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Effect of spray drying on the fatty acids content and nutritional indices of buffalo powdered milk

Mariana Ferreira ALVES[1], Marília Viana BORGES[1], Daniel FLORÊNCIO FILHO[1], Modesto Antônio CHAVES[1], Dante Pazzanese LANNA[2], Márcio dos Santos PEDREIRA[1], Sibelli Passini Barbosa FERRÃO[1], Sérgio Augusto de Albuquerque FERNANDES[1]*

Abstract

The buffalo's reproductive seasonality determines the decrease in milk and cheese production generating economic losses on the production system. Among various food process, we find the spray-dryer as an essential tool which helps food conservation. We achieved the milk powder in three replicates and each repetition processed 10 L of buffalo milk. After obtaining the final product, three samples (200 g) were packaged for each evaluated storage time (0, 30, 60, 90, 120 and 150 days at room temperature). In this context, we assessed the effects of drying buffalo's milk by atomization (spray dryer) and storage time effects on the milk fat. We observed that the spray drying did not alter the fatty acid content and nutritional indices evaluated, except the ratio DHA / EPA. Also, the storage time did not change the lipid content (fatty acid) and nutritional indices assessed. The processing of buffalo milk by a spray dryer and the milk powder hermetically stored can be used as a strategy for mitigating the economic losses caused by reproductive seasonality.

Keywords: DHA; EPA; public health; seasonality.

Practical Application: Commercialization of buffalo powdered milk in the period of lesser production.

1 Introduction

The drying of the milk prolongs its shelf life, allows its use in times outside the production season and permits its international commercialization (Paez et al., 2006; Davis et al., 2017). The production of whole buffalo milk is ranked second after whole cow`s milk, as 14% and 81%, respectively (Food and Agriculture Organization of the United Nations, 2019). The Buffaloes have a reproduction seasonality which affects the distribution of the milk during the year (Ramadan, 2017). To solve this question research has construct ways in the technological field as reproductive techniques (Frares et al., 2013) and drying (Hammes et al., 2015). These ways have sought outputs for the seasonality of milk production of buffaloes and can transfer milk production to another time of the year (Arena et al., 2016). The international milk market is growing, and the possibility of market share by buffalo milk producers is attractive, especially to the larger countries like India and Pakistan that have a large heard, and this indicates that studies with the techniques of drying of buffalo milk should evolve to facilitate trade in buffalo milk powder (Gharsallaoui et al., 2007).

Heat treatments (ultra-high temperature, microwave) alter the profile of fatty acids in milk, especially polyunsaturated fatty acids (Batiston et al., 2012; Rodríguez-Alcalá et al., 2014; Pestana et al., 2015). In the spray dryer high temperature are used (Kim et al., 2009a) and several studies have examined the spray dryer effects on the physical and chemical characteristics (Murtaza et al., 2015) as well as the technological characteristics (Hammes et al., 2015; Borges et al., 2017) of the powder buffalo's milk. Studies with powder milk fatty acid were from bovine (Paez et al., 2006), goat milk (Batiston et al., 2012; Davis et al., 2017), ewes (Regula et al., 2005), or camel (Habtegebriel et al., 2018). The buffalo`s milk is different from the cow`s in fat, protein and minerals, among other contents and composition (Hinz et al., 2012; Medhammar et al., 2012). As observed, the globule fat size is higher than cows (El-Zeini, 2006; Ménard et al., 2010). In cow`s milk, the large globule size between 1-4μm is 68.4% while in buffalo's milk are 23.7%. In turn, the buffaloes milk present 35.2% fat globule size up 6 μm, and the casein micelles are bigger than cow`s milk, 110-160 nm, and 70-110 nm, respectively (El-Zeini, 2006). Also, casein subfraction are higher in buffalo`s milk (Arora & Khetra, 2017). Thus, the spray dryer changes the milk fatty globules composition and physics, and chemical structure (Toro-Sierra et al., 2013; Yao et al., 2016). In this sense, how spray dryer can affect the buffalo`s milk, how fat and casein micelles interactions can affect the fatty acid composition (Foerster et al., 2016)? This is our question which we try answer in this work. Thus, our goals with the conduct of this study were to evaluate the effects of spray drying on the fatty acids content in the buffalo powder milk.

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[1]*Departamento de Tecnologia Rural e Animal, Universidade Estadual do Sudoeste da Bahia – UESB, Primavera, BA, Brasil*
[2]*Departamento de Zootecnia, Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo – USP, Piracicaba, SP, Brasil*
*Corresponding author: sfernandes@uesb.edu.br, saaf.science@gmail.com

2 Material and methods

2.1 Obtaining the raw material and powder milk production.

The buffalo milk used to prepare the powdered milk was from healthy Murrah buffaloes mechanically milked once a day and raised in based-pasture of a commercial farm.

The milk powder was produced at the Centre for Development and Technology Diffusion (CEDETEC) of the State University of Southwest of Bahia (UESB).

2.2 Experimental design

The production of milk powder was performed in three replicates and each repetition processed 10 L of buffalo milk. After obtaining the final product, three samples (200 g) were packaged in vacuum packaging machine BS 320 (Uba-MG, Brazil) for each evaluated period. The samples were stored for 0, 30, 60, 90, 120 and 150 days at room temperature.

2.3 Powdered buffalo milk production.

The step of spray drying of buffalo milk was performed in the mini spray dryer model MSD 3.0 (LABMAQ of Brazil LTDA, Ribeirao Preto, Brazil) in the co-current cycle with the air temperature at the inlet and outlet dryer 140 °C and 80 °C, respectively, nozzle of 1.0 mm thick with a flow of air in the nozzle 40 L min $^{-1}$, drying air flow rate 3 m^3 min $^{-1}$ and flow rate of the peristaltic pump of 1.07 L h $^{-1}$. These parameters have been established by preliminary tests.

2.4 Analysis of fatty acids

In each storage period studied, the samples were prepared for lipid extraction by weighing about 10 g of buffalo milk powder in a 250 mL becker and mixed with the extraction solvents in duplicate. All reagents presented chromatographic grades.

2.5 Total lipids extraction

The lipids of the milk powder samples were extracted with chloroform, methanol and water (2:1:0.75) according to the procedure presented by Folch (Folch et al., 1957).

Afterwards, 25 mL of methanol was added stirred to the sample (Marconi, model MA085, Piracicaba, SP, Brazil). After 5 min of continuous stirring, 50 mL of chloroform were added continuously stirred for 10 min. The sample was filtered with the aid of a Bunchner funnel coupled to kitassato and vacuum pump (Model 132, trade mark Prismatec, ITU-SP Brazil).

Subsequently, the filtered material was collected and the residue (solid sample) was returned to the beker and 30 mL of the MIX solution containing chloroform and methanol (2:1) was added to the beaker. The solution was stirred again for 5 min, 45 mL of water was added, and filtered after 5 more min of stirring. The filtrate was placed into a separating funnel with a capacity of 250 mL and maintained until complete phase separation. After separation, a lower phase consisting of chloroform (CHCl3) and fat appeared that had a higher phase methyl alcohol (MeOH). The lower phase was collected and transferred to a 250 mL flat-bottomed flask where the evaporation step was performed while the phase that remained in the flask was discarded. The evaporation step was conducted in the rotavapor rotary (Fisatom, model 801, Sao Paulo, SP, Brazil) at a temperature between 33-34 °C, which all the chloroform present in the mixture was evaporated and left only a fraction of the fat sample.

2.6 Preparation of methyl esters of fatty acids

The lipids extracted from samples of milk powder were subjected to the preparation of methyl esters of fatty acids according to the methodology described by Christie (Christie, 1982).

2.7 Chromatographic analysis of fatty acid esters

The esterified samples were analyzed by gas chromatography Focus – CG (Thermo Finnigan, Darmstadt, Germany) with flame ionization detector capillary column CP-Sil 88 (Varian), 100 m long and 0.25 μM internal diameter and 0.20 μM thick for the film. A carrier gas of hydrogen was used at a flow 1.8 mL min $^{-1}$. The initial oven temperature program temperature was 70 °C with a stand by time 4 min, increased to 175 °C at 13 °C / min, 27 min after was increased to 215 °C at 4 °C / min with a stand by time 9 min, and increased to 230 °C at 7 °C / min up to 230 °C with a standby time for 5 min, which totaled 65 min. The vaporizer temperature was 250 °C and the detector was 300 °C. A 1 μL aliquot of the esterified extract was injected into the chromatograph and identification of fatty acids was performed by comparing retention times and the percentages of fatty acids were obtained via software - Chromquest 4.1 (Thermo Electron, Italy).

2.8 Identification and quantitative analysis of methyl esters of fatty acids

The fatty acids were identified by comparing retention times of the methyl esters of the samples with standards of butter fatty acids and were quantified by area normalization of the methyl esters. The results of fatty acids are expressed as g 100 g $^{-1}$ as fat matter

2.9 Nutritional indices

The nutritional quality of the buffalo milk powder was evaluated by the following variables: sum of the saturated fatty acid (SFA, g 100 g $^{-1}$ as fat matter); sum of the mono-unsaturated fatty acid (MUFA, g 100 g $^{-1}$ as fat matter); sum of the polyunsaturated fatty acid (PUFA, g 100 g $^{-1}$ as fat matter); sum of the omega 6 (n6, g 100 g $^{-1}$ as fat matter); sum of the omega 3 (n3, g 100 g $^{-1}$ as fat matter), sum of the n3n6, g 100 g $^{-1}$ as fat matter), Rumenic acid (cis9, trans 11, C18:2, g 100 g $^{-1}$ as fat matter); Eicosapentaenoic acid (EPA, g 100 g $^{-1}$ as fat matter); Docosahexaenoic acid (DHA, g 100 g $^{-1}$ as fat matter); DHA/EPA ratio and n3/n6 ratio ratio, Health promoting index (HPI) (equation 1) (Chen et al., 2004), and atherogenic index (AI) (equation 2); thrombogenic index TI (equation 3) (Ulbricht & Southgate, 1991).

Equations:Number

$$HPI = (\Sigma MUFA + \Sigma PUFA) / (C12:0 + (4 \times C14:0) + C16:0) \quad (1)$$

$$AI = (C12:0 + (4 \times C14:0) + C16:0) / (\Sigma MUFA + \Sigma n6 + \Sigma n3) \quad (2)$$

$$TI = (C14:0 + C16:0 + C18:0) / \begin{pmatrix} (0.5 \times \Sigma MUFA) + (0.5 \times \Sigma n6) + \\ (3 \times \Sigma n3) + (\Sigma n3 / \Sigma n6) \end{pmatrix} \quad (3)$$

2.10 Data analysis

Data were analyzed using analysis of variance (ANOVA) and the means were compared by F test ($\alpha = 0.05$). To evaluate the effect of buffalo milk powder storage time on the parameters studied, we used a completely randomized design, performing regression analysis ($\alpha = 0.05$). The mathematical models were selected according to the model proposed significant effects ($p < 0.05$) and coefficients of determination (R^2).

3 Results and discussion

3.1 Drying effect on the fatty acids of buffalo milk

The drying spray dryer did not affect the fatty acids observed in raw milk. None of the evaluated fatty acids presented a significantly decreased in its content in buffalo powder milk (Table 1). The major fatty acids content in the fluid milk buffaloes was C16:0, followed by cis9C18:1, C18:0, C14:0, total trans C18:1, and C4:0, similar to observed in literature (Terramoccia et al., 2013). This order was not changed in the milk powder obtained.

Heat treatment (pasteurization and ultra-high temperature) can change the fatty acids profile (Habtegebriel et al., 2018; Javed et al., 2018). As observed by (Pestana et al., 2015) a decrease of the C4:0, C6:0 and C8:0; hence, the overall SFA also decreased. These authors reported increased MUFA content and no effect on PUFA due to the thermal treatments. The temperatures used by these authors were 75 °C (15 seconds) and 140 °C (3 seconds) for pasteurization and ultra-high temperature, respectively. Drying by spray drying transforms the fluid (milk) into droplets that are then exposed to hot air (inlet air of 140-180 °C) and cause the water-evaporate, which leaves the powder (Kim et al., 2009b; Batiston et al., 2012; Habtegebriel et al., 2018). The inlet air temperature used in our study was 180 °C. The water evaporates at the lower temperature (100 °C) which prevents the final product (powder milk) to reach high temperatures. We also emphasize that the inlet air temperature, although high, did not affect the final product once the powder milk outlet temperature was close to 80 °C as used in pasteurization. In fact, the temperature of the milk powder was not measured; however, the bottle handling during collection was done by hand, indicating that the product was not at elevated temperatures. Additionally, even if the particles leave at a temperature of 80 °C, this temperature is not able to alter the fatty acids of buffalo milk. Despite these results, the

Table 1. Fatty acids content (g 100 g $^{-1}$ as fat matter) on the raw buffalo milk (RM) and buffalo powder milk (PM) obtained by spray dryer.

Fatty acid	RM	PM	P *Value**
	Saturated		
C4:0	3.56±0.29	3.45±0.30	0.5863
C6:0	1.21±0.1	1.19±0.15	0.5799
C8:0	0.45±0.14	0.47±0.15	0.4226
C10:0	0.83±0.25	0.91±0.33	0.2180
C12:0	1.28±0.33	1.31±0.37	0.6667
C14:0	8.07±1.91	8.23±2.12	0.6464
C15:0	1.65±0.16	1.67±0.15	0.4380
C16:0	30.68±4.72	30.02±3.24	0.5417
C17:0	1.13±0.10	1.06±0.05	0.5112
C18:0	14.30±2.68	14.11±3.72	0.7891
C20:0	0.24±0.04	0.23±0.02	0.8740
C22:0	0.08±0.02	0.06±0.05	0.5736
	Monounsaturated		
Cis9 C14:1	0.49±0.22	0.52±0.24	0.3555
Cis9 C16:1	2.01±0.48	2.08±0.58	0.4967
Total *trans* C18:1	3.72±2.03	3.70±1.89	0.9120
C18:1 cis9	19.72±1.94	21.39±2.14	0.1061
	Polyunsaturated		
Cis9 cis12C18:2	0.50±0.20	0.54±0.12	0.7910
Cis9 trans11C18:2	1.13±0.47	1.11±0.36	0.7693
C18:3 n6	0.00±0.00	0.01±0.00	0.1835
C18:3 n3	0.41±0.09	0.46±0.02	0.4778
C20:4 n6	0.05±0.01	0.05±0.02	0.1835
C20:5 n3 (EPA)	0.02±0.00	0.03±0.00	0.1835
C22:6 n3 (DHA)	0.02±0.00	0.01±0.00	0.1835

*$P < 0.05$; EPA = Eicosapentaenoic acid; DHA = Docosahexaenoic acid; Standard deviation (SD).

eicosanoids precursors (Calder, 2006) EPA and DHA did not decrease significantly with spray dryer (Table 1). However, in absolute terms, the EPA content increased while DHA declined. This result indicates that new studies should be performed to better understand the behavior of these two essential fatty acids. These results are of importance to producers and the buffalo dairy industry, and it indicates the possibility of commercially produced powdered buffalo milk.

3.2 Drying effects on the nutritional indices in buffalo milk

There are no differences in nutritional indices except to the DHA/EPA ratio (Table 2). The EPA content in milk powder increased by approximately 22% compared with the content on the fluid milk. In turn, the concentration of DHA decreased about 45%. In both cases, there was no treatment effect (Table 1). However, this behavior probably explains the results observed in the DHA/EPA ratio, which was not detected when fatty acids were compared alone.

The intake of n-6 fatty acids has recommended limits of ingestion [22]. The C18:2 n-6 and C18:3 n-3 polyunsaturated fatty acids compete for the same enzymatic system (Delta-6 desaturase, elongase and delta-5 desaturase) (Sprecher, 1981; Kinsella et al., 1990) and exhibit opposite physiological functions (Pawlosky et al., 2003). As a result, researchers and health institutions have proposed the ideal ratio between these fatty acids to balance the derived metabolites. Institutions and researchers indicate values between 10:1 to 5:1 (Chardigny et al., 2001; Institute of Medicine, 2003) ; in addition (Khan et al., 2015) and (Schaefer, 2002) indicated a ratio of 4:1 to 2:1, while (Russo et al., 2012) and (Harnack et al., 2009) reported a ratio of 1:1. On the other hand (Masters, 1996) indicates the optimal ratio of 2-3:1, because this reason produces higher conversion of alpha-linolenic acid to DHA. In its turn, (Becker et al., 2004) suggest intake 3% of n-3. In fact this questions are still controversial yet (Yang et al., 2014), however in the human diets, during evolution, the n3/n6 ratio was 1:1 (Simopoulos, 2008).

3.3 The effects of storage time on fatty acids buffalo milk powder.

In addition to the study we also investigated the effects of storage on the fatty acids content. The results indicate that storing the vacuum-packed powder milk did not affect the fatty acids content of (Table 3).

Scientific reports on the effects of storage on the fatty acids in buffalo milk powder produced by spray drying are related to the technological aspects (Hammes et al., 2015). However, the storage of dry foods such as powdered milk and infant formula, whose base is powdered milk, can change the profile of saturated and unsaturated fatty acids (Paez et al., 2006; Rodríguez-Alcalá et al., 2007).

We emphasize that the strictly essential fatty acids (not produced by the human body) linoleic (cis9cis12C18:2) and alpha-linolenic (cis9cis12cis15C18:3) were not affected by storage time. Similarly, the essential fatty acids (produced by the human body from precursors), such as EPA and DHA, were also not affected by storage time.

These results are important for the buffalo dairy sector that has the assurance that the milk powder by spray dryer and its storage can be used as a technological tool to provide buffalo milk in seasonal shortages due to reproductive seasonality, however other studies should be done to create a specifics spray-drying conditions for the buffalo milk, as developed to others species (Habtegebriel et al., 2018; Javed et al., 2018).

3.4 The effects of storage time on the nutrient contents in buffalo milk powder

Between the nutritional indices evaluated, only two have been changed during the storage time (Table 4), the sums n3+n6 and n6. In fact, there was a linear decrease in Σ n6 that interfered with the sum of the omegas. We observed (Table 3) that the cis12, cis9 C18: 2, and C18:3n-6 decreased in absolute

Table 2. Impact of drying by spray drying of raw buffalo milk (RM) and buffalo powder milk (PM) on the fatty acid/class (g 100 g $^{-1}$ as fat matter) and nutritional indices (absolute number).

Fatty acid/classes	RM	PM	P *Value**
SFA	66.94±5.55	66.23±3.29	0.8582
MUFA	30.79±4.86	31.43±2.87	0.8524
PUFA	2.27±0.70	2.37±0.37	0.8379
n-3	0.48±0.07	0.53±0.04	0.3603
n-6	0.57±0.19	0.65±0.10	0.5831
n3+n6	1.05±0.25	1.17±0.07	0.4690
Rumenic acid (cis9. trans11C18:2)	1.13±0.47	1.11±0.36	0.9489
EPA	0.02±0.00	0.03±0.00	0.4918
DHA	0.02±0.00	0.01±0.01	0.1161
Nutritional indices			
DHA/EPA	**0.90±0.27**	**0.38±0.15**	**0.0420**
n-6/n-3	1.18±0.23	1.25±0.27	0.7771
Health Promoting Index	0.54±0.21	0.55±0.17	0.9677
Atherogenicity index	2.09±0.66	2.00±0.53	0.8721
Thrombogenicity index	2.99±0.67	2.80±0.29	0.6736

*$P < 0.05$. SFA - saturated fatty acid; MUFA - monounsaturated fatty acid; PUFA - polyunsaturataed fatty acid; n-3 - omega 3 fatty acid; n-6 - omega 6 fatty acid; EPA - Eicosapentaenoic acid; DHA - Docosahexaenoic acid.

Table 3. Fatty acids content (g 100 g $^{-1}$ as fat matter) on the buffalo milk powder stored for different periods.

Fatty acid	Storage (days)						*P Value**	
Saturated	0	30	60	90	120	150	L	Q
C4:0	3.45	3.59	3.70	3.64	3.58	3.66	0.3551	0.3987
C6:0	1.19	1.20	1.35	1.23	1.23	1.25	0.8286	0.6481
C8:0	0.47	0.47	0.54	0.47	0.46	0.46	0.8214	0.6478
C10:0	0.91	0.85	1.06	0.88	0.84	0.84	0.6494	0.6073
C12:0	1.31	1.30	1.48	1.33	1.28	1.28	0.8092	0.5948
C14:0	8.23	8.14	9.22	8.29	8.04	8.14	0.8320	0.6368
C15:0	1.67	1.66	1.73	1.68	1.64	1.66	0.7564	0.6352
C16:0	30.02	29.88	32.56	29.98	30.38	30.51	0.9253	0.6281
C17:0	1.06	0.78	1.15	1.05	1.04	1.06	0.5707	0.9980
C18:0	14.11	13.87	12.04	13.97	14.32	14.41	0.7331	0.5089
C20:0	0.23	0.24	0.26	0.22	0.24	0.21	0.5335	0.4180
C22:0	0.06	0.10	0.13	0.09	0.11	0.09	0.4502	0.0818
Monounsaturated								
Cis9 C14:1	0.52	0.53	0.65	0.52	0.52	0.50	0.7733	0.5649
Cis9 C16:1	2.08	2.10	2.40	1.97	2.06	2.01	0.7086	0.6430
Trans C18:1	3.70	3.76	2.53	3.77	3.61	3.72	0.9118	0.6158
Cis9 C18:1	21.39	21.37	19.68	21.25	21.06	21.29	0.9876	0.4851
Polyunsaturated								
Cis9 cis12 C18:2	0.54	0.55	0.41	0.53	0.45	0.38	0.0730	0.7623
Cis9 trans 11C18:2	1.11	1.19	0.94	0.80	1.10	1.06	0.7487	0.4610
C18:3 n6	0.01	0.00	0.00	0.00	0.00	0.00	0.1069	0.3137
C18:3 n3	0.46	0.49	0.41	0.41	0.44	0.41	0.1076	0.5132
C20:4 n6 (AA)	0.05	0.05	0.06	0.06	0.06	0.05	0.7869	0.2200
C20:5 n3 (EPA)	0.03	0.03	0.03	0.03	0.03	0.03	0.9257	0.6199
C22:6 n3 (DHA)	0.01	0.01	0.01	0.02	0.02	0.01	0.9332	0.1684

**P<0.05*; Models: L - Linear; Q - Quadratic; AA- Araquidonic acid; EPA - Eicosapentaenoic acid; DHA - Docosahexaenoic acid.

Table 4. Impact of the storage time on the buffalo powdered milk fatty acid/classes (g 100 g $^{-1}$ as fat matter) and nutritional indices (absolute numbers).

	Storage time (days)						*P values**	
	0	30	60	90	120	150	L	Q
Fatty acid/classes								
Vaccenic acid	3.70	3.76	2.53	3.77	3.61	3.72	0.9118	0.6158
Total trans	3.86	3.93	2.67	3.99	3.84	3.90	0.8794	0.6379
Vaccenic/trans	0.96	0.95	0.95	0.94	0.94	0.95	0.1897	0.2548
Rumenic	1.11	1.19	0.94	0.80	1.10	1.06	0.7487	0.4610
SFA	66.23	65.60	68.91	66.27	66.58	66.99	0.8021	0.7118
MUFA	31.43	31.95	29.08	31.74	31.18	30.93	0.8803	0.7400
PUFA	2.37	2.45	2.02	1.98	2.24	2.09	0.3496	0.5224
n3	0.53	0.56	0.48	0.50	0.52	0.48	0.1525	0.8360
n6	**0.65**	**0.61**	**0.49**	**0.60**	**0.53**	**0.45**	**0.0312**	**0.9221**
n3+n6	**1.17**	**1.17**	**0.97**	**1.10**	**1.04**	**0.93**	**0.0216**	**0.9480**
EPA	0.03	0.03	0.03	0.03	0.03	0.03	0.9257	0.6199
DHA	0.01	0.01	0.02	0.02	0.02	0.01	0.9332	0.1684
Nutricional indices								
PUFA/SFA	0.03	0.04	0.03	0.03	0.15	0.15	0.1015	0.4309
DHA/EPA	0.38	0.55	0.58	1.15	0.69	0.38	0.7361	0.1760
n6/n3	1.25	1.09	1.03	1.22	1.02	0.96	0.1474	0.9204
Health Promoting Index	0.55	0.56	0.44	0.55	0.54	0.53	0.9852	0.6700
Atherogenicity index	2.00	1.97	2.36	2.01	2.00	2.07	0.9797	0.6544
Thrombogenicity index	2.80	2.75	3.13	2.83	2.87	2.97	0.5858	0.7561

*P<0.05; SFA - saturated fatty acid; MUFA - monounsaturated fatty acid; PUFA - polyunsaturataed fatty acid; n3 - omega 3 fatty acid; n6 -omega 6 fatty acid; Models: L - Linear, Q - Quadratico.

terms, which may explain the significant decrease in Σ n3n6 and Σ n6. The most interesting look to be launched on the n-6/n-3 ratio, however, did not change significantly during the remaining storage time standing close to indicated ratio by (Russo et al., 2012). In the human diet before modern times, the n-6/n-3 ratio was 1:1 (Simopoulos, 2008, 2016) so ours results showed that buffalo milk powder, could be used to increased intake of n-3 fatty acids.

The storage temperature can change the fatty acids in milk powder (Paez et al., 2006). Temperatures above 30–35°C, which leaves the milk powder more susceptible to oxidation (Romeu-Nadal et al., 2007). In our study, the average storage temperature was near 26°C, which aids to explain the reduced negative impact on the powder milk fatty acids produced by spray dryer.

The sensitivity of food to temperature process requires several studies regarding food science (Habtegebriel et al., 2018). In fact, each new product should be evaluated in its original features to know the effect of processing in its nutritional aspects, because fatty acids in foods are sensitive to processing temperatures. Our results were encouraging because and showed that the spray-dryer technique as then as the storage time did not affect the fatty acids. Probably these results can be explained in the function of the buffalo milk microstructure, rheological and geometrical properties (El-Zeini, 2006; Arora & Khetra, 2017), since the interactions among fat globule micelles, casein, mineral, and others can be change the technological properties (Vignolles et al., 2007) and studies with buffalo milk should be develop to find the better conditions for drying milk (Erbay et al., 2015).

Our results associated with other literature relates can encourage the productive buffalo chain to improve the powder milk international trade and solve the seasonality that determines a lack of dairies during some months in the year. In Asia, economic actors linked in the buffalo production chain expected information such as this to boost international economic participation (Hamid et al., 2016).

4 Conclusion

The powder milk can be a strategy to mitigate the economic losses caused by reproductive seasonality on the water buffalo.

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