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Determination of some chemical compositions and heavy metal residues in sheep and goat milk

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Abstract

The present investigation was carried out to determine fat and total solids of sheep and goat milk, and also to evaluate and highlight the public health importance of six heavy metals residual concentration including Lead (Pb), Cadmium (Cd), Copper (Cu), Manganese (Mn), Iron (Fe), and Nickel (Ni) in sheep and goat milk using Atomic Absorption Spectrophotometer (AAS). Seventy samples of sheep and goat milk (35 of each) from different places especially Bedouin areas at El-Beheria governorates, Egypt were collected and examined. The obtained results revealed that the mean concentration of fat and total solid percent were (6.71±0.37, 16.16±0.44) and (5.10±0.09, 14.16±0.44) in sheep and goat milk, respectively. Regarding the essential trace elements, the mean concentration of Cu, Mn, Fe and Ni in sheep milk were 0.59±0.05, 0.16±0.01, 0.86±0.02 and 0.038±0.001 ppm, respectively. In goat milk were 0.30±0.01, 0.20±0.01, 0.65±0.004 and 0.047±0.001 ppm, respectively. Regarding the toxic heavy metals such as Pb and Cd could not be detected in both examined sheep and goat milk. It is concluded that essential trace elements Cu, and Fe were higher in sheep milk and other trace elements Mn, and Ni were higher in goat milk, while Pb and Cd could not be detected in sheep and goat milk.

Keywords: *Goat milk, sheep milk, toxic heavy metals, essential trace elements.*

Introduction

Dairy goat and dairy sheep farming are a vital part of the national economy in many countries, especially in the Mediterranean and Middle East region **(FAO, 2003).**

Goat milk provides a healthy and a balanced diet for the children who are allergic to cow milk, as the symptoms may disappear with goat milk consumption **(Merin *et al.,* 1988)**. Although goat milk doesnot differ significantly from the composition of cow milk in terms of total solids, protein, fat and lactose there is a marked difference in the structur, composition and size of casein micelles **(Domagala, 2009).** While sheep milk contains higher total solids and major nutrient contents than goat milk **(Park *et al.,* 2007).**

Sheep milk has higher specific gravity, viscosity, refractive index, titratable acidity, and lower freezing point than average cow milk (**Haenlein and Wendorff, 2006**). Goat milk possesses special attributes such as high digestibility, distinct alkalinity, high buffering capacity and certain therapeutic values in medicine (**Park, 2009**) Lipids in sheep and goat milk have higher physical characteristics than in cow milk (**Park, 2006**).

Physicochemical parameters including moisture content, total solid, total protein, fat content, ash contents, and pH are important tools to monitor the quality of milk in dairy animals **(Abay and Kebede, 2018).**

Heavy metals pollution enter the human body mainly by two routes i.e. inhalation and ingestion **(Tripathi *et al.,* 1997)**. Animals milk contain important elements phosphorus, calcium, potassium, magnesium, sodium, chloride and trace elements including copper, zinc, manganese, iron , cadmium and **Nickel** (**Buachoon, 2004**). Lactating animals when exposed to high concentration of heavy metals like Cu, Cd, Zn, Ni, Hg, Pb, Fe As and Cr, the metals amassed in their milk, which when consumed by consumers cause serious health issues (**Jeng *et al.*, 1994)** Milk contain microelements such as copper (Cu), iron (Fe) , selenium (Se), and zinc (Zn) which are known to be essential for human growth. However, heavy metals such as arsenic (As), cadmium (Cd), lead (Pb) have health impacts on human wellbeing if it is more than maximum permissible level **(Babu *et al.*, 2018).**

Sources of contamination with heavy metals may be directly by grass and crops grown as animal feed or via soil contamination by fertilizers where the use of cadmium contaminated phosphate fertilizers is associated with accumulation of cadmium in animal offals **(Bramely, 1992)**. While, industrially, through contaminated water polluted by discharging the wastes of factories. In addition, environmentally, by the gasses from mining or the motor vehicles powered by leaded gasoline.

Prolong or over exposure to heavy metals will leads to abdominal pain, hepatotoxicity, neurotoxicity, vomiting, decreasing of intelligence quotient (IQ) level, Alzheimer's disease, behavioral disorders, tissue injury, irritation of lungs, cancer etc. **(Babu *et al.*, 2018).**

The regular consumption of small amounts of certain metals, such as lead, may cause different impacts on the health of growing infants and children. For instance, retardation of mental development (such as reading and learning disabilities) and deficiencies in concentration, the adverse effects on kidney function, on blood chemistry, and on the cardiovascular system, and hearing degradation. Therefore, it is of significant importance to monitor the level of trace elements in milk and dairy products, which are accounted as the major sources of nutrition in childhood **(Nejatolahi *et al.*, 2014).**

Complete elimination or prevention of chemical contaminants can not be achieved from milk because the lipophilic contaminants will find its way into the persistent fat compounds from where heavy metals cannot be removed readily **(Girma *et al.*, 2014)**. Besides heavy metals are non-biodegradable in nature and become accumulated in the food chains via biotransformation, bio-accumulation and bio-magnifications **(Aslam *et al.*, 2011)**

Therefore, this study was planned to determine fat and total solids percent of sheep and goat milk. In addition, determination of some toxic heavy metal (lead, cadmium) and some essential heavy metals (Cu, Mn, Fe and Ni) and their effect on public health.

Material and Methods

1. Samples collection:

Seventy samples of sheep and goat milk (35 of each) were collected randomly from different places specially Bedouin areas at El-Beheria governorates, Egypt. Samples were transferred as soon as possible in an icebox to the laboratory with a minimum of delay to be examined.

2. Determination of gross composition:

Fat content was estimated using Gerber's methods Also, total solids was determined according to **AOAC, (1993)**

3. Determination of some heavy metals and trace elements according to (Ahmad *et al.*, 2017):

3.1. Preparation of samples:

Ten ml of Milk were digested with 1:3 of H_2O_2 and HNO_3 on a hot plate. The samples were heated on hot plate until their volume reduces to 2 ml. This 2 ml sample solution was then diluted with 20 ml distilled water and make a clear solution of it. The contents of the beaker brought to the required volume with distiled water and were examined by Flame Atomic Absorption Spectrophotometer.

3.2. Preparation of standards for heavy metals:

The heavy metals selected for study were Pb, Cd, Cu, Mn, Fe, and Ni. In each case of the selected metals, three different concentrations were made to calibrate the Flame AAS. These concentrations are as follows: 1.0 ppm, 1.5 ppm and 2.0 ppm. The resultant calibration curve of well-prepared standard concentrations gives linear curve by Atomic Absorption Spectrophotometric Analysis by using Perkin Elmer PinAAcle™ 900T atomic absorption (AA) spectrophotometer (Shelton, CT, USA) which is equipped with the sensitive WinLab32™ for AA software running under Microsoft® Windows™ 7 for flame absorption spectrophotometry. Sample preparation and analysis were done in Food Hygiene Dept ., Animal Health Research Institute, Dokki,. Egypt

4. Statistical Analysis:

Data were statistically evaluated by one-way analysis of variance. All statistical analyses were done using the Statistical Package for Social Sciences (SPSS 20) program.

Results

Table (1). Statistical analytical results of some chemical composition of sheep milk

Chemical composition	Minimum	Maximum	Mean ± SEM
Fat %	4.10	10.08	6.71±0.37
Total solid %	12.80	20.18	16.16±0.44

Table (2). Statistical analytical results of some chemical composition of goat milk

Chemical composition	Minimum	Maximum	Mean ± SEM
Fat %	4.38	5.66	5.10±0.09
Total solid %	11.28	16.32	14.16±0.44

Table (3). Fat percent of sheep and goat milk in comparison with Egyptian standard, 2005.

Species	Egyptian standard 154/1, (2005_	Fat percent			
		Samples comply with ES, 2005		Samples not comply with ES, 2005	
		No.	%	No.	%
Sheep	**Not less than 5%**	28	80	7	20
Goat	**Not less than 3%**	35	100	0	0

Table (4). Statistical analytical results of some toxic heavy metals and essential minor elements (ppm) in sheep milk.

Heavy metals	Minimum	Maximum	Mean±SEM
Lead (Pb)	< 0.022	--	--
Cadmium (Cd)	< 0.022	--	--
Copper (Cu)	0.21	1.13	0.59±0.05
Manganese (Mn)	0.12	0.25	0.16±0.01
Iron (Fe)	0.72	1.07	0.86±0.02
Nickel (Ni)	0.031	0.044	0.038±0.001

0.022= Detection limit

Table (5). Statistical analytical results of some toxic heavy metals and essential minor elements (ppm) in goat milk.

Heavy metals	Minimum	Maximum	Mean±SEM
Lead (Pb)	< 0.022	--	--
Cadmium (Cd)	< 0.022	--	--
Copper (Cu)	0.20	0.46	0.30±0.01
Manganese (Mn)	0.14	0.31	0.20±0.01
Iron (Fe)	0.62	0.69	0.65±0.004
Nickel (Ni)	0.039	0.052	0.047±0.001

0.022= Detection limit

Discussion

Results illustrated in table (1) showed that fat content of sheep milk samples was in the range of 4.10-10.08 with a mean value of 6.71±0.37. Meanwhile, the total solid was in the range of 12.80-20.18 with a mean value of 16.16±0.44.

Our findings were similar to (**Asif and Sumaira, 2010**) who reported that the mean value of fat content in sheep milk samples was 6.49. In addition, (**Abo El-Makarem, 2016)** reported that the mean value of fat content of ewe's milk collected from Alexandria and Kafr El-Sheikh Governorate, Egypt was 6.89±0.22. In addition, **Hayam *et al.,* (2017)** reported higher total solids percent 17.43% in examined sheep milk in Giza, Egypt, while fat percent in sheep milk samples was 6.30%. This finding was nearly similar to our finding

Egyptian Standards (2005) stated that sheep milk fat percent should not be less than 5% and according to this standard 7 samples (20 %) of examined sheep milk samples were not compatible with permissible fat percent (table 3).

The obtained results in table (2) revealed that fat contents of goat milk samples were in the range of 4.38-5.66 with a mean value of 5.10±0.09. Meanwhile, the total solid was in the range of 11.28-16.32 with a mean value of 14.16±0.44.

Saima *et al.,* (2016) who examined 6 samples of goat milk in Pakistan and they found that the mean values of fat was 4.61±0.02. **El-Bendary *et al.,* (2017)** who reported that the mean values of fat percent in goat milk, from 100 native breeds from Alexandria governorates, was 4.14±0.09.

Lower results of fat percent obtained by **Helmut and Gregor, (2012)** who examined 102 goat milk samples from six most common breeds (17 for each breed) in Austria and found that mean value of fat was 3.67. In addition, **Mahmood and Usman (2010)** reported that the fat content of goat milk was 3.97% in Gujarat, Pakistan. **Hayam *et al.*,, (2017)** reported that fat percent in examined goat milk in Giza Egypt was 3.40

Nearly similar result of total solid in goat milk obtained by **Soliman (2005)**; **Mahmood and Usman (2010) and Saima *et al.,* (2016)** who found that mean values of total solid in examined goat milk were 12.62, 12.84 and 13.56 %, respectively. Higher total solid percent of sheep milk was 18.1% recorded by **Raynal-Ljutovac *et al.,* (2008).**

Total fat content in goat milk are predominated by smaller fat globules where 90% of the fat particles in goat milk were less than 5.21μm **(Tziboula-Clarke, 2003).**This related property of smaller fat globules with the broader surface area was giving the benefits of easy to digest and quicker lipase activity **(Chandan *et al.,* 1992).**

According to **Egyptian Standards (2005)** The goat milk fat percent should not be less than 3% and according to this standard all examined goat milk samples comply with fat percent (Table 3).

Micronutrient elements such as iron and Mn, Ni and Cu are essential for many biological functions. Deficiencies of such elements contribute significantly to the global burden of disease; however, if present at higher levels, they can have a negative effect on human health. Both toxicity and necessity vary from element to element. Milk and dairy products are considered very poor sources of iron and copper **(Kazi *et al.,* 2009).** The trace element contents of milk depends on the stage of lactation, nutritional status of the animal, environmental and genetic factors, characteristic of the manufacturing practices and possible contamination from the equipment during processing **(Cashman, 2011).**

The obtained results in table (4) illustrated that the minor essential elements such as Cu, Mn, Fe and Ni were found in range of (0.21-1.13), (0.12-0.25), (0.72-1.07), and (0.031-0.044) ppm, respectively in sheep milk with mean values 0.59±0.05, 0.16±0.01, 0.86±0.02 and 0.038±0.001 ppm, respectively. Meanwhile, heavy metal such as Pb and Cd could not be detected in examined sheep milk.

Our finding disagree with **Cadar *et al.* (2016)** Who reported that the mean concentration of lead and cadmium in examined sheep milk in Romania were 35.6±6.82 and 5.25±1.85 µg/l, respectively. In addition they found that the mean concentration of Cu, Mn and Ni in the same examined sheep milk samples were 98.9±10.1, 89.3±11.2 and 4.32±2.01 µg/l, respectively. **Ahmad *et al.* (2017)** reported that the mean concentration of Cu, Mn, Fe and Ni in examined sheep milk, were 0.151±0.011, 0.078±0.018, 0.592±0.321 and 0.34±0.001 mg/kg, respectively.

According to **Egyptian Standards (2010)** which stated that lead level in raw milk must not exceed 0.02 ppb, there are examined sheep and goat milk samples comply with these standard. In addition, According to **Egyptian Standards (1993)** the cadmium level in raw milk must not exceed 0.05 ppm, therefore all examined sheep and goat milk samples comply with these standards.

Data obtained in table (5) showed that the minor essential elements in goat milk Cu, Mn, Fe and Ni were found in the range of (0.20-0.46), (0.14-0.31), (0.62-0.69), and (0.039-0.052) ppm, respectively with mean values 0.30±0.01, 0.20±0.01, 0.65±0.004 and 0.047±0.001 ppm, respectively. Meanwhile, toxic heavy metal such as Pb and Cd could not be detected in examined goat milk.

The obtained results from goat milk disagree with **Cadar *et al.,* (2016)** who reported that the mean concentration of lead and cadmium in examined goats milk in Romania were 20.5±6.12 and 3.56±2.01 µg/l, respectively. In addition they found that the mean concentration of Cu, Mn and Ni in the same examined goat milk samples were 58.6±7.38, 25.6±7.48 and 5.80±2.45 µg/l, respectively. **Ahmad *et al.,* (2017)** reported that the mean concentration of Cu, Mn, Fe and Ni in examined goat milk, Pakistan were 0.212±0.010, 0.065±0.032, 0.950±0.305 and 1.152±0.045 mg/kg, respectively.

Copper as an essential trace element is necessary for the adequate growth, integrity of the cardiovascular system elasticity of the lungs, neuron endocrine function, and iron metabolism. **(Sieber *et al.,* 2006).**

Iron as an essential trace element participates as catalyst in several metabolic reactions. As a component of hemoglobin, myoglobin, cytochromes and other proteins, plays an essential role in the transport, storage and utilization of oxygen. It is also a cofactor for a number of enzymes and its deficiency results in anemia **(Meshref *et al.,* 2014)**

Overall results of heavy metals investigation indicated that the mean concentration of essential minor elements (Cu and Fe) were slightly higher in sheep milk than in goat milk, while the mean concentration of (Mn and Ni) essential elements were slightly higher in goat milk than in sheep milk.

Our finding agree with **Cadar *et al. (2016)*** who reported that mean concentration of copper in sheep (98.9±10.1 µg/l) were higher than mean concentration in goat milk (58.6±7.83µg/l). Also, reported that the mean concentration of Nickel in goat milk (5.80±2.45 µg/l) were higher than mean concentration in sheep milk (4.32±2.01 µg/l). In addition, **Hayam *et al.* (2017)** reported that mean concentration of Mn in goat milk (0.99 mg/l) was higher than Mn in sheep milk (0.54 mg/l). In the contrary, **Ahmad *et al.* (2017)** reported that mean concentration of Fe was higher in goat milk (0.95±0.30 mg/kg) than sheep milk (0.59±0.32 mg/kg), in addition, the mean concentration of Mn was higher in sheep (0.078±0.018 mg/kg) than mean concentration of Mn in goat (0.065±0.032 mg/kg).

Lead is a potent neurotoxin **(US Environmental Protection Agency, 2003),** it may causes damage to kidneys, the cardiovascular, immune, hematopoietic, central nervous and reproductive systems. Short-term exposure to high level of lead can cause gastrointestinal distress, anemia, encephalopathy and death. Cd and Pb have the greatest dangerous effects on renal tissue and nervous system (**Neal and Guilarte, 2013).**

Cadmium is a toxic metal with extremely long biological half life time of 15-20 years in human, cadmium exposure can cause a variety of adverse health effects among which kidney dysfunction, lung disorders, disturbed calcium metabolism and bone effect are most prominent. Cadmium is the most compound that give rise to lung cancer after inhalation. Since the blood -brain barrier keeps cadmium outside the CNS reported neurotoxin effect of cadmium during development are likely to be secondary to an interference of cadmium with zinc - metabolism **(Jin *et al.,* 1998).**

It is concluded that, sheep milk contain higher fat and total solid than goat milk. Regarding heavy metals, both sheep and goat examined milk samles were free from toxic heavy metals such as lead and cadmium, meanwhile, Cu and Fe essential trace elements were slightly higher in sheep than goat milk, other essential trace elements including Mn and Ni were slightly higher in goat milk than sheep one.

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