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Study on chemical composition, oxidative indicators and heat load indicators of camel and cow milk powders

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Abstract
In this study, chemical composition, heat load and oxidative indicators were analyzed for camel milk powders and also compare with cow milk powder. The levels of vitamin C, ash, and chloride content were found to be higher in camel milk powders when compared to cow milk powders. A significant difference (p<0.05) was observed in all oxidative parameters of the milk powders. Our results clearly indicate that antioxidant activity of camel milk powder was higher than other powder. Cow milk powder had higher HMF and lactulose content. It is worth mentioned that camel milk powder was higher WPNI (less denaturized) due to the absence of the heat-sensitive β-lg in camel milk.

Keywords: HMF, WPNI, Oxidation, β-lg, camel milk powder, cow milk powder

Introduction
Milk is an almost complete food containing essential biological compounds such as fat, protein, carbohydrate, minerals, vitamins, and other micronutrients. Numerous research has been conducted on the composition and properties of cow and buffalo milk and milk products. Despite their nutritional relevance, research on other dairy animals (camel, yak, donkey, and mare) is fairly limited. Non-bovine milk especially camel milk getting more popularity due to its medicinal properties and Health benefits. Research on camel milk or camel milk product is no longer an uncommon subject, it is gaining popularity worldwide. Camel milk contains all the essential nutrients found in bovine milk. It is mainly in lack of β-lg while higher in immune-active proteins, PGRP, vitamin C, minerals and insulin which increase the therapeutic values of camel milk (Felfoul *et al.* 2017; Kappeler, 2004) [13, 20].
Camels are considered as goal animal in desert areas due to their sustainability to stay in hot climatic conditions where lack of water and fodder. They contribute a big role in the lives of many people particularly those who stay in arid or deserts area and semi-arid areas of the world and are also significant contributors to their ecologies. According to FAO (2019), around 34 million camels in the world contribute to 0.4% of the world's milk production. The global production of camel milk amounted to 31.37 million tonnes, with India contributing 7.96 million tonnes. In India, the Food Safety and Standards Authority has established legal requirements for camel milk, stipulating a minimum of 2% milk fat and a minimum of 6% solids-not-fat, highlighting its potential for commercialization. As the consumption spectrum of camel milk is becoming wider and wider, especially in many non-regular consuming countries, the availability of camel milk as and when required is a necessity of the present era. Camels are typically raised in desert areas by nomadic that limiting the continued supply of camel milk. The drying of camel milk is one of the alternatives of it. Camel milk powder is an emerging non-bovine milk product.
Production of dried milk has become an important segment of the dairy industry which is expected to grow further. The presence of camel milk and its unique properties create a favourable opportunity for dairy industries to innovate and introduce new products to the market of milk and milk products. The ultimate goal of the sector is to produce milk powder that, when reconstituted with water, retains almost the original properties of liquid milk with little or no indication of adverse change in reconstituted milk.

It has a better shelf life, reduces transportation costs and has wider application in food product formulation as an ingredient. The spray drying technique is widely used for producing dried milk with acceptable nutritional value and functional properties. Most of the quality indicators are related to their chemical composition or chemical characteristics (e.g., protein, lactose, acidity, HMF, FFA etc.). Recently, HMF most widely used as a marker of Millard browning, especially in dried milks. Lactulose is an isomerized derivative (glucose moiety change to fructose) of milk powder which is also nowadays used as a heat load indicator. Fat oxidation decreases the oxidative stability of whole fat powder. Therefore, the evaluation of quality parameters for milk powders are crucial for quality control and shelf-life evaluation. The objectives of the present research were to analyse the chemical composition, oxidative and heat load indicators of spray-dried camel milk powders and for comparative study, we also evaluated cow milk powder following the same analytical test used for camel milk powder.

Materials and Methods

Materials

The fresh spray-dried camel and cow milk powders used for this study were purchased from the market. The most commonly available two different brands of spray-dried camel milk powder (CMP1 and CMP2) were selected for the study. A cow milk powder (COM) was also purchased from the market.

Determination of chemical composition

The samples of camel and cow milk powders were analysed for chemical composition. The contents of moisture, ash, fat and titratable acidity were determined using the method described by FSSAI/IDF method whereas protein content of milk powders was determined method described by AOAC (2006) [1]. Ascorbic acid content was determined in spray-dried milk powder samples according to the BIS method. Chloride content was measured using the direct method also known as Mohr's method (Hammer and Bailey, 1917) [17].

Determination of fat oxidation in the powders

The determination of Free Fatty Acids (FFA) can be carried out using the method described by Deeth *et al.* (1975) [8], as outlined below.

Five g of sample was weighed into a 60 ml test tube. Ten ml of extraction mixture (40:10:1 of Iso-propanol: Petroleum ether: 4N sulfuric acid) was added. Followed 6 ml petroleum ether and 4 ml distilled water were added to it. The test tube was stoppered and tempered at 40°C for 10 minutes. The two layers were allowed to separate for 10-15 minutes and an aliquot of the upper layer (approximately 5-8 ml) was withdrawn. This aliquot was then titrated against a 0.02 N methanolic KOH (potassium hydroxide) solution, using 1% methanolic phenolphthalein as an indicator. The free fatty acids (%) were measured using the following equation:

$$\text{FFA}(\%\ \text{oleic acid}) = \frac{\text{T} \times \text{N}}{\text{P} \times \text{W}} \times 10^3$$

T=ml of 0.02 N methanolic KOH
N=Normality of methanolic KOH solution
P=Proportion of upper layer of aliquot
W=Weight of sample taken in g

Peroxide value

Peroxide value determined by the method described by AOAC (2006) [1]. Five g milk powder sample were soaked in chloroform for the period of 12 h in an airtight flask. The content was filtered and transferred to a 50 ml test tube; to which 1 g KI powder and 10 ml glacial acetic acid were added. The tubes were kept in a boiling water bath until the content of tubes started to boil followed by immediately cooling of the contents. Subsequently, 20 ml KI solution (5% w/v) and 20 ml distilled water were added to it and then titrated against a 0.002 N sodium thiosulfate solution using starch as an indicator. The peroxide value was expressed in ml of 0.002 N sodium thiosulfate solution per g of powder. The peroxide value of powder was determined by following formula:

$$\text{Peroxide value} = \frac{(\text{A} - \text{B}) \times \text{N}}{\text{M}}$$

A-Sample reading
B-Blank reading
N-Normality of sodium thiosulphate
M-Mass in g of sample

TBA value

It was determined according to the method described by (Sun, 2013) [35]. The milk powder was reconstituted by 12%, w/v and the 35.2 ml of reconstituted milk was poured in a sugar tube and kept in a water bath at 30°C. Then, 2 ml TCA solution (40% w/v) and 4 ml ethanol solution (95%) were added to sugar tube. After 15 min the milk fat and proteins were removed by filtration. 1 ml TBA solution was added to the clarified filtrate. Filtrate was incubated in a water bath (60 °C) for 60 min. The absorbance was measured at 538 nm at room temperature.

Antioxidant activity (DPPH assay)

The DPPH (2, 2-diphenyl-1-picrylhydrazyl) radical scavenging activity was assessed using a procedure initially described by Brand-Williams *et al.* (1995) [5] and subsequently modified by Song *et al.* (2010) which is described below:

Five g sample was treated with 10 ml of methanol and water mixture (8:2, v/v) in a shaking water bath at 35 °C for 24 hr. The mixture was then centrifuged at 3000 rpm for 10 min and filtered using Whatman no.42 filter paper. Then 0.5 ml filtrate and 0.5 ml methanol were taken in test tube and 3 ml DPPH solution was added. Incubate at room temperature for 35 min and measured at 517nm wavelength using a spectrophotometer against blank (methanol). The DPPH radical scavenging activity, expressed as the inhibition percentage and calculated using the following formula:

$$\text{DPPH (\%inhibition)} = \frac{\text{Absorbance of control} - \text{Absorbance of sample}}{\text{Absorbance of control}}$$

Determination of heat load indicators of milk powders

HMF

The HMF content was determined using a method previously described by Keeney and Bassette in 1959 and later modified by Chavez-Servin *et al*. (2015). The reconstituted milk sample was digested with 3N oxalic acid. To determine total HMF, the mixture was heated in a

boiling water bath at 100 ºC for 1 h. The reaction was terminated by use of 40% TCA solution. Filtrate was reacted with 0.05 N TBA solution and absorbance was taken at 443 nm. The free and total HMF was estimated by using the following formulas:

Free HMF (micromoles/litre) = (Absorbance-0.015)×81

Total HMF (micromoles/litre) = (Absorbance-0.055)×87.5

Lactulose

The lactulose content of milk powder was determined by method described by Amine *et al.* (2000). The 8 ml of 10% reconstituted milk powder sample was digested with 4 ml of zinc sulphate and 4 ml of potassium ferrocynate. Volume was made to 20 ml with distilled water. Contents were filtered and reacted with 2 ml of seliwanoff's reagent. The mixture was incubated at 90°C±0.1 °C for 5 minutes and then cooled under tap water. Contents were filtered (0.22 µ) and absorbance was taken at 482 nm against blank.

Whey protein nitrogen index (WPNI)

WPNI of milk powders determined by ADPI method. The reconstituted milk powder sample was mixed with NaCl powder. Contents were vortex to complete dissolve the NaCl powder. Contents were incubated at 37±0.5°C for 30 min. Mixture was filtered using S & S 602 filter paper and 1 ml of filtrate was mixed with 10 ml of saturated NaCl in glass stoppered test tube. For the sample, 1 drop of 10% HCl solution was added to each test tube, with the mixture without HCl used as blank. Transmittance was taken at 420 nm immediately after addition of HCl drops. The standard curve was prepared by use of standard low heat and high heat powder having WPNI of 8 and 0.63 mg/g.

Statistical analysis

The Statistical analysis was done by using the simple and two-factorial completely randomized design (CRD), (Steel and Torrie, 1980) [33]. Data are expressed as the mean ± standard deviation.

Results and Discussion

Composition of camel and cow milk powders

The compositions of powders are shown in Table 1. The moisture content of milk powder is an important parameter which indirectly affects the other properties of dried milks and shelf life of powder. The moisture of different samples ranged between 2.30 to 2.68%. It is influenced by inlet and outlet temperatures of dryer, design of drying chamber, contact time of hot air with the milk particles and packaging material etc. The moisture value found in this present study for the milk powder from different brands is in general agreement with the literature values (Zouari *et al.* 2021) [40]. They found the moisture content in spray dried camel milk and cow milk powder ranging from 1.01 to 2.41% and 1.7 to 2.4%, respectively while Zouari *et al*. (2021) [40] reported 2.50% and 2.30% moisture content in camel and cow milk powder, respectively.

The composition of milk powders is shown in Table 1. The significant (p<0.05) difference was observed in fat, protein, vitamin C and chloride content of camel and cow milk powders. Fat important constituent which affects the sensorial aspects of whole milk powder and affects other functional properties of dried milks. The average fat content of milk powder samples varied between 26 to 27.4%. Our results indicated that all samples significantly varied (p<0.05) between the different brands. The variation might be due to differences in the initial fat content in milk, operating conditions, types of milk etc. Moreover, Indicated that drying temperature affects the fat content of dried milk. High temperature drying could cause milk protein and fat to adhere together, lowering the amount of fat in the powder. The fat value in whole camel milk powder was observed as 23.17% by Ho *et al*. (2019) [18] and 28.23% by Deshwal *et al*. (2020) [9]. The fat content in cow milk powder varied from 25.5 to 31.57% (Elsara, 2009; Pugliese *et al.* 2017; Magan *et al.* 2019) [10, 29, 26]. The fat values found in the present study are almost similar to that reported in the literature. Protein is a valuable component which directly affects the functional properties of milk powder. A significant (p<0.05) difference was observed in the protein content of milk powders. The protein content varied from 23.0 to 24.60% in camel milk powder samples while 26.41 to 27.0% ranged observed in cow milk powder. However, our result is nearer to Sulieman *et al.* (2014) and Ho *et al*. (2019) [18] report. The variation in the protein contents among the different samples might be due to various chemical reactions in which protein involves, interactions between proteins and other components during processing and other manufacturing parameters (Schuck, 2011) [30].

Ash represented inorganic material, such as minerals, present in milk powder. No any significant difference was observed among different brands of camel milk powders. Ash content of camel milk powders ranged from 7.34 to 7.87% whereas cow milk powder was observed 6.56% ash. Camel milk powder contains higher ash compared to other species which contributes slightly salty taste and more buffering capacity (affecting protein stability). Ash content in whole milk powder was reported from 5.1 to 7.0% (Pugliese *et al.* 2017; Magan *et al.* 2019) [29, 26]. Observed ash content in camel milk powder varied from 6.93 to 7.69% and cow milk powder varied from 5.71 to 6.83%. Our result is align closely with that reported in the above literature.

The amorphous form of lactose present in milk powder account most abundant part (38% to 42%) in dry products which leads to many changes in powder. The average carbohydrate value ranged from 38.33% to 40.47% in camel and cow milk powders. The lactose content of camel milk powder was 40.7% by Zouari *et al*. (2020) [39] which is nearer to our findings. The Lactose content of milk powder is affected by various chemical reactions between the ingredients, hot air temperature, design of drying chamber, storage conditions, species and breed of animal, etc. (Elsara, 2009) [10]. The chloride content in milk products correlates with the higher mineral content and gives a salty taste to camel milk. The average chloride content varied between 0.20 to 0.42 per cent in camel and cow milk powder. The chloride content in CMP1 varied from 0.22 to 0.58 per cent, 0.23 to 0.42 per cent in CMP2 and 0.14 to 0.25 per cent in a sample of COM. Yoganandi *et al*. (2015) observed chloride in different breeds of a camel which varied between 0.20 to 0.25 per cent whereas 0.11 per cent chloride content in cow milk. Vitamin C is an essential water-soluble vitamin. Vitamin C content of camel milk powders varied from 13.76 to 37.52 mg/l whereas cow milk powder showed that significantly (p<0.05) less value of vitamin C (8.60 to 14.64 mg/l). Our findings are almost close to the reported value of vitamin C by various researchers for various milk powders.

Ibrahim and Khalifa (2015) [19] prepared freeze-dried camel milk powder using fresh whole and skimmed camel milk having 35.50 mg/l and 38.23 mg/l of vitamin C, respectively. After freeze-drying, the vitamin C content decreased to 29.73 mg/l and 30.23 mg/l in whole and skimmed camel milk powders, respectively. Fresh whole milk powder averaged 12.5 mg/l of vitamin C (Stewart *et al*. 1946) [34]. The average chloride content varied between 0.20 to 0.42% in camel and cow milk powder. CMP1 had the highest chloride content followed by CMP2 and the least amount of chloride present in the cow milk powder sample.

Acidity already developed in the milk will be retained in the powder, which acquires an unpleasant flavour and affects the functional characteristics. During heating leads to lactose degradation which increase acidity value. The titratable acidity of all three samples varied significantly (p<0.05) as shown in Table 1. The titratable acidity of milk powder CMP1 was found to be highest (0.19 per cent lactic acid) followed by CMP2 (0.18 per cent lactic acid) and COM (0.16 per cent lactic acid)The titratable acidity of camel milk powders ranged from 0.17 to 0.18% lactic acid while cow milk powder had 0.16% lactic acid. Elsara (2009) [10] observed 0.17 and 0.15% lactic acid in camel and cow milk powder, respectively. Fresh camel and cow milk powder had 0.24 and 0.18% lactic acid acidity (). Ibrahim and Khalifa (2015) observed 0.15 per cent lactic acid in freeze dried whole and skim camel milk powder. Spray dried skim and whole camel milk powder was 0.202 and 0.211 per cent lactic acid, respectively (Deshwal *et al*. 2020) [9]. The reason behind the variation observed in the titratable acidity among all powders might be due to different chemical changes taking place during drying or high heat treatment, lactose to lactic acid and formic acid. According to Chudy *et al.* (2015) [6], the type of powder, timing, formation of lactic and formic acid and storage method such as air or vacuum all significantly influenced variations in acidity.

Table 1: Chemical composition and titratable acidity of camel and cow milk powders

Types of milk powder	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Lactose (%)	Chloride (%)	Vitamin C (mg/l)	Titratable acidity (%LA)
CMP1	2.68±0.93	26.00±0.51^{a}	23.28±0.80^{a}	7.87±0.62^{b}	40.47±0.87^{b}	0.42±0.16^{b}	33.09±5.36^{b}	0.19±0.001^{b}
CMP2	2.30±0.69	27.40±0.20^{b}	23.22±0.39^{a}	7.34±0.23^{b}	39.74±0.58^{b}	0.34±0.08^{a}	18.12±3.48^{a}	0.18±0.001^{b}
COM	2.60±0.24	26.10±0.37^{a}	26.41±0.38^{b}	6.56±0.16^{a}	38.33±0.57^{a}	0.20±0.03^{a}	12.01±2.88^{a}	0.16±0.001^{a}
SEm	0.34	0.19	0.28	0.20	0.29	0.05	2.02	0.01
CD	NS	0.59	0.86	0.61	0.88	0.17	6.24	0.01
CV%	30.28	1.62	2.58	6.05	1.61	37.80	21.48	3.75

$^{a-c}$: values with different letters between a row are significantly different at 5% (i.e., p<0.05)

Determination of fat oxidation

Oxidation deterioration is the main bottleneck of milk powder quality which leads to rancidity in whole fat powder (Li *et al.* 2013a) [24]. Our powder sample contains higher fat leads also oxidation deuteriation in milk powder. To measure oxidative stability by different parameters such as FFA, peroxide, TBA value and indirectly by measuring antioxidant activity of milk powders. Different oxidative indicators for camel and cow milk powders are shown in Table 2.

Free fatty acids

Free fatty acid is a chemical characteristic which affects keeping quality and sensorial aspects of milk powder. It also contributes tallowy, metallic, rancid flavour in milk powder due to fat hydrolysis which forms different chemical compounds such as aldehyde and ketone. FFA content of camel and cow milk powders are shown in Table 2.

The average FFA content of powder samples were found in the range of 1.92 to 3.07% oleic acid. CMP1 had a higher FFA value followed by COM while CMP2 observed the lowest FFA value. FFA values of CMP1, CMP2 and COM were found between 2.6 to 3.99, 1.8 to 1.99 and 2.39 to 3.77% oleic acid, respectively. However, our findings fall in the range reported by Snebergrova *et al*. (2016) for whole milk powder. They reported free fat contents varied from 12.69 to 81.15 gm/kg of whole milk powder. The reason behind the variation observed in milk powders may be due to different manufacturing processes, homogenization, drying and processing parameters such as outlet temperature of drying, atomizer pressure (Paez *et al.* 2006) [28].

Peroxide value

Peroxide value is well known parameter for the measurement of primary lipid oxidation of dried milk. The peroxide value of the milk powders is presented in Table 2. Peroxide values of CMP1, CMP2 and COM varied between 2.80 to 2.16 mEq/kg fat, 0.28 to 0.88 mEq/kg fat and 0.42 to 0.96 mEq/kg fat. However, our values are lower than Elsara (2009) report. They reported peroxide value of camel milk powder was 9.85 mEq/kg fat and 5.85 mEq/ kg fat for cow milk powder. Whole milk powder ranged from 0.57 to 12.37 mEq/kg fat. Peroxide value of different milk powders varied may be due to the result of light exposure, inappropriate packaging in the presence of transition metals or milk powder fortified with fat with more polyunsaturated fatty acids. The higher peroxide value is a result of an accumulation of oxidised lipid intermediates whereas a drop in the peroxide value in the sample might be attributed to more oxidation with the creation of small molecules including acids, ketones, and aldehydes (Thomas *et al.* 2004) 3[6].

TBA value

TBA value is the main parameter to measure the secondary oxidation of milk lipids. The TBA value measures the presence of malondialdehyde (MDA), a byproduct of lipid oxidation. It is generated by the further degradation of lipid hydroperoxides. The significant (p<0.05) variation was found in the TBA value of each powder sample between the different brands. The mean value of TBA in milk powder samples varied from 0.012 to 0.119. Among the all sample, CMP1 reported the highest TBA value and COM observed the lowest TBA value. TBA values of CMP1, CMP2 and COM ranged from 0.110 to 1.51, 0.024 to 0.065 and 0.002 to 0.015, respectively. TBA value of whole milk powder was reported as 0.044 and 0.02 (Li *et al.* 2019; Chudy *et al.* 2015) [23, 6].

Table 2: Oxidative indicators of camel and cow milk powders

Types of milk powder	FFA (% oleic acid)	Peroxide Value (mEq/kgfat)	TBA Value (OD at 538nm)	Antioxidant activity (%inhibition)
CMP1	3.07±0.49[b]	2.56±0.34[b]	0.119±0.016[b]	18.83±9.91[a]
CMP2	1.92±0.09[a]	0.64±0.28[a]	0.048±0.018[a]	33.13±1.37[b]
COM	2.79±0.51[b]	0.73±0.22[a]	0.012±0.002[a]	14.27±8.26[a]
SEm	0.21	0.14	0.005	3.74
CD	0.64	0.44	0.016	11.54
CV	17.96	24.33	20.913	36.24

[a-c]: values with different letters between a row are significantly different at 5% (i.e., $p<0.05$)

Antioxidant Properties

The antioxidative capacity of a product can also be used to assess oxidation sensitivity. It was estimated by using DPPH assay method in milk powder samples. The antioxidant activity of milk powder is mainly due sulfur containing amino acids, Vitamin E, Vitamin C, and various enzymes. Our results are presented in Table 2. The average antioxidant capacity of milk powder varied range from 17.52 to 33.13% inhibition. The antioxidant capacity of CMP1 varied from 11.21 to 31.49% inhibition whereas 32.13 to 32.86% inhibition was found in CMP2 samples and 11.30 to 17.2% inhibition in COM. Al-Saleh *et al*. (2014) [3] studied the antioxidative activity of camel milk casein hydrolysate. They reported a range of 27.05% to 36.82% inhibition of camel casein samples and 27.05 and 11.95% inhibition for unhydrolyzed camel casein and cow casein, respectively. Lugonja *et al*. (2021) [25] reported 35.51% inhibition of cow milk powder. The variation among different brands of samples might be caused by the loss of vitamins and sulphur-containing amino acids due to heat treatment and drying process.

Heat load indicators of camel and cow milk powders

Many constituents are present in milk powders which leads to browning in milk powders. It also imparts the sensory quality of milk powder by producing off flavour. It mainly formed due to high heating temperature during drying, leading to many biochemical changes. Heat load indicators are used as a marker of browning or to measure intensity of dried milks. Heat indicators' primary goal is to ascertain how the heating process. It is also evaluated the impact of storage on the nutritional status, organoleptic qualities, and even potential toxicity of the food in order to produce goods with high nutritional value and excellent quality (Contreras-Calderon *et al*. 2017) [7].

HMF (Hydroxy methyl furfural)

HMF is an intermediate product formed during non-enzymatic browning. It is mainly formed due to the reaction that takes place between lactose and protein (lysine). HMF is a better heat load indicator due to its relatively great sensitivity to changing processes, simple analysis and storage conditions, and an indication of the early stage of the Maillard reactions. In our study, we analysed both total and free HMF content of milk powders. The free and total HMF content of powder samples are shown in Table 3.

Among all the powder samples cow milk powder significantly ($p<0.05$) differ from other two samples of camel milk powders. The mean value of free HMF of milk powder samples CMP1, CMP2 and COM were 1.13, 0.81 and 8.58, respectively. Free HMF of camel milk powder ranged from 0.810 to 2.430 µmol/kg whereas cow milk powder ranged from 7.290-9.720 µmol/kg, respectively. The average value of total HMF content in camel and cow milk powder varied between 35.175 to 43.926 µmol/kg. Total HMF of CMP1, CMP2 and COM ranged from 33.250 to 46.375, 30.625 to 40.250 and 42.870 to 44.630 µmol/kg. However, all findings are in agreement with below reported values. Grigioni *et al*. (2007) [16] reported free HMF of whole milk powder values ranged from 0.31 to 0.81 µmol/L or 3.10 to 8.10 µmol/kg during different seasons. Li *et al*. (2019) [23] reported 8.4 to 66.50 µmol /litre free HMF in infant formula. Observed that free HMF was 4.95 mol/litre in fresh samples of skim milk powder. Morales and Jimenez-Perez (1999) observed that free HMF content in sterilised milk was varied from 37 to 76 g/litre. Czerwonka *et al*. (2020) reported HMF content in the range of 229.2 to 2769.2 µg/ kg in powder milk and 217.2 to 4329.6 µg/ kg in infant formula. HMF content of whole spray dried milk powder was 7.25 µmol/L (Chudy *et al.* 2015) [6]. It mainly affects by enzyme reactions, the ratio of protein and lactose, pH, hot air temperature, design of drying chamber and contact time of hot air with the milk particles.

Lactulose

Lactulose is the isomerized derivative of lactose where glucose moiety is changed to fructose. It is used as heat load indicator in dried milks. Our result is shown in Table 3.

The significant ($p<0.05$) difference was observed in the lactulose content of camel and cow milk powder. Lactulose content of CMP1, CMP2 and COM ranged between 154.09 to 154.70 mg/L, 138.11 to 147.80 mg/L, and 207.91 to 214.95 mg/L. Our result clearly indicates cow milk powder had more lactulose contents compared to camel milk powder. In other studies, spray-dried milk powder had a lactulose content of 261.40 to 268.34 mg/100g (Adhikari *et al*. 1991) [2]. Marconi *et al*. (2004) [27] observed 3.5 mg/L lactulose in pasteurised milk and 744 mg/L in in-container sterilized milk. The reason behind the variation in lactulose content of different milk powders due to drying conditions (inlet and outlet temperature), pre-treatment, compositional differences (lactose), storage conditions etc. Especially, cow milk powder's higher lactulose content may be a reason for the higher temperature used during the drying process.

Whey Protein Nitrogen Index (WPNI)

WPNI is widely used for categorising milk powder based on the heat sensitivity of whey proteins. It is useful for the heat classification of milk powders and the end use of powder during different food formulations. The WPNI of milk powders is shown in Table 3. The WPNI value of CMP1, CMP2 and COM range from 5.68 to 9.84 mg/gm of powder, 5.6 to 7.83 mg/gm of powder and 4.99 to 6.22 mg/gm of powder. The average WPNI value of camel milk powders ranged from 6.93 to 7.22 mg/gm of powder while cow milk powder had an average WPNI value as 7.22 mg/gm of powder. However, we observed that camel milk powder was less denaturized than those of cow milk powder (Table 3).

Similar. Zouari *et al.* (2021) [40] was observed camel milk powders (WPNI ≈ 9.6 mg/gm) were less denaturized than those of bovine ones (WPNI ≈ 8.5 g of mg/gm). In fact, Farah (1986) analyzed the heat denaturation of camel whey proteins by means of WPNI and concluded that camel milk whey proteins had a significantly lower heat sensitivity than those of bovine milk. The absence of β-lg in camel milk has already been reported by several previous studies (Felfoul *et al.* 2017; Lajnaf *et al.* 2018) [13, 22]. It was reported that the β-lg was the most heat-sensitive protein in cow milk. This could be the reason for less denaturation in camel milk compared to cow milk or the higher WPNI value of camel milk.

Table 3: Heat load indicators of camel and cow milk powders

Types of milk powder	Free HMF (µmol/kg)	Total HMF (µmol/kg)	Lactulose (µmol/kg)	WPNI (µmol/kg)
CMP1	1.13±0.83^{a}	36.93 ±4.90^{a}	154.34±1.72^{b}	7.22±2.32
CMP2	0.81±0.51^{a}	35.18± 3.89^{a}	142.09±3.50^{a}	6.93±0.95
COM	8.58±0.82^{b}	43.93±0.66^{b}	209.49±4.39^{c}	6.10±0.46
SEm	0.37	1.82	1.86	0.67
CD	1.13	5.60	5.73	NS
CV	23.45	10.50	2.46	22.17

$^{a-b}$: values with different letters between a row are significantly different at 5% (i.e., $p<0.05$)

Conclusions

The chemical composition, oxidation indicators as well as heat load indicators of these powders, were investigated and compared to those of cow milk powder. Results of this study indicated that the composition of camel and cow milk powders served significant ($p>0.05$) variation in fat, protein, and lactose while moisture content was almost similar in all the samples. Results of this study indicated that camel milk powder presented higher vitamin C, ash including chloride as compared to cow milk powder. It was observed that camel milk powder had a higher acidity than cow's milk powder. According to our analysis, camel milk powder had higher antioxidant activity. Further addition, the investigated camel and bovine milk powders presented a variation in oxidative parameters. Heat load indicators such as free HMF, total HMF and lactulose were higher amounts in cow milk powder as compared to camel milk powder. Besides, analysis of the WPNI indicated that camel milk powders were less denaturized than those cow milk powder. It is linked to absence of β-lg in camel milk. The present research work gives some insightful information about camel milk powder related to its chemical characteristics which could help researchers and industry to conduct further investigations or also help generate data. This study encourages the usage of camel's milk powder as food ingredients or end use of products.

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