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Composition and Microstructure of Buffalo Skim Milk Powder as Influenced by Concentration and Drying Temperatures

Mian Anjum Murtaza,[1,]* Nuzhat Huma,[2] Irfan Mustafa,[3] Haq Nawaz,[4] Mian Shamas Murtaza[2] and Muhammad Irfan Ullah[5]

[1]*Institute of Food Science and Nutrition, University of Sargodha, Sargodha-40100, Pakistan*
[2]*National Institute of Food Science and Technology, University of Agriculture, Faisalabad-38040, Pakistan*
[3]*Department of Zoology, University of Sargodha, Sargodha-40100, Pakistan*
[4]*Institute of Animal Nutrition and Feed Technology, University of Agriculture, Faisalabad-38040, Pakistan*
[5]*Department of Entomology, University College of Agriculture, University of Sargodha, Sargodha-40100, Pakistan*

Abstract.- Buffalo milk is at the top in Pakistan's milk production and has established emergent research curiosity owing to its nutrient profile. The study was intended to assess the influence of concentration and drying temperatures on manufacturing and characteristics of buffalo skim milk powder. Buffalo skim milk having 10.50% total solids (TS) was concentrated at 50°C to 25, 30, 35 and 40% TS. The concentrated samples were spray dried with an inlet temperature of 185, 186, 187 and 188°C. The powder was then analyzed for moisture, fat, protein, acidity, ash, scorched particles, bulk density and solubility index and examined by scanning electron microscopy (SEM). The increase in brix considerably decreased the moisture content from 3.50 to 3.15%, increased the bulk density from 0.34 to 0.40 g/cm³ and the acidity from 1.06 to 1.18%. No significant change was recorded in scorched particles grade and solubility index. As anticipated, the rise in inlet drying temperature significantly decreased the moisture from 3.55 to 3.18% and increased the total solids from 96.82 to 96.45%, acidity from 1.04 to 1.17%, solubility index from 0.75 ml to 1.1 ml, the bulk density from 0.35 to 0.42 g/cm³ and the ashes from 7.8 to 8.0%. As perceived by SEM, particles had smooth surfaces with dents of varying sizes. The particle sizes ranged from 2 to 52 µm in diameter. Hence the study discriminated the characteristics of buffalo milk powder from that of cow as illustrated by previous studies and will facilitate further studies on buffalo milk.

Key words: Buffalo, skim milk powder, spray drying.

INTRODUCTION

Cow milk is under focus in most of the studies on milk, though milks of other species like sheep, goat, camel and buffalo have nutritional potential in human diet in different parts of the world (Menard *et al*., 2010). Buffalo milk ranks at the top in Pakistan's milk production and India and Pakistan both produce about 80% of the world's buffalo milk (Murtaza *et al*., 2012, 2014; Tahira *et al*., 2014). It is more nutritious being richer in fat, lactose, protein, total solids, calcium, magnesium, inorganic phosphate and vitamins as compared to cow's milk (Fundora *et al*., 2001; Ahmad *et al*., 2008). Buffalo milk owing to its composition, offers exceptional prospects for development of different dairy products (Murtaza *et al*., 2008, 2013).

Skim milk powder is one of the most commonly used raw materials of different food products because of low moisture, less weight helping in easy transportation and excellent preservation (Shiratsuchi *et al*., 1994). The imperative properties related to the handling, storage and applications like flow-ability, dispersibility, wet-ability, and oxidative stability of dairy powders are influenced by the composition particularly on the surface (Kim *et al.*, 2009).

The occurrence of fat in the powder and on the surface causes the surface to be hydrophobic, deteriorate the wet-ability and dispersibility (Kim *et al.*, 2002). Fat also acts as a bridge among the particles and reduces the powder flow-ability (Onwulata *et al.*, 1996; Kim *et al.*, 2005), and is also inclined towards oxidation and rancidity development (Granelli *et al.*, 1996; Hardas *et al.*, 2000). Moreover, during powder manufacturing, there is relocation of milk components,

* Corresponding author: anjum_ft@yahoo.com / mian.anjum@uos.edu.pk
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predominantly the fat amassing on the surface of the powder as compared to the fat distribution in the bulk powder. Even in low fat milk powders, the fat is over-represented on the surface of the powders (Kim *et al.*, 2009).

The prominence of calorie intake and control, particularly in developed countries, in the past 3 decades has principally been responsible for development of low fat or fat free milk products including skim milk powder. Literature review also illustrated that copious works have focused on the characterization of cow milk and its products but the information on buffalo milk composition and description lacks in the scientific prose and needs improvement.

Keeping in view the above facts, the study was designed to produce and characterize the buffalo skim milk powder dried at various temperatures.

MATERIALS AND METHODS

Raw buffalo milk

Raw milk was obtained from the buffalo farm house in Bhalwal region of district Sargodha, Pakistan.

Powder manufacturing (spray drying)

The skim milk powder was manufactured following the procedure adopted by Patel and Mistry (1997) with some modifications. A centrifugal separator (Modern Dairy Appliances, New Delhi, India) was used to separate the milk. The skim milk was pasteurized at 72°C for 20 seconds and cooled to 50°C. The skim milk was concentrated to 25°, 30°, 35° and 40° Brix through ultra-filtration using a hollow fiber membrane (Romicon membrane, type PM50; Alfa Laval, Copenhagen, Denmark). The concentrated milk samples were dried in a spray drier (model AEF-3D; Anhydro, Copenhagen, Denmark) equipped with a centrifugal atomizer and having a drying capacity of 20 to 25 kg/h. The inlet temperature was adjusted at 185°C, 186°C, 187°C and 188°C. Powder recovered from the main chamber was sieved (USA standard testing sieve no. 18, Tyler Equivalent 16 mesh; Fisher Scientific Co., Minneapolis, MN) to remove the burnt particles.

Physico-chemical analysis of powder

The skim milk powder was then analyzed for moisture content by oven drying at 105°C, protein content by Kjeldahl method, acidity by titration (AOAC, 2005), fat content by Gerber method and ash content by incineration at 600°C in a muffle furnace (Atherton and Newlander, 1982). The amount of scorched particles in skim milk powder was determined by comparison with the ADMI chart, Scorched Particles Standards for Dry Milk, the bulk density to check whether milk powder is light or heavy by the method described by Svarovsky (1987) and the solubility index to measure the ability of skim milk powder to dissolve in water.

Microstructure of powder by scanning electron Microscopy (SEM)

Skim milk powder samples were prepared for microstructure examination through SEM as described by Kalab (1981) and Kalab *et al.* (1989). Both sided sticky tape was attached to aluminum stub of SEM by means of a silver-based paint. A thin layer of the powder was spread over the tape and spit coated at 10 mA for 2-3 min in arsenic atmosphere to deposit about 20 nm of Au and Pd. These samples were examined by SEM (International Scientific Instruments Super IIIA SEM; TopCon Technologies, Inc., Pleasanton, CA) at 15 kV. Photomicrographs were taken and studied.

Statistical analysis

The results obtained were analyzed statistically using the analysis of variance technique and Duncan's Multiple Range test to determine the significance of work (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Physico-chemical characteristics of powder

The physico-chemical analysis of the skim milk powder showed that composition of buffalo skim milk varied significantly from that of cow as observed in previous studies by Caric and Kalab (1987) and Shiratsuchi *et al*. (1994).

Regarding the effect of brix and drying temperatures on powder milk composition, the increase in brix significantly decreased the moisture

Table I.- Effect of brix on physico-chemical composition of skim milk powder.

Brix	25°C	30°C	35°C	40°C
Moisture (%)	3.50a	3.39b	3.29c	3.15d
Total solids (%)	96.50d	96.61c	96.71b	96.85a
Ash (%)	7.86	7.90	7.89	7.93
Protein (%)	32.07	32.08	32.08	32.07
Fat (%)	0.99	0.99	0.99	0.99
Acidity (%)	1.06c	1.08bc	1.13b	1.18a
Bulk density (g/cm³)	0.34c	0.37b	0.39ab	0.40a
Solubility Index (ml)	1.0	1.0	1.1	1.1
Scorched particles	A- Grade	A- Grade	A- Grade	A- Grade

Values in a row having different letters (a, b, c, d) are significantly different

Table II.- Effect of drying temperatures on physico-chemical composition of skim milk powder.

Temperature	185°C	186°C	187°C	188°C
Moisture (%)	3.55a	3.49b	3.30c	3.18d
Total solids (%)	96.45d	96.51c	96.70b	96.82a
Ash (%)	7.80c	7.85b	7.88ab	8.00a
Protein (%)	32.13	32.14	32.11	31.90
Fat (%)	0.99	0.99	0.99	0.99
Acidity (%)	1.04c	1.06bc	1.10b	1.17a
Bulk density (g/cm³)	0.35c	0.36bc	0.39b	0.42a
Solubility Index (ml)	0.75c	1.0b	1.0b	1.1a
Scorched particles	A- Grade	A- Grade	A- Grade	A- Grade

Values in a row having different letters (a, b, c, d) are significantly different.

content from 3.50 to 3.15%, increased the bulk density from 0.34 to 0.40 g/cm³ and the acidity from 1.06 to 1.18%. No significant change was recorded in scorched particles grade and solubility index (Table I). These results are supported by the findings of Patel and Mistry (1997), who studied the physic-chemical and structural properties of buffalo milk powder prepared from milks of varying total solids.

The increase in inlet drying temperature significantly decreased the moisture from 3.55 to 3.18% and increased the total solids from 96.45 to 96.82%, the acidity from 1.04 to 1.17%, the solubility index from 0.75 ml to 1.1 ml, the bulk density from 0.35 to 0.42 g/cm³ and the ashes from 7.8 to 8.0%. However, the other parameters were non-significantly affected (Table II).

Microstructure of powder

Sometimes spray drying results in burnt particles particularly in the case of high protein foods as skim milk and these particles can produce relics in microscopic examination. So, the powder samples were sieved during the sample preparation (Patel and Mistry, 1997).

The microstructure of buffalo skim milk powder is shown in Figure 1. On the whole, the varying level of brix and drying temperatures did not show noteworthy effects on the microstructure. The particle sizes ranged from 2 to 52 μm in diameter and dents with different depths and sizes were obvious (Fig. 1). Some of the particles were found cracked, however, smooth surfaces were observed in all the particles. Most of the microstructures were analogous to those of cow milk (Caric and Kalab, 1987; Mistry *et al*., 1992). Milk powders having less than 20% lactose show smooth surface particles (Mistry *et al*., 1992) as was observed in the case of buffalo skim milk. The results illustrated that skim milk powders of buffalo vary in composition from cow but might not be enough to influence the microstructure properties.

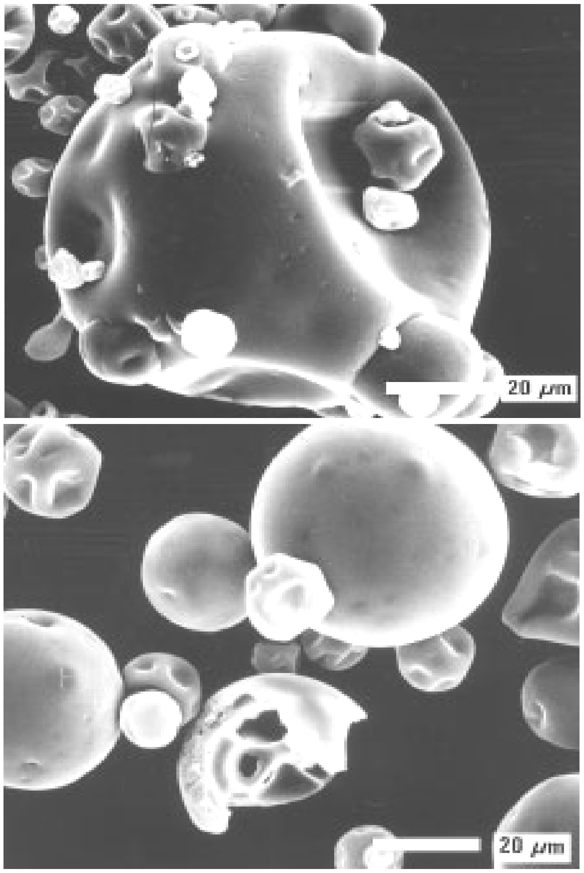

Fig. 1 Scanning electron micrographs of buffalo skim milk powder. A, Skim milk powder particles varied in size having deep dents; B, Skim milk powder particles having shallow dents but smooth surfaces.

Hence, the study showed the composition and microstructure of skim milk powder from buffalo and discriminated these characteristics from that of cow as revealed by previous works and it will facilitate the further studies and applications of buffalo milk.

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Conflict of interest statement

The authors have no conflict of interest to declare.

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