cheftel and Lorient, 1982; Fox and Mulvihili, 1983; Kinsella, 1984; De Wit, 1984, Kinsella and Fox, 1985; Modler, 1985, Anderson et al., 1987; Colas, 1988; Dumay, 1988; Leman and Kinsella, 1989; Yoshida and Antunes, 2004 ; Ashokkumar et al., 2009). The functional properties of whey can be improved by changing the medium (electredialysis, ultrafiltration, ion exchange), by denaturing by heat at neutral or acidic pH, in batch or continuous treatment (scraped surface exchangers, cooking-extrusion), chemical treatments are laboratory methods used to explain the structure-function relationships, for proteolysis, it may apply only to improve solubility (Lorient et al, 1991).In light of this work, our research conducted by our team aims at studying the relationship: whey proteins, medium (crude and modified) and the emulsifying power of whey proteins, in the first part we have changed the crude whey (acid and soft) for producing deproteinized, demineralized and delactozed serums while using appropriate techniques (thermal precipitation, bioconversion of lactose and ion exchange chromatography) and the second part residing in the evaluation of the stability of emulsions prepared based on crude whey (acid or soft) and modified (deproteinized , delactozed and demineralized wheys).

Materials and Methods

Crude whey:

Both types of whey are prepared in the laboratory from a powdered skim milk (0% fat) manufactured using cow's milk by Fonterra Ltd., 9 Princes Street, Auckland, New Zealand. The crude acid whey (LSAB) was prepared by adjusting the pH of the milk reconstituted10% in the isoelectric pH of insoluble proteins by serum against crude soft whey (LSDB) is prepared from the same type of milk by adding rennet 2V at 1%, and heated to 35°C/40min (Baumy and Brule, 1986), both types of serum were recovered by simple filtration after filter paper (Folded filters of Germany, 185mm diameter) and kept at 4°C.

Modified whey:

The use of a resin type: Data Sheet cationic ion exchange resins such as by S100 provides chemicals nde Keyserlei 58-B-2018 ANTWERP / BELGIUM phase Na+ (regeneration with HCl 4% w / v) we have can demineralize our crude whey calcium (LSADM, LSDDM).According Racotta et al., (1978), the deproteinized whey (LSADP, LSDDP) are obtained by thermalcoagulation (95°C/30min) followed by centrifugation 4500tours/5min also direct inoculation of thermophilic lactic acid bacteria yogurt (CHR HANSEN Danish brand marketed for direct seeding in lyophilized form) at different doses 1%, 0.5% and 0.25% and incubated at 45°C in crude whey (acid or soft) produced delactozed whey ( LSADL LSDDL), then to maintain the pH of the initial crude soft whey, the pH of LSDDL is corrected by addition of sodium hydroxide 1/9N which the bioconversion of lactose into lactic acid is controlled by the kinetic parameters of pH and titratable acidity of the medium (Larpent, 1997, Stokes et al, 2001).The physico-chemical tests and biochemical applied to different types of serums and sweet almond oil are: pH (pH meter CG 822 GHS), lactose using the DNS method according to Miller (1959), proteins (Lowry method et al., 1951), the Ca content (flame photometer Jenway PEP 7), the viscosity by a falling ball viscometer (viscometer: Hoeppler BH2), the ash content by the method AFNOR (1980), the interfacial tension is determined by bidimensional Dunouy 70545, density by pycnometer according to Hardy (1987) and the acid value is determined using the method described by Schnadeltach (1997).

Emulsions:

The emulsion is composed of a dispersed phase (the sweet almond oil provided by the Algerian trade; Mazouza origin, Algeria) and a dispersing phase (crude and modified whey), dispersions are prepared in the presence or absence of sodium caseinate (stabilizer) in a ratio V / V equal to 0.0526%; each mixture is homogenized at 25°C depending on the speed 8000tours/30min by a homogenizer (Ultraturrax Janke and Kunckel, IKA, labotechnik).Stability of emulsions spectral measurement is determined using a spectrophotometer Bausch and Lomb, Spectronic 70 and is calculated following the formula given by Pearce.
and Kinsella (1978) whose data were statistically analyzed by software R (ANOVA). The mean diameter of the globules is determined using an ocular micrometer graduated from 0 to 10 whose graduations are spaced apart from 0.1 μm.

Results and Discussion

Table 1 shows the physico-chemical and biochemical means of wheys studied.

<table>
<thead>
<tr>
<th>Wheys Parameters</th>
<th>Crudes (Crudes Demineralized Deproteinized Delactozed)</th>
<th>Crudes Demineralized Deproteinized Delactozed</th>
<th>Crudes Demineralized Deproteinized Delactozed</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH at 25°C</td>
<td>4.65, 6.72, 4.25, 1.09, 3.55, 6.67, 3.64, 4.1, 6.72</td>
<td>4.65, 6.72, 3.55, 6.67, 3.64, 4.1, 6.72</td>
<td>4.65, 3.55, 6.67, 3.64, 4.1, 6.72</td>
</tr>
<tr>
<td>Calcium (g/l)</td>
<td>0.0255, 0.086, 0.001, 0.0004</td>
<td>Nd, Nd, Nd, Nd</td>
<td>Nd, Nd, Nd, Nd</td>
</tr>
<tr>
<td>Ashes (g/l)</td>
<td>7.97, 6.82, 4.67, 0.43</td>
<td>Nd, Nd, Nd, Nd</td>
<td>Nd, Nd, Nd, Nd</td>
</tr>
<tr>
<td>Proten (g/l)</td>
<td>7, 13, 1.1, 11.9</td>
<td>1, 1.2, 13.7</td>
<td>1, 1.2, 13.7</td>
</tr>
<tr>
<td>Lactose (g/l)</td>
<td>47.36, 48.42, Nd, Nd</td>
<td>Nd, Nd, Nd, Nd</td>
<td>Nd, Nd, Nd, Nd</td>
</tr>
<tr>
<td>Viscosity (cP) at 25°C</td>
<td>1.223, 1.323, 1.177, 1.263</td>
<td>1.183, 1.225, 1.291</td>
<td>1.183, 1.225, 1.291</td>
</tr>
<tr>
<td>Density at 25°C</td>
<td>1.027, 1.031, 1.0258, 1.024</td>
<td>1.0262, 1.0269, 1.0279</td>
<td>1.0262, 1.0269, 1.0279</td>
</tr>
<tr>
<td>Interfacial tension (Dynes/cm) at 25°C</td>
<td>35.5, 34.4, 32, 31.1</td>
<td>35, 35, 35</td>
<td>35, 35, 35</td>
</tr>
<tr>
<td>Nd: not determined</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**pH and lactose:**

Table 1 indicates that the majority of the physico-chemical and biochemical modified whey (deproteinized, demineralized and delactozed) underwent a variability relative to those found in crude whey (acid or soft); for demineralized whey, the cationic resin increased the concentration of H+ whey which explains the drop in pH in demineralized whey: pH = 4.25 for LSADM against 4.65 for LSAB and pH = 1.09 for LSDDM against pH = 6.72 for LSDB, thermal coagulation of whey crude has changed their settings; a slight variation of pH; we note a pH = 3.55 for LSADP against a pH = 4.65 for registered LSAB and pH = 6.67 for LSDDP against a pH = 6.72 marked in LSDB, the pH of the delactozed whey are lower than those measured in the crude whey: pH = 3.64 for LSADL against a pH 4.65 for LSAB and from pH = 6.72 for LSDB to pH = 4.10 noted in LSDDL.

The levels of lactose in whey are roughly lower than those found by Croguennec et al. (2008), they found the following values: a value of 50 g lactose / l for soft whey and acid whey cheese, its content equal to 44 g / l or 50 g / l of lactose is recorded for acid whey from casein, in addition to the lactose content in the delactozed whey decreased compared to those found in the crude whey; we record a decrease of 62.5% or 29.6 g / l of lactose found in LSADL compared to that obtained in LSAB and a reduction of 38.58% is 18.68g / l lactose determined in LSDDL and LSDDLC, we note that the lactose content expressed as g / l of crude whey is higher than that found in delactozed whey; this decrease is probably related to the number of lactic bacteria that is the degradation of this substrate (microbial activity) in which lactic acid production of lactic acid by microorganisms is due to the richness of metal ion environments (Boy Aval, 1989), becoming the main fermentation used in food microbiology is the thermophilic lactic acid fermentation in which lactic acid is produced from lactose. For this reason we used a strain of yogurt that is made using a special yeast in which there are two bacteria, *St. thermophilus* and *L. bulgaricus* during the parallel growth of these organisms, lactic acid is produced by streptococci and aromatic compounds are formed by the lactobacilli (Prescott et al, 2003). The pH is decreasing with acidity, it evolves with the composition and high content of acidic substances (Mathieu, 1998); according Multon (1993), the thermophilic enzymes are less sensitive to pH than mesophilic: *Lactobacillus bulgaricus* and *Streptococcus thermophilus* grow in milk, respectively, to pH 4.1 and 3.8; according to Eck and Gillis (1997), their ability to grow at temperatures above 40°C, optimal growth between 40 and 50°C. The results of physicochemical analysis of soft whey from the manufacture of Camembert from the ORLAC Draa Ben Khedda (Tizi-Ouzou, Algeria) determined by Boudjema et al. (2009) show that this medium culture has a decent quality saw its high nutritive materials: 57.9 g / l of lactose, 1.12 g / l of matières azotés, 7 g / l of proteins, 1.75g / l of chloride and 0 g / l of fat. This bioprocess resulting in the bioconversion of lactose into lactic acid is controlled by two very important clues: the pH and titratable acidity; finding the optimal inoculum of lactic acid bacteria selected needed to convert in a shorter time as possible whey lactose to lactic acid compared to unseeded liquid whey to produce delactozed whey, allows us to have the results given by Figures 1.
and 2 respectively show that the kinetics of acidity and pH of crude whey and seeded by thermophilic lactic acid bacteria, recent evidence that the dose of 1% compared with thermophilic lactic whey and other witnesses doses used (0.25% and 0.5%) seeded directly into the whey (soft) has increased its power acidifying, for example crude soft whey (LSDB) unseeded gives after 4 hours of incubation pH = 5.38 and an acidity equal to 2.16g / l, which become stable thereafter or soft whey inoculated with 1% of thermophilic lactic acid bacteria after 6 hours alters the pH and acidity titratable environment which become respectively: pH = 3.96 and acidity equal to 8.73g / l compared to other doses 0.5% and 0.25% respectively which generate values of pH and titratable acidity different: pH = 4.20 and acidity equal to 6.98 g / l after 7 hours, pH = 4.63 and acidity equal to 4.7g / l after 8 hours, in addition to the crude acid whey (LSAB) control and inoculated with 1% of thermophilic lactic acid bacteria are then tested after 6 hours of incubation: pH = 4.37 and an acidity equal to 4.9g / l, pH = 3.74 and an acidity equal to 5.38g / l, it appears that growth and lactic acid production are inhibited when the pH drops, this is due to the high acidity (pH below) which results from the accumulation of lactic acid; and in this sense Amrane (2001) concluded that inhibition may be due to depletion of carbon source, but in our work, this is not the case, because the concentration of lactose in the LSAB pass 47.36g / l to 29.6g / l with a yield of bioconversion of lactose into lactic acid equal to 62.5%, and increased in LSDB of 48.42g / l at 18.68g / l with a yield of bioconversion of lactose into lactic acid equal to 38.58%, other researchers such as Somkuti and Steinberg (1979) showed that galactose is one factor responsible for inhibiting growth of *Streptococcus thermophilus*, this work is confirmed by Levander and Radstrom (2001) who showed that *Streptococcus thermophilus* are considered galactose (-) and they can ferment galactose although they possess the gene required for the catabolism of galactose.

![Fig. 1: Kinetics of pH (A) and titratable acidity (B) of crude soft whey (LSDB) and seeded (LSDBE) by thermophilic lactic acid bacteria.](image1)

![Fig. 2: Kinetics of pH (C) and titratable acidity (D) of crude acid whey (LSAB) and seeded (LSABE) by thermophilic lactic acid bacteria.](image2)
Ashes and calcium:

In addition to the ash content of whey studied are lower than those found by Croguenec et al. (2008), they obtained the following results: 7.5 g/l for soft whey, 12 g/l for acid whey cheese and 9 g/l for the acid whey from casein, or we see a decrease of approximately 100% ash content of demineralized soft whey (LSDDM) compared to that obtained in the crude soft whey; we believe 0.43 g/l for LSDDM against 6.82 g/l for the LSDB, and a drop of nearly half the ash content in LSADM marked compared to that seen in the LSAB; we record 4.67 g/l for LSADM against 7.97 g/l for LSAB; these results are comparable to those found by Racotta et al. (1978) who concluded that the mineral content of soft whey decreased from 7.3% to 1% of the dry following an ion exchanger, in which case the lowering of pH by cation exchange causes a lower yield of proteins and a higher rate of mineral matter (Racotta, 1976). Same observation was recorded for the calcium (Ca), 0.001 g/l and 0.0004 g/l respectively recorded for LSADM and LSDDM; content of calcium (Ca) demineralization rate is 98% and 96% for LSDB and LSAB respectively) decreases in the whey demineralized on cationic resin; this strong binding of calcium is mainly due to the selectivity of the cation exchange resin to the cations of whey calcium and a drop of nearly half the ash content in LSADM marked compared to that seen in the LSAB; we record 0.43 g/l for LSDDM against 6.82 g/l for the LSDB, according to Mathieu (1998), thermal coagulation causes precipitation of 97% soluble proteins, the proteins content of deproteinized whey are lower compared to crude whey. Proteins levels of delactozed whey are superior compared to the crude whey, these variations are probably related to the proliferation of native microbial load and exogenous (bacterial growth of the thermophilic strain seeded) of whey, by correction against LSDDL by NaOH decreased proteins content (LSDDL), this observation can be explained by several authors (Cheftel and Lorient, 1982; Baumy and Brule, 1986; Pernoud et al., 2005) as the solvent (NaOH) a distorting effect on the structure proteins while changing the appearance of the environment (haze formation tends to white). For the surface properties: sweet almond oil / whey; all interfacial tensions are found below that obtained for oil almond / water which is equal to 45 Dynes/cm or the interfacial tension values vary from serum to a another which are the lowest recorded in demineralized whey: 32 Dynes/cm for LSADM and 31.1 Dynes/cm for LSDDM, whereas we find values that are closer to the rest of whey: 35.5 Dynes/cm and 34.4 Dynes/cm respectively for LSAB and LSDB; 35 Dynes/cm for LSADP and 35 Dynes/cm for LSDDP and for delactozed whey, we save: 35 Dynes/cm for LSADL and 35.1 Dynes/cm for LSDDL. According Jeantet et al. (2006); Jeantet et al. (2007), at the interface between two phases (liquid / gas, liquid / liquid immiscible), the molecules are in an environment asymmetrical and the
attractive forces exerted by each phase of the molecules located at the interface are different, resulting in an energy or interfacial tension that corresponds to an energy per unit area, however the organic molecules are preferentially concentrated at the interface and lower the interfacial tension in the case where they have hydrophilic and hydrophobic areas (amphiphilic character). However Jeantet et al. (2007) point out that the interfacial tension decreases with the concentration of solute in solution until a level corresponding to the organization of amphiphilic molecules into micelles, this concentration limit is called concentration critical micelle (CMC), in addition to the phenomena of diffusion and adsorption of molecules at the interface mechanisms are often slow and must displace solvent molecules present initially and suffer, in the case of conformational changes of macromolecules which can facilitate the formation of intermolecular interactions up to the formation of an interfacial film cohesive; also the proteins macromolecules generally exhibit good interfacial properties because they are indeed made of hydrophobic areas (presence of proline, leucine, isoleucine, tryptophan, phenylalanine) and hydrophilic areas (presence of aspartic acid, glutamic acid, phosphoserine), the hydrophilic regions of globular proteins are well exposed to the aqueous solvent while the hydrophobic regions are mostly located in the heart of the structure with the minimum of contact with water.

**Sweet almond oil:**

Table 2 shows some physicochemical parameters means of sweet almond oil commercial studied.

<table>
<thead>
<tr>
<th>Parameters at 25°C</th>
<th>sweet almond oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity (cP)</td>
<td>69.0963</td>
</tr>
<tr>
<td>Acidity(%)</td>
<td>0.72</td>
</tr>
<tr>
<td>Density</td>
<td>0.9155</td>
</tr>
<tr>
<td>pH</td>
<td>5.83</td>
</tr>
</tbody>
</table>

The average value of the viscosity of sweet almond oil is slightly lower than that found by Morin (1992), who found a value of 71cP; according Karleskind (1992), the viscosity vary from 68 to 76 cP at 20°C and is dependent upon the chemical structure of fats, temperature and molecular weight resulting in an increase in viscosity. The acid of sweet almond oil is equal to 0.72%, this value is consistent with the standard cited by AFNOR (2005) that requires a value lower than 2%, in general, the index of acidity of an oil depends on its chemical composition and storage conditions (Karleskind, 1992). The density obtained is comparable to that found by Morin (1992), who found a value of 0.911 to 0.917 for the sweet almond oil, according Karleskind (1992), the density of a fat depends on its temperature and its chemical composition, and Roger (1974), note that the density of vegetable oils vary from 0.915 to 0.964. We note that the pH of the sweet almond oil studied is similar to that of neutrality, which is better suited to the skin (Schmaitlach, 1997).

**Stability of emulsions:**

From figure 3, we note that all curves of the stability of emulsions prepared with crudes (soft and acid) and modified whey are decreasing over time.

![Fig. 3: Emulsions stabilities of crude (A) and modified whey (B, C and D) in the presence (as) or absence (ss) of sodium caseinate.](image)
We record that emulsion stability depends on the type of whey used in preparation and the presence or absence of sodium caseinate, whey and oils are characterized by average stabilities (MS) (Table 3) are the highest denoted respectively: 75.6% and 72.8% for LSAa and LSDa and are reflected by a decrease after 2 hours, and decreased stability after 6 hours (LSAa case), the LSDa was characterized by a decrease after 2 hours and high stability up to 8 hours. For deproteinized whey; we notice an improvement was apparent in most emulsions checked against crude whey; the emulsion made of LSDa has an average of stability equal to 87.22% decrease after 2 hours and it stabilizes after 4 hours but that of LSDs whose stability is estimated at 79.02%; it weakened after 2 hours and remains stable up to 8 hours slightly. But the delactozed whey compared to those whose crude emulsions made by LSDs and LSAa, emulsifiers have improved their behavior, they are manifested by different paces, the stability of the first is characterized by high stability up to 8 hours (an average of stability reaches 93.01%), for the second a gradual decrease after 2 hours until up to 8 hours with an average of 82.50% of stability. By demineralized whey against the show behaviors different emulsifiers; improved stability for emulsions made by the LSDs (MS = 84.6%), LSAa (MS = 64%) and LSAa (MS = 86%) and decreased stability of the emulsion based LSDa (MS = 63.6%).

Table 3: Descriptive statistics of stability (%) of emulsions prepared with crude and modified whey.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Br</td>
<td>60</td>
<td>69.47</td>
<td>82.5</td>
<td>86</td>
</tr>
<tr>
<td>Dp</td>
<td>75.6</td>
<td>74.89</td>
<td>73.46</td>
<td>64</td>
</tr>
<tr>
<td>Dl</td>
<td>72.8</td>
<td>87.22</td>
<td>64.28</td>
<td>63.6</td>
</tr>
<tr>
<td>Dm</td>
<td>54.8</td>
<td>79.02</td>
<td>93.01</td>
<td>62</td>
</tr>
</tbody>
</table>

The table 4 shows the ANOVA test for different types of wheys; the pace of acid whey stabilized by the sodium caseinate is highly significant (0.008933**), however the soft whey no stabilized by the sodium caseinate is significant compared to the other wheys.

Table 4: Anova stability test of crudes and modified wheys.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
<th>Pr (&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crudes wheys LSAa</td>
<td>1</td>
<td>1483.72</td>
<td>1483.72</td>
<td>5078.052</td>
<td>0.008933**</td>
</tr>
<tr>
<td>LSDa</td>
<td>1</td>
<td>9.11</td>
<td>9.11</td>
<td>31.181</td>
<td>0.112811</td>
</tr>
<tr>
<td>LSDs</td>
<td>1</td>
<td>50.08</td>
<td>50.08</td>
<td>171.406</td>
<td>0.048532 *</td>
</tr>
<tr>
<td>Residuals</td>
<td>1</td>
<td>0.29</td>
<td>0.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deproteinized wheys LSAa</td>
<td>1</td>
<td>732.39</td>
<td>732.39</td>
<td>60.4758</td>
<td>0.08142.</td>
</tr>
<tr>
<td>LSDs</td>
<td>1</td>
<td>66.35</td>
<td>66.35</td>
<td>5.4787</td>
<td>0.25704</td>
</tr>
<tr>
<td>Residuals</td>
<td>1</td>
<td>2.35</td>
<td>2.35</td>
<td>0.1939</td>
<td>0.73594</td>
</tr>
<tr>
<td>Delactozed wheys LSAa</td>
<td>1</td>
<td>2461.00</td>
<td>2461.00</td>
<td>36.8893</td>
<td>0.1039</td>
</tr>
<tr>
<td>LSDa</td>
<td>1</td>
<td>361.61</td>
<td>361.61</td>
<td>5.4203</td>
<td>0.2583</td>
</tr>
<tr>
<td>LSDs</td>
<td>1</td>
<td>108.68</td>
<td>108.68</td>
<td>1.6291</td>
<td>0.4231</td>
</tr>
<tr>
<td>Residuals</td>
<td>1</td>
<td>66.71</td>
<td>66.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demineralized wheys LSAa</td>
<td>1</td>
<td>203.35</td>
<td>203.35</td>
<td>32.0479</td>
<td>0.1113</td>
</tr>
<tr>
<td>LSDa</td>
<td>1</td>
<td>0.529</td>
<td>0.529</td>
<td>0.0833</td>
<td>0.8211</td>
</tr>
<tr>
<td>LSAa</td>
<td>1</td>
<td>6.579</td>
<td>6.579</td>
<td>1.0369</td>
<td>0.4942</td>
</tr>
<tr>
<td>Residuals</td>
<td>1</td>
<td>6.345</td>
<td>6.345</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

The study of emulsion stability showed that it varies with the type of whey used; emulsion stability depends on the type of whey and the presence or absence of sodium caseinate. Figure 3 shows that the sodium caseinate has a slight effect on emulsion stability. According Dickinson (1992); Morr and Ha (1993); Cayot (1998); to pH = 6 and 8, the emulsion made with sodium caseinate has a stability greater than that obtained with a concentrate of proteins which all temperatures, however Cayot and Lorient (1998) show that the loss of the calcium ion causes changes albeit limited in the α-lactalbumin, but makes it vulnerable to changes in environmental conditions, in addition Pérez-Gago and Krochta (1999) note that the formation of a film based interfaciale of whey proteins in an emulsion depends on the pH. environmental changes are responsible for reversible and irreversible changes of proteins structures, they produce the phenomena that reflect the functional properties (Cayot, 1998). Data on the functional properties of different whey proteins are influenced by the composition, structure, environmental conditions (pH, ionic strength, temperature, etc.), pretreatment, manufacturing processes, the extent of denaturation (De Wit and Hontelez-Backx, 1981, De Wit et al, 1983; Zadow, 1986), interactions with other compounds of the system (Zadow, 1986) and methods used for determining the functional properties, in the same context, Lorient et a., (1991) conclude that the functional behavior of milk proteins depends largely on their behavior towards water in relation to their spatial structure and physico-
chemical properties (bulking, surface hydrophobicity, amphipolarité) and flexibility in relation to the spatial structure and the water content, moreover, the globular proteins such as β-lactoglobulin is adsorbed less rapidly to interfaces. Some authors such as Nakai (1983), Townsend and Nakai (1983) have attempted to correlate the hydrophobicity to the surface properties and it appears that surface hydrophobicity is correlated with emulsifying properties while the average hydrophobicity is rather to foaming properties. According to De Wit and Hontelez-Backx (1981), whey proteins (β-Lactoglobulin, α-Lactalbumin, immunoglobulins, serum albumin, proteoses-peptones) are in a complex system, they are influenced by lactose, pH, salt, fat, heating and other proteins. The emulsions which recorded values of the highest stability with the very lowest standard deviations are shown by the pictures given by Figure 4.

**Fig. 4:** Photos of emulsions of sweet almond oil (HA) in crude whey (Br) and sweet almond oil (HA) in modified whey (deproteinized (Dp), delactozed (Dl) and demineralized (DM)) taken by a light microscope (photon microscope: PHYWE, hund WETZLAR, GERMANY, GX10) at time t0 showing the influence of the composition of the dispersing phase on the average size and dispersion of droplets (spherical shapes) of oil almond: HA emulsion / crude whey (Br); case of HA / LSAas (7 g/l of proteins: Φ = 0.8μm, SD = 16.26%), emulsion HA / deproteinized whey (Dp) ;case of HA / LSDas (1.2 g / l of proteins: Φ = 0.399μm, SD = 10.69%), emulsion HA / delactozed whey (Dl);case of HA / LSDss (4g / l of proteins: Φ = 0.239 μm , SD = 5.34%) , emulsion HA / demineralized whey (Dm),case of HA / LSASS (1.1g/l of proteins:Φ = 0.94 μm , SD = 10.32%).

**Conclusion:**

The present study has dual interests; ecological interest lies in reducing water pollution of freshwater ecosystems is the result of direct discharges of raw whey into the environment (as in cheese, Trefl, sidi saada, yellet, relizane, ALGERIA) and economic interest covering the search for new surface-active substances of animal origin crude whey in order to value in the field of emulsions. This research is focused in the biochemical and physicochemical characterization of raw and modified whey and study of the behavior of their protein emulsifiers; changes in crude whey was carried out by two physical methods: thermalcoagulation and cationic ion exchange chromatography generating respectively the deproteinized whey and demineralized whey, and a biological method for the job of a lactic thermophilic strain for the production of delactozed whey, these methods have proven their own applications and reliability. Physicochemical and biochemical parameters of crude whey and modified depending on the type of whey and its modification technique implementation. The results show that the physicochemical parameters of sweet almond oil are suitable for the emulsification, the values of physicochemical parameters of crude soft whey are higher than those found in whey including crude acid: proteins, lactose, density and viscosity; against by those obtained in the modified whey is variable depending on the nature of the techniques applied, we record the values of interfacial tension lower for demineralized whey compared with other serums changed. The statistical study shows that emulsion stability depends on the nature of whey (crude or modified), the presence or absence of sodium caseinate as a stabilizing agent, the oil / whey, the average size and dispersion of blood fat, proteins composition of the dispersing phase (crude and modified whey), the tool and the stirring speed, the stabilities recorded for emulsions of crude whey and modified are: emulsion HA / crude whey (Br) ; case of HA / LSAas (7g/l of proteins: Φ = 0.8μm, SD = 16.26%), emulsion HA / deproteinized whey (Dp);case of HA / LSDas (1.2g/l of proteins: Φ = 0.399 μm, SD = 10.69%), emulsion HA / delactozed whey (Dl);case of HA / LSDss (4g/l of proteins: Φ = 0.239 μm, SD = 5.34%) , emulsion HA / demineralized whey (Dm),case of HA / LSASS (1.1g/l of proteins:Φ = 0.94 μm, SD = 10.32%). The stability of the emulsions studied did not necessarily translate into lowering the diameter of fat.
globules at time \(t_0\), but indicates its stability over time. Looking ahead, we plan to apply other gentle techniques to improve conditions and profitability of changes in crude whey (acid or soft) such as ultrafiltration, electrodialysis to compare the behavior of their protein emulsifier.

List of abbreviations:

- **HA/LSAss**: Emulsion type of sweet almond oil in acid whey without stabilizer
- **HA/LSAs**: Emulsion type of sweet almond oil in acid whey with stabilizer
- **HA/LSDss**: Emulsion type of sweet almond oil in soft whey without stabilizer
- **HA/LSDas**: Emulsion type of sweet almond oil in soft whey with stabilizer
- **MS**: Average stability
- **SD**: Standard deviation
- **\(\Phi\)**: Mean diameter of fat globules
- **G**: magnification
- **LSAB**: Crude acid whey
- **LSDB**: Crude soft whey
- **LSADM**: Demineralised acid whey
- **LSDDM**: Demineralised soft whey
- **LSADP**: Deproteinised acid whey
- **LSDDP**: Deproteinised soft whey
- **LSADL**: Delactozed acid whey
- **LSDDL**: Delactozed soft whey
- **LSDDLs**: Delactozed soft whey corrected

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