ISSN: 2456–4397 RNI No.UPBIL/2016/68067 Vol-6* Issue-5* August-2021
Anthology : The Research

# Estimation and Bioavailability of Milk Minerals using Atomic Absorption Spectrophotometry

Paper Submission: 03/08/2021, Date of Acceptance: 15/08/2021, Date of Publication: 25/08/2021

**Manju Singh**
Associate Professor,
Dept. of Chemistry,
KVA DAV College for Women, Karnal, Haryana, India

**Abstract**

The current research work was aimed at studying the total mineral content, their distribution in milk of different species.Five minerals (calcium, magnesium, sodium, potassium, phosphorus) have been estimated in milk of three different species (cow, buffalo and goat) including three indigenous breeds of India. Among the species studied, buffalo milk had highest calcium, phosphorus and magnesium contents whereas sodium content was found lowest in buffalo milk while potassium was found maximum in goat milk. Potassium was a major mineral in cow and goat milk while calcium was a major mineral in buffalo milk. Mineral distribution data indicated that colloidal minerals were maximum in buffalo milk followed by goat and cow milk. Milk mineral bioavailability data is scarce. The objective of this research is to point out content, distribution and bioavailability of major minerals present in milk of different species.

**Keywords:** Mineral, Milk, Calcium, Potassium, Buffalo,Bioavailability.

**Introduction**

Minerals are important for building strong bones and teeth and also for maintaining the ionic equilibrium of the body fluids. Even in trace amounts, these minerals perform innumerable vital body functions like acting as catalysts, activators for physiological functions. Also, these help in transporting various nutrients to blood, to nerve impulses. Some of them act as antioxidants (e.g.zinc, selenium). Toxic minerals like lead, cadmium, aluminium, mercury, etc. are introduced into the body through contaminated food and polluted environment.Deficiency of minerals in body is responsible for health problems like stunted growth, skin rashes, hair loss, physical stamina, impaired mobility, lack of coordination, disease susceptibility, anaemia, diarrhoea, hormonal dysfunction, low and high blood pressure, hypocalcaemia, osteomalacia, nausea, vomiting,headache and premature ageing, etc. So proper analysis of minerals in any food is necessary for overall human health.The minerals /salt in milk and milk products play an important role in the stability of proteins and in their nutritional and organoleptic characteristics. Minerals are differently distributed into aqueous and micellar phases of milk, depending on their nature.

**Aim of the Study**

To estimate Total mineral content , soluble mineral content and thus bioavailability of minerals present in milk.

**Samples and Reagents**

Fifteen individual milk samples of cow (Sahiwal and Tharparkar breeds), buffalo (Murrah breed) and goat (Alpine x Beetle) were collected from apparently healthy animals from the Institute's Livestock Research Centre during winter months. All the milk samples were collected fresh and transferred to the laboratory immediately for analysis. Water with conductance 0.055 mhos/cm was used in the study. Nitric acid, hydrochloric acid of analytical grade was procured from Merck KGaA, Dramstadt, Germany. NIST traceable standard solutions for all the elements and lanthanum chloride were purchased from Sigma-Aldrich Inc., St. Louis, USA.

**Mineral Estimation**

Mineralization of whole milk samples and of permeate (obtained after fractionation) was done by dry digestion method. For this, 10 g milk sample or permeate was charred in a silica crucible and ashed in a microprocessor-controlled muffle furnace at 550°C for 5 h. Major mineral elements such as calcium, magnesium, sodium and potassium were quantified using methods suggested by International Organization for Standardization (ISO: 8070, 2007) using atomic absorption spectrophotometer (Model: AA-7000; Shimadzu, Japan). Phosphorus was estimated spectrophotometrically at 820 nm

(ISO 9874: 2006 (E)).

**Results**

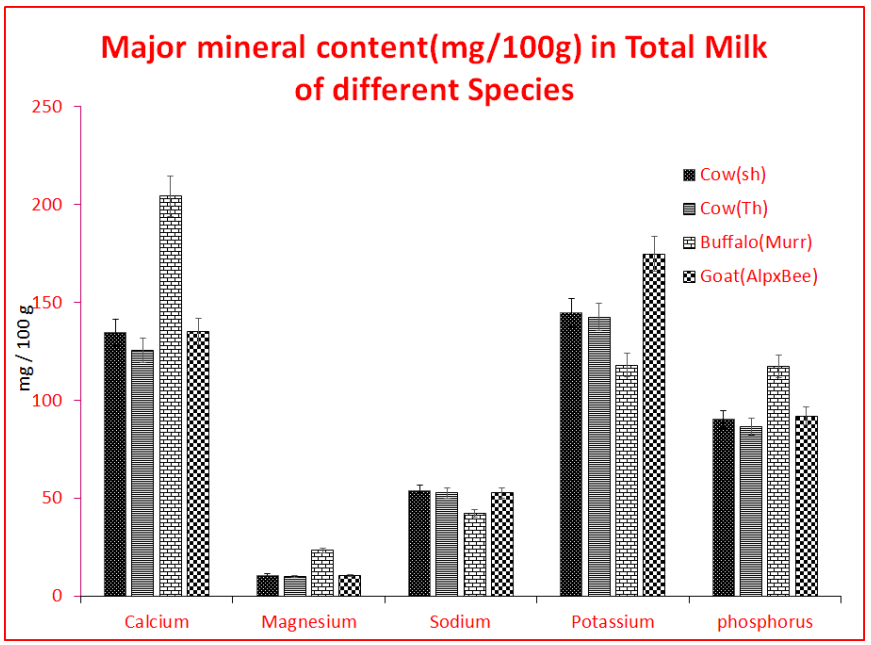
**Table 1: Ash (MIneral) content in milk of different species.**

| No. | Species | Ash (%) |
|---|---|---|
| 1. | Cow | 0.72 ± 0.003 |
| 2. | Buffalo | 0.80 ± 0.002 |
| 3. | Goat | 0.76 ± 0.008 |

Average of six observations ± S.D.

**Table 2: Range of Major Minerals (mg /100 g) in milk of different species**

| Minerals | Cow Milk (Sahiwal) | Cow (Tharparkar) | Buffalo (Murrah) | Goat (Alpine Beetle) |
|---|---|---|---|---|
| **Calcium** | 112-155 | 114-142 | 191-215 | 121-158 |
| **Potassium** | 136-156 | 133-152 | 100-125 | 165-181 |
| **Magnesium** | 9-13 | 8-13 | 20-25 | 9 -14 |
| **Phosphorus** | 87-92 | 76-91 | 108-127 | 89-96 |
| **Sodium** | 36-60 | 49 -59 | 41- 45 | 50 -55 |
| **Iron** | 0.75-0.12 | 0.06-0.14 | 0.088-0.149 | 0.068-0.12 |
| **Zinc** | 0.43-0.83 | 0.35-0.59 | 0.43-0.71 | 0.38-0.58 |
| **Copper** | 0.06-0.08 | 0.04-0.09 | 0.031-0.097 | 0.024-0.066 |
| **Manganese** | 0.023-0.05 | 0.042-0.062 | 0.029-0.071 | 0.014-0.057 |



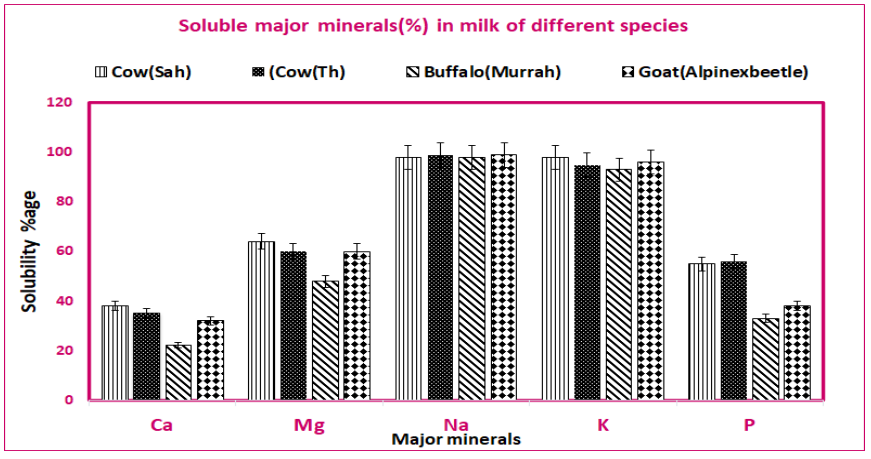
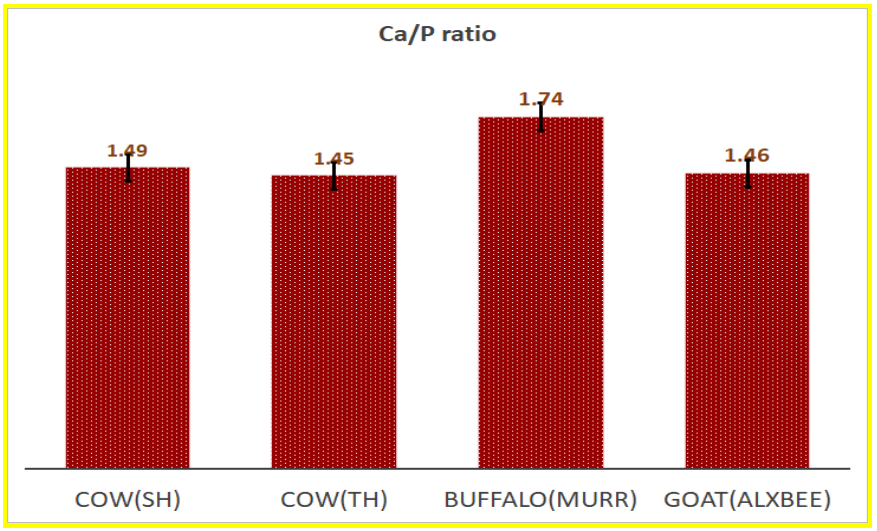



**Table 3: Comparison of solubilities of minerals in milk of different species (%)**

| Mineral | Cow Sahiwal | Cow Tharparkar | Buffalo Murrah | Goat Alpinex Beetle |
|---|---|---|---|---|
| **Calcium** | 38 | 35 | 22 | 32 |
| **Magnesium** | 64 | 60 | 48 | 60 |
| **Sodium** | 98 | 99 | 98 | 98 |
| **Potassium** | 98 | 95 | 93 | 96 |
| **Phosphorus** | 55 | 56 | 33 | 38 |




**Figure; Calcium / Phosphorus ratio in the milk of different species**

**Discussion**

Mineral distribution indicated that sodium (> 98%) and potassium (> 93%) are almost entirely present in soluble fraction of milk of all the species studied. The other minerals, major as well as trace elements, are distributed between colloidal and soluble phases. In general, the contents of soluble minerals were less in buffalo milk and more in cow milk. Maximum fraction of two major minerals i.e. calcium and phosphorus were found to be associated with colloidal phase in buffalo and goat milk. More than 60% of phosphorus was found to be in colloidal phase in buffalo milk (67%) and goat milk (62%), while in cow milk, a major amount (55%) of this element was associated with soluble phase. In case of magnesium, the maximum content was associated with colloidal phase in buffalo milk (52%) while in milk of other species, this element was associated with soluble milk fraction (60-64%).

The present study indicated the highest Ca:P ratio in buffalo milk.Calcium and phosphorus are main bone forming minerals. As calcium phosphate, phosphorus is the most important structural component of bones and teeth but excessive intake of phosphorus combined with reduced calcium intake may have negative effects on bones (Cashman, 2006). There must exist an appropriate Ca: P ratio in the human diet to ensure optimal bone health. Excessive dietary phosphorus intake alone can be deleterious to bone through increased parathyroid hormone (PTH) secretion, and adverse effects on bone increases when dietary intake is low. Based on calculation of recommended dietary calcium and phosphorus intakes, the optimal dietary Ca: P ratio (Infants, Children, Adults and Lactating Mothers) varies from 1-2. Low Ca: P ratio affects calcium metabolism and leads to bone loss and osteopenia. A high Ca: P ratio due to low P intake was found to be favourable for bone mineralization. Milk and milk products are rich sources of phosphorus and calcium for the required Ca :P ratio, and also meet the recommended Ca: P ratio (Kemi et al., 2009). Also, higher intake of calcium decreases absorption of phosphorus in the intestine (Nolan and Qunibi, 2003).

Magnesium was maximum contributed by buffalo milk, it activates and regulates about 100 enzymes and more than 300 enzymatic reactions in our body. Many of these reactions are directly related to cardiovascular health & help in nerve &

muscle function. Magnesium is required for insulin activity & is therefore important for prevention of type 2 diabetes (Nielsen, F. H.,2010). Sodium was maximum contributed by Cow milk, it maintains water balance, acid-base balance, muscle contraction, nerve contraction in human body (Anderson, 2004).Potassium was maximum contributed by Goat milk, it plays important role in nerve conduction, maintaining acid-base balance, water & fluid balance, muscle contraction and in regulating heartbeat in human body. Zinc was maximum contributed by Cow milk followed by Buffalo milk. Milk and milk products are very important in human nutrition, but an insufficient source of zinc (Cashman, 2002). Zinc is also an important component of hormone insulin. It is part of more than 200 enzymes involved in digestion, metabolism, protein synthesis, reproduction & wound healing (Salgueiro et al.,2002).

The chemical form of minerals is important as it determines their absorption in the intestine and their biological utilization and thus, bioavailability. Bioavailability is the degree to which a nutrient is absorbed and utilized by the body. The soluble fraction of all the minerals present in milk provide more bio utilization. Calcium bioavailability means, the fraction of dietary calcium which is actually absorbed and incorporates absorbed calcium into bone. Calcium bioavailability is affected by many dietary factors like vitamin D, Lactose, Casein phosphopeptides in milk. All these acts synergistically promote calcium absorption and thus its bioavailability. Cow milk has very good bioavailability of calcium (30-35%). Without consuming milk and milk products, less than half of the calcium requirements would be met.

**Conclusion**

Out of all the four breeds studied, buffalo (Murrah) milk provided the highest mineral content except sodium and potassium. Sodium content was found highest in cow milk while potassium was found maximum in goat milk.Mineral distribution study indicated that sodium (> 98%) and potassium (> 93%) are almost entirely present in soluble form in milk of all the species studied.Maximum fraction of two major minerals i.e. calcium and phosphorus were found to be associated with colloidal phase in buffalo milk in comparison to milk of other species. Solubility of most of the minerals was found maximum in cow milk.It has very good bioavailability of calcium.High levels of soluble mineral content in cow milk could favour the absorption of these minerals in gastrointestinal tract and thus their bio-utilization. Buffalo milk is a richer source of major minerals except sodium that is highest in cow milk.Minerals are essential to provide the nutritional requirements to the human body.

**Acknowledgements**

Author thanks to the Department of Dairy Chemistry, ICAR-NDRI,Karnal.

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