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# Evaluation Some Trace Elements and Heavy Metals in Breast Milk and Artificial Milk

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# تقدير بعض العناصر الاساسية والمعادن في حليب الأمهات وحليب الأطفال الصناعي

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**Abstract:**
The study had two principal objectives: firstly, to survey the nutritional awareness of mothers with regard to the proper nutrition of their children; and secondly, to evaluate the content of mothers' milk and powdered industrial milk in terms of its content of the element's sodium, potassium, calcium and magnesium. In addition, the study sought to estimate the proportions of some heavy metals, specifically iron, lead and cadmium. The results of the survey indicate that 71.4% of mothers use formula milk for their babies during the first three months of childbearing. Furthermore, 42.9% of women do not adhere to the correct method of preparing formula milk. It is notable that the majority of mothers do not care about maintaining a balanced diet during the breastfeeding period. Additionally, a significant difference was observed. The content of the elements in both types of milk shows that formula milk contains almost double the amount of sodium, calcium and magnesium. However, this increase is not beneficial as it can lead to incomplete kidney function in children. This results in the kidneys being unable to excrete all the sodium, which can cause an increase in sodium levels in the blood and watery stiffness. Furthermore, the addition of vitamin D by some companies may result in an increased absorption of calcium, which could potentially lead to the formation of cysts in the kidneys or bladder. The presence of certain heavy metals, such as lead, in quantities exceeding the limits set by the World Health Organization (WHO) in mothers' milk provides a significant indication of the extent of food safety concerns in our local environment.

**Keywords:** Breast milk, Artificial infant milk, Nutritional element, Minerals, Heavy metals.

**الملخص**
كان للدراسة هدفان رئيسيان: أولاً، استطلاع الوعي الغذائي للأمهات بشأن التغذية السليمة لأطفالهن؛ وثانياً، تقييم محتوى حليب الأمهات وحليب الأطفال الصناعي من حيث محتواه من العناصر مثل الصوديوم والبوتاسيوم والكالسيوم والمغنيسيوم.

بالإضافة إلى ذلك، سعت الدراسة إلى تقدير نسب بعض المعادن الثقيلة، مثل الحديد والرصاص والكادميوم. تشير نتائج الاستطلاع إلى أن 71.4% من الأمهات يستخدمن حليب الأطفال الصناعي خلال الأشهر الثلاثة الأولى من الولادة. علاوة على ذلك، فإن 42.9% من النساء لا يلتزمن بالطريقة الصحيحة لتحضير حليب الأطفال. ومن الجدير بالذكر أن الغالبية العظمى من الأمهات لا تهتم بالحفاظ على نظام غذائي متوازن خلال فترة الرضاعة. بالإضافة إلى ذلك، لوحظت فروق كبيرة. تظهر محتويات العناصر في كلا النوعين من الحليب أن حليب الأطفال الصناعي يحتوي على ما يقرب من ضعف كمية الصوديوم والكالسيوم والمغنيسيوم. ومع ذلك، فإن هذه الزيادة ليست مفيدة، حيث يمكن أن تؤدي إلى عدم كفاءة وظيفة الكلى لدى الأطفال، مما يجعل الكلى غير قادرة على إخراج كل الصوديوم، مما قد يسبب زيادة في مستويات الصوديوم في الدم وتصلب مائي. علاوة على ذلك، قد يؤدي إضافة فيتامين د من قبل بعض الشركات إلى زيادة امتصاص الكالسيوم، مما قد يؤدي بشكل محتمل إلى تكوين كيسات في الكلى أو المثانة. تواجد بعض المعادن الثقيلة، مثل الرصاص، بكميات تتجاوز الحدود التي وضعتها منظمة الصحة العالمية (WHO) في حليب الأمهات، يشكل مؤشراً هاماً على مدى مخاوف سلامة الغذاء في بيئتنا المحلية.

**الكلمات المفتاحية**: حليب الأم، حليب الأطفال الصناعي، العناصر الغذائية، المعادن، المعادن الثقيلة.

## Introduction

Breast milk is the optimal nourishment for infants, as it is uniquely designed to provide them with the essential nutrients for optimal growth and development. The composition of breast milk adapts to the infant's growth, thereby meeting the changing needs of the child. Furthermore, breast milk provides protection against infection and disease (Ballard & Morrow, 2013). Furthermore, it is readily accessible and available at all times to meet the infant's needs. In the immediate postnatal period, breast milk is referred to as colostrum, a thick, yellow liquid that is particularly rich in protein and antibodies. These components help to prevent jaundice in newborns and maintain the baby's health.

Following the initial three-day period following the birth of the infant, the composition of the breast milk begins to change, evolving into a more mature form over the course of approximately one week. The composition of breast milk varies between the morning and evening. Furthermore, the characteristics and composition of breast milk change during a single feeding session. At the beginning of a feeding, the milk is relatively thin and watery, while at the end, it becomes thicker and more fat-rich, providing the infant with a sense of fullness. Furthermore, the milk of a mother who gives birth prematurely (i.e., before the end of the gestational period) differs from the milk of a mother whose pregnancy is complete. This is due to the fact that the milk of the mother of the premature baby is easily digestible and proportional to the immaturity of the premature infant's digestive system (Mosca & Giannì, 2017). Furthermore, the volume of milk produced by the mother is subject to change in accordance with the infant's requirements. The volume of milk produced by the mother initially reaches 50ml in the first days after birth, before increasing to reach one litre in the sixth month. The composition of the milk produced by each mother is tailored to meet the nutritional requirements of her infant. It has been demonstrated that the antibodies, hormones, vitamins and minerals present in breast milk are produced in accordance with the requirements of the newborn.

The process of milk formation is subject to both regulatory and hormonal control. A number of hormones are involved in the process of breast development and the maintenance of lactation. In general, the hormone estrogen is necessary for the reproduction, growth and branching of the mammary gland ducts, while the hormone progesterone plays a role in stimulating the breast tissue and the glands responsible for milk secretion. The hormone prolactin, secreted by the anterior pituitary gland, plays a fundamental role in the maturation of the mammary gland and the formation of milk. The hormones prolactin and oxytocin are instrumental in the process of milk production and secretion. Prolactin is responsible for maintaining milk secretion, while oxytocin facilitates the relaxation of uterine muscles and the release of milk. Estrogen is a principal stimulant of prolactin production and secretion, increasing the number of milk-producing cells and their size. Estrogen is the primary stimulant for the production and secretion of large prolactin during pregnancy. Prolactin plays a crucial role in milk formation by drawing glucose and amino acids from the blood to the mammary gland, where casein, lactalbumin (milk proteins), lactose (milk sugar), and milk fats are formed through a secretory process in the mammary gland (Savino, 2013).

### Artificial milk

The product is a modified and fortified dried cow's milk that has been processed to closely resemble breast milk according to international standards for dried infant milk for healthy infants. The modification and fortification process includes the addition of nutrients to the milk to achieve the desired nutritional profile. The majority of these types exhibit minimal differences from one another (Lönnerdal, B., 2014).

The different types are manufactured with specifications that cater to the nutritional requirements of the typical child and those with special dietary needs. For instance, the types of milk prepared for infants during the first six months of life are formulated with protein, fat, and mineral components that align with the physiological maturity of the digestive system and the nutritional requirements of the child during this initial stage. During the second six months of the first year, as the child's growth and size increase and his overall nutritional needs increase, the milk prepared for this age is suitable for this change in growth and for the needs of the second stage (Koletzko et al., 2005).
The milk has been subjected to a drying process whereby the water is removed, resulting in a powder with a moisture content of between 3 and 5%. The final product is referred to as milk powder or dried milk. It may be produced from whole milk or partially or entirely skimmed milk. The milk powder may be fortified with vitamins and minerals, resulting in a fortified milk product. In certain instances, the raw milk is subjected to modifications prior to drying, with the objective of achieving a composition that closely resembles that of human milk. This process results in the production of a milk substitute that closely resembles breast milk, and it is therefore designated as "modified milk." (Kent, G., 2015).

**Colostrum**

The production of colostrum, the initial milk secreted by the mammary glands, commences during the seventh month of gestation. It is a viscous, transparent liquid with a yellowish hue resulting from its high carotenoid content. The mammary glands secrete milk in quantities ranging between 2 and 10 deciliters per feeding during the initial days following birth. The secretion of colostrum persists for a period of three to four days following the birth of the infant. The volume of colostrum produced is correlated with the number of births. A mother who has previously given birth and breastfed is more likely to begin producing colostrum at an earlier stage and in larger quantities.
Colostrum represents the optimal initial nourishment for the infant, offering a higher concentration of antibodies and protein than full or mature milk, while containing smaller amounts of sugar and fat. Consequently, colostrum has a lower energy content than mature milk, while the concentration of sodium, potassium and chlorine is higher in colostrum than in mature milk as illustrated Table 1 for a breakdown of the nutritional components of colostrum).

**Table 1.** Colostrum Nutrient Composition (1-5 Days).

| Nutrients | Average in 100 ml |
|---|---|
| Energy K K | 67 – 49 |
| Lactose (g) | 6.4 – 4.4 |
| Fat (g) | 4.1 – 2.2 |
| Total Cholesterol (g) | 36 – 13 |
| Total Protein (g) | 5.5 – 2.0 |
| Non-Protein Nitrogen (mg) | 91 |
| Ash (g) | 0.36 – 0.30 |
| Calcium (mg) | 48 – 23 |
| Phosphorus (mg) | 16 – 13 |
| Magnesium (mg) | 4 – 3 |
| Potassium (mg) | 14 |
| Iron (mg) | 0.13 – 0.04 |
| Copper (mg) | 0.06 – 0.04 |
| Zinc (mg) | 0.74 – 0.56 |
| Iodine (mg) | 12.2 |
| Chlorine (mg) | 159 – 59 |
| Sodium (mg) | 50 – 47 |
| Sulfur (mg) | 23 – 20 |
| Vitamin A µg | 161 – 51 |
| Carotene µg | 137 – 85 |
| Vitamin E (mg) | 1.5 – 1.1 |
| Vitamin C (mg) | 7.2- 1.4 |
| Thiamine µg | 35 – 2 |
| Riboflavin µg | 32.0 – 26.7 |
| Niacin µg | 75 |
| Biotin µg | 0.1 |
| Folate µg | 0.05 |
| Pantothenic Acid µg | 183 |
| Vitamin B12 µg | 0.045 |

**Chemical composition of milk**

On initial observation, milk presents itself as a uniform liquid. However, in reality, it is a complex mixture comprising a wide range of chemical compounds. Milk is a complex colloidal system, comprising a range of macromolecules, including proteins, fat, lactose, salts, minerals and vitamins. These macromolecules are linked in a special system and balance. These components exist in three forms:

dissolved, colloidal and emulsified in a special mixture and in balanced proportions (Nour, 1989). In general, milk consists of minor components, including enzymes, vitamins, microorganisms, and somatic cells. The major components are divided into water and solids. The majority of milk components are water, which constitutes approximately 80-90% of the total, with the remaining portion consisting of solids (Al-Khawli, 1999; Meurant, 1995).

**Fat**

It is regarded as one of the most significant constituents of milk, and its concentration is often used as an indicator of the milk's overall richness. The quality, economic value and price of milk are typically determined based on its fat content. From a nutritional standpoint, milk is an excellent source of thermal energy and fat-soluble vitamins, including vitamins A, D, E, and K. Additionally, it contains essential fatty acids. The fat content of milk is distributed throughout the aqueous medium in the form of a fatty emulsion. (Al-Khawli, 1999) The composition of milk fat is an emulsion of granules or globules of fat dispersed in the aqueous medium of milk. The granules of fat are found in the emulsion in the form of clusters when they come into contact with each other due to the presence of the membrane surrounding them. The membrane is composed of 60% fat and 40% protein in each granule or globule. (Harding, 1995) Triacylglycerols are regarded as the principal type of fat present in the milk of all mammalian species. It constitutes 97-98% of the total fat in most types of milk, and is primarily composed of fatty acids, with minor constituents including diacylglycerol, monoacylglycerols, cholesterol, free fatty acids, and phospholipids.

The composition of fatty acids in milk is subject to influence from a number of factors, including the surrounding environment and physiological variables such as nutrition and lactation stage (milk production), as well as breed-related differences. The results demonstrate that the working model of short-chain fatty acids C4-C12 is present in very small quantities in camel milk in comparison to cow's milk, which may contain up to 7%. However, the concentrations of saturated fatty acids (C14:0, C16:0, C18:0) are considered relatively high (Farah, Z., 1993).

Additionally, milk fat provides the body with calories, which are considered the highest value. The primary components of milk fat provide 9 calories per gram and contribute to the intake of vitamin A, which is essential for maintaining ocular health. However, there have been instances where children who consumed skimmed milk exhibited symptoms of poor eyesight. The volatile fatty acids present in milk fat, including butyric and caproic acids, are readily digestible. Furthermore, milk fat contains essential fatty acids, particularly unsaturated ones such as linoleic and arachidonic. Deficiency of these acids can result in symptoms similar to those observed in cases of vitamin A or D deficiency. The consumption of milk fat has been demonstrated to stimulate the growth of intestinal flora and to facilitate the absorption of calcium and phosphorus (Slice, 2000).

**Milk proteins**

Proteins are present in milk in a colloidal state, and the protein granules are of a smaller size than the fat granules. The protein content of milk is sufficient to provide the body with all the essential amino acids it requires, which is why it is considered a complete protein source. Proteins play a significant role in determining the intrinsic characteristics of milk and its behaviour during manufacturing processes. Additionally, they exert a considerable influence on the thermal stability of milk during various thermal treatments. (Omar, 1985).

Milk proteins are regarded as one of the most complex types of proteins in terms of their composition and diverse properties. They possess distinctive characteristics and encompass a range of compounds, some of which exist in a colloidal state within milk, such as casein, and some of which are soluble, collectively known as whey proteins. Caseins constitute the primary proteins present in milk, existing in a colloidal state as casein micelles. Caseins constitute between 70 and 80 percent of the total protein content of milk. The caseins comprise a number of distinct molecular species, including casein s1α (CN) -s1α), casein - s2α (CN) -s2 α), casein - β (CN) - β), and casein K-CN) -K). Whey proteins, which constitute approximately 20-30% of the total protein in milk, encompass a number of different types, including α-La α-lactoalbumin, β-La lactoglobulin β, SA serum albumin, and Ig immunoglobulin. Furthermore, a number of peptides are produced as a result of the hydrolysis of casein molecules following the secretion of milk, catalysed by protease enzymes (Omar, 1985).

Protein is comprised of three primary categories: casein (78%), sorghum proteins (17%), and the remaining 5% comprising non-protein nitrogenous materials, including peptides, amino acids, and urea. The nutritional value of protein is contingent upon the essential amino acids it contains. Milk proteins are regarded as proteins with comprehensive nutritional value, surpassed in this regard only by egg proteins (Ahmed Ashour, 2002). Milk protein is one of the proteins with high nutritional value, and its nutritional importance is due to its containing the two amino acids lysine and tryptophan, which are found in very small or low quantities in grains. The primary protein in milk, casein, comprises the eight essential amino acids in optimal proportions, with the exception of cysteine, which is present in a relatively minor quantity. The significance of milk proteins lies in their ability to facilitate a balanced intake of amino acids when consumed alongside plant-based proteins. The nutritional value of milk can be enhanced by incorporating it into a variety of dishes. For instance, dry milk can be added to bread (Harding, 1995). Milk protein contains 20 amino acids, including all the essential amino acids that are crucial for building and maintaining body tissues, as well as replacing damaged ones. Additionally, these amino acids are essential for mental growth and energy production. 1) The calorific value of a gram of protein is 4 calories (Ahmed Ashour, 2002).

**Milk sugar**

Lactose is the primary source of carbohydrates in milk and is colloquially referred to as "milk sugar" due to its exclusive occurrence in this particular food source. Lactose is a disaccharide, comprising two units of glucose and galactose. When lactose is broken down by the enzyme lactase, the resulting monosaccharides are galactose and glucose, which are a valuable source of energy. Galactose is a component of the nervous system, occurring in brain and nerve cells. Consequently, it facilitates the growth and development of the nervous system in young children, given that approximately 70% of the human brain is fully developed by the end of the first year of life. In the intestines, the slow absorption of lactose results in the activation of bacteria that produce organic acids, such as lactic acid bacteria, and the creation of elements of the vitamin B complex, including biotin, nicotinic acid, and folic acid. The high acidity resulting from the fermentation of lactose and its conversion to lactic acid provides an unsuitable environment for the growth of putrefactive bacteria and most pathogenic microbes in the intestines. This leads to their inhibition and facilitates the absorption of calcium, phosphorus, and magnesium from the intestines and their retention in the tissues, which reduces the incidence of rickets in children. Consequently, lactose renders milk an antidote and even prevents rickets (Al-Khawali, 1999).

Furthermore, lactose plays a crucial role in the proliferation of beneficial intestinal flora following the administration of antibiotics orally. Therefore, it can be posited that lactose is of significant importance following the completion of antibiotic treatment, as it serves to prevent pellagra. This is due to the fact that lactose activates bacteria that are responsible for the creation of nicotinic acid within the intestine. Furthermore, the low solubility of lactose makes it less irritating to the membranes lining the stomach and intestines, which makes milk an effective treatment for gastric and duodenal conditions. Additionally, lactose constitutes 30% of the thermal energy obtained from milk, with 1 gram of lactose providing 4 calories (Harding, 1995). Lactose is also employed in the production of dairy ice cream and foodstuffs for infants and young children, as well as in the manufacture of medical products (Meurant, G., 1995).

**Mineral salts**

Milk is a rich source of minerals, with calcium being the most prominent. Additionally, milk contains all the minerals essential for maintaining optimal bodily health, including phosphorus, potassium, magnesium, sodium, chlorine, and sulfur. The presence of iron and copper is minimal. The principal minerals present in milk are calcium and phosphorus. These salts are present in a true solution and in a colloidal state due to their association with proteins (Oskarsson et al., 1995). The salt content of milk can be inferred from the ash, which constitutes less than 1% of the milk. Milk is regarded as a valuable source of salts, as calcium and phosphorus salts contribute to the formation of bones and teeth, while sodium and potassium play a role in the formation of body fluids and muscles, and iron is involved in the formation of red blood cells (Meurant, G., 1995). Additionally, milk contains twenty rare elements that are involved in enzymatic reactions, the majority of which are co-factors in enzyme composition, such as iron, zinc, copper, and manganese. These elements play a crucial role in numerous physiological functions of humans and animals (Al-Khawali, 1999).

**Similarities and differences between types of milk**

Breast milk contains all the essential nutritional components required for the child's growth and development in a balanced manner, according to the child's age, weight, and ability to digest and absorb nutrients. The composition of breast milk is subject to daily fluctuations, even within the span of an hour, in response to the infant's nutritional requirements and the mother's dietary intake. The initial milk produced by the mother, known as colostrum, is characterised by a high concentration of antibacterial agents and ease of digestion, which makes it particularly beneficial for premature infants. Following the initial three-day period following the child's birth, the composition of breast milk undergoes a gradual transition towards a more mature profile over the course of a week. Furthermore, there are notable differences in the composition of breast milk consumed in the morning compared to that consumed in the evening. Furthermore, the characteristics and composition of breast milk change during a single feeding, with the fat content increasing towards the end of the feeding period.

This is intended to provide the infant with a feeling of fullness. The milk produced by a mother who has given birth prematurely (i.e., before the full term) differs from that produced by a mother who has completed her pregnancy. The milk produced by a mother of a premature baby is easy to digest and is proportional to the poor digestive capacity of the premature baby (Fride, et al., 2005). Additionally, the volume of milk produced by the mother changes according to the child's needs. The volume of milk produced by the mother initially reaches 50ml in the first days following birth, increasing to one litre by the sixth month. Despite extensive research, the composition of breast milk remains unknown to scientists. They were ultimately persuaded that this was an untenable position. This is due to the fact that no single milk type can be identified that meets the same specifications across all mothers. The composition of milk produced by each mother's body is tailored to meet the nutritional requirements of her newborn, and this milk provides the optimal nutrition for the child, to the extent that no other food can be considered a suitable substitute. It has been demonstrated that the antibodies, hormones, vitamins, and minerals present in breast milk are contingent upon the requirements of the newborn (Labbok, M.H., 2001).

The process of milk formation is subject to both regulatory control and hormonal regulation. A number of hormones are involved in the process of breast development and the maintenance of lactation. In general, the oestrogen hormone is necessary for the processes of reproduction, growth and branching of the mammary gland ducts, while the progesterone hormone plays a role in the development of the acini and lobules. The anterior pituitary gland also secretes the prolactin hormone, which plays a fundamental role in the maturation of the mammary gland and the formation of milk (Junqueira & Carneiro, 2005). The prolactin and oxytocin hormones play a pivotal role in the process of milk production and secretion. The prolactin hormone plays a role in maintaining milk secretion, while oxytocin, a hormone secreted by the posterior pituitary gland, stimulates the relaxation of the uterine muscles and the release of milk (Neville, M.C., 1999).

Estrogen is one of the basic stimulating factors for the manufacture and secretion of prolactin. Furthermore, estrogen increases the number of milk-producing cells and their size. It is the primary stimulus for the significant increase in prolactin levels during pregnancy (Scheithauer et al., 1990). Prolactin plays a crucial role in milk formation by drawing glucose and amino acids from the blood to the mammary gland and stimulating the synthesis of casein and lactalbumin (milk proteins), as well as lactose and milk fat, in the secretory process within the mammary gland. Molina (2006) posited that high levels of prolactin, reaching 200 ng/ml, and low progesterone are necessary for the onset of abundant milk secretion after birth. Low progesterone is an important factor in milk secretion (Peaker, M. and C.J. Wilde, 1996).It is inevitable that an artificial milk substitute will never be able to replicate the benefits of breast milk. Even if companies were able to match the chemical composition of an artificial milk substitute to that of breast milk, they would be unable to replicate the psychological and emotional benefits, hormonal and structural changes that are available in breastfeeding. Furthermore, research has indicated that breast milk is more beneficial as a food for the child, and that each mother's milk benefits her newborn more than another mother's milk (Donath & Amir, 2000).

The properties of human milk are numerous and continue to be revealed as scientific knowledge advances. The superiority of breast milk is increasingly evident when compared to other types of milk. It maintains a suitable temperature for the infant, is free from microbes and germs that cause disease, and adapts to the infant's nutritional needs, containing a balanced ratio of nutrients appropriate for the infant or newborn. The composition of breast milk is subject to change in accordance with the nutritional requirements of the infant. The quality of a nursing mother's milk differs at the beginning of the breastfeeding process from that at the end. This indicates that breast milk is variable and not constant throughout the year, with its components changing during the seasons in accordance with the child's nutritional needs. The proportion of fat in breast milk rises during the winter months, reflecting the increased energy demands of the body during this period. Conversely, the percentage of protein and mineral salts in breast milk tends to increase during the summer (Ballard & Morrow, 2013; Lawrence & Lawrence, 2010).The act of feeding an infant with breast milk has been demonstrated to confer a number of benefits, both psychological and economic, in addition to the obvious health advantages. posit that breast milk is the optimal nourishment for infants, surpassing cow's milk, other milks, and artificial infant formula in numerous ways. Breastfeeding, or the act of feeding an infant with breast milk, is considered the optimal nutrition for newborns during their first year of life. It may be the case that the benefits of breastfeeding for both infant and mother have been presented in an objective manner, which has prompted mothers in developed societies to reconsider this option that they had previously overlooked.

Nevertheless, in instances where breastfeeding the infant naturally from the mother is not a viable option, the use of artificial feeding is a necessary measure to ensure the nutritional requirements of this age group are met. In some cases, it may be necessary to replace breast milk with another type of milk, such as cow's milk. Although cow's milk provides a calorific value similar to that of breast milk, it is not a suitable substitute for human milk for infants due to its fundamentally different composition. The principal minerals present in milk are calcium, potassium, phosphorus and sodium. Additionally, human milk contains other elements, albeit in trace amounts. In addition, milk is composed primarily of proteins, lactose, lipids, and fats. Despite the crucial importance of these two substances, milk contains only minute quantities of iron and vitamin C. The infant is born with a sufficient iron reserve that will last for several weeks. Additionally, vitamin C can be sourced from orange juice for infants. The nutritional components of human milk are derived from three primary sources. Nutrients are derived from three sources: synthesis in the mammary glands, food, and the mother's body stores. In general, the quality of the nutritional components of human milk is maintained by the mother's adherence to a specific diet. It is crucial to provide some vitamins and some fatty acids that constitute human milk (Lawrence & Lawrence, 2010). Table 2 provides a comparison of the chemical composition of human milk with that of the milk of other animals.

**Table 2.** Comparison of the chemical composition of human milk with that of some animals.

| Contents | Human | Horses | Sheep | Camels | Goats | Cows |
|---|---|---|---|---|---|---|
| Water % | 78.4 | 90.6 | 82.6 | 86.6 | 87.0 | 87.0 |
| Protein % | 1.4 | 2.0 | 5.5 | 4.0 | 3.3 | 3.4 |
| Fat % | 4.0 | 1.1 | 6.5 | 4.3 | 4.2 | 3.9 |
| Sugars % | 7.0 | 5.9 | 4.5 | 4.2 | 4.8 | 4.9 |
| Minerals % | 0.2 | 0.4 | 0.9 | 0.8 | 0.9 | 0.7 |

**The Major (Major) Components of Human Milk**

The nutrient composition of human milk exhibits considerable variation between mothers and during lactation. The mean nutrient composition of mature milk is estimated to be approximately 0.9 to 1.2 g/dL for protein, 3.2-3.6 g/dL for fat, and 6.7-7.8 g/dL for lactose. The estimated energy content of human milk ranges from 65 to 70 kcal/dL and is closely correlated with the fat content of the milk. The composition and quantity of essential nutrients in the milk of mothers of premature infants tend to be higher in protein and fat. The most significant proteins present in human milk are casein, α-lactalbumin, lactoferrin, secreted immunoglobulin IGA, lysozyme and serum albumin. Approximately 25% of the nitrogen content of human milk is derived from non-protein nitrogen compounds, including urea, uric acid, creatine, creatinine, amino acids and nucleotides.

Furthermore, protein constitutes an essential component of milk, with observations indicating a decline in protein levels in human milk following the infant's first 4-6 weeks of life. In the context of premature infant nutrition, it has been observed that the level of total protein and amino acids typically declines in accordance with the duration of pregnancy and lactation. The concentration of protein in milk is not affected by the diet of the mother, but there is a positive correlation between protein concentration and maternal weight. Specifically, protein concentration is higher in mothers with a higher body mass index (BMI) and lower in mothers who produce higher quantities of milk (Nommsen et al., 1991).

One of the most fundamental constituents of milk is fat, which represents the most basic component found in milk. The concentration of fat at the conclusion of a single feeding period is approximately three times higher than its concentration at the commencement of breastfeeding. The fat content of human milk is distinguished by a high concentration of palmitic acid and oleic acid. A study (Lönnerdal, 2014) was conducted on the milk of 71 mothers over a period of 24 hours, and it was found that the percentage of fat in the milk was significantly lower at night and in the morning compared to the evening period (Rodr´ et al., 2000) The primary carbohydrate in milk is lactose. The concentration of lactose in human milk is the least variable of the basic nutrients, but higher concentrations of lactose have been observed in the milk of mothers who produce higher quantities of milk (Nommsen et al., 1991).

With regard to other sugars or carbohydrates, they are polysaccharides (oligosaccharides), which have been found to be approximately 1 g/dL in human milk, depending on the stage of breastfeeding and the genetic factors of the mother. A study estimating the basic components and mineral content of milk samples from cows, goats, sheep, and humans (Etonihu & Alicho, 2010) revealed that human milk exhibited the lowest fat content (13.7%) and ash concentration (0.61%) and the highest protein concentration (4.77%) compared to the other species. The concentration of minerals in the samples (Fe 0.51-0.21 mg/L, Zn 0.89-0.19 mg/L, Cu 0.06-0.01 mg/L) was within the acceptable range as defined by the WHO, although the content of Ni, Cr, and Mn was higher. 2.5.1 Micronutrients of breast milk: Human milk provides a variety of micronutrients that fluctuate depending on an individual's dietary intake and body reserves. These include vitamins D, B12, B6, B2, B1, and A, as well as iodine. It is not always the case that the diet of the mother is optimal.

Therefore, it is recommended that multivitamins be provided to the infant during the period of breastfeeding, regardless of the quality of the mother's diet. World Health Organization. In 1996, it was observed that vitamin D levels in breast milk were notably low, particularly in mothers with minimal sun exposure. The recommendations indicate that vitamin D supplementation should be initiated following birth for infants who are breastfeeding. This is based on a scientific comparison between breast milk as the primary food source for infants and the various mixtures that provide nutrition for infants in exceptional circumstances. The findings suggest that breast milk remains the optimal choice in the majority of cases (Ballard & Morrow, 2013). One of the most remarkable attributes of human milk is its compositional variability throughout the year. The components of milk change in accordance with the nutritional requirements of the human body, with the percentage of fat increasing during the winter months due to the body's greater need for energy, and the percentage of protein and mineral salts rising in the summer to compensate for any deficiencies (Kulski & Hartmann, 1981).

**Essential Minerals in Breast Milk**

The child's mineral requirements, with the exception of iron, are met if the requisite amount of breast milk is consumed, given that breast milk is deficient in iron. The infant is born with an adequate supply of this element within the body. During the infant's first year of life, there is an increased requirement for calcium and phosphorus, which are essential for the growth and development of the skeletal system and teeth. The provision of vitamin D ensures that breast milk provides the child with an adequate intake of these two elements. Breast milk contains essential minerals, including calcium, potassium, sodium and phosphorus, in sufficient quantities to meet the infant's requirements during different stages of growth. The proportions of these elements vary in accordance with the infant's age. (Dawodu et al., 2010).

Minerals play a significant role in human life, with some, such as manganese, being essential for life in small quantities. Furthermore, human milk contains essential minerals that are necessary for the child's growth and development. These include sodium, potassium, calcium, and phosphorus, as well as other minerals that contribute to the formation of the child's systems in quantities that are appropriate for the infant's age. Furthermore, it should be noted that not all minerals are naturally present in human milk. In the event that they are present, they are often a by-product of pollution. A number of toxic elements have been identified in breast milk at elevated concentrations, suggesting that children may be exposed to these substances prior to birth and throughout the breastfeeding period (Al-Takrouri, 1989). However, the concentrations of minerals in breast milk are contingent upon two significant factors:

- The length of time the nursing mother is exposed to pollutants during breastfeeding is a significant factor.
- The potential for exposure to these substances prior to birth (Dorea, J.G., 2000).

The majority of minerals present in breast milk are also found in drinking water. Air is regarded as a source of pollution, with certain toxic compounds entering the body's tissues via the respiratory system, digestive system, or skin as a consequence of contamination of plant and animal foods with a range of pollutants. The human body is capable of eliminating toxic metals through a number of mechanisms, including the excretion of metals in the hair, nails, and breast milk of nursing mothers. A comparison of the level of lead in the blood of a nursing mother with its percentage in milk revealed a high probability of lead transfer from the blood to the milk (Kinsara & Farid, 2008).

**Heavy metals in breast milk**

**Iron**

The iron content of the milk of a breastfeeding woman is, on average, 3 ppm. This quantity is higher in the early stages of the milk cycle, reaching 4 ppm, and then gradually decreases during the first 6-8 weeks. It has been previously observed that the concentration of iron in the milk of mothers who are breastfeeding premature infants is significantly higher during the breastfeeding stages. However, in other studies, the percentages were not found to be statistically significant. It has been demonstrated that the supplementation of a mother's diet with incremental quantities of iron does not influence the concentration of iron present in her milk. In a number of studies, researchers administered a concentration of iron to breastfeeding mothers in addition to their natural stores, and no change was observed in the percentage of iron present in their milk (Silvestre et al., 2000).

**Cadmium**

It is one of the non-essential mineral elements required by humans, yet it is also a toxic element. The absorption rate for adults is estimated at approximately µg Cd/day, with 200 µg Cd excreted in the urine and approximately 0.9–1.8% excreted through feces, sweat, and hair. The remainder may be excreted through breast milk if its concentration exceeds the required limit (Mahabbis et al., 2009). The absorption rate of cadmium in the body can be increased for a number of reasons, including a deficiency of certain minerals such as iron and calcium, as well as age-related factors. With regard to the element's cobalt and selenium, these have been demonstrated to reduce the absorption of cadmium in the body and are therefore considered to be factors that remove its toxicity. Similarly, the presence of zinc has been demonstrated to reduce the toxicity of cadmium. Furthermore, studies have demonstrated that the concentration of cadmium in maternal milk is influenced by the level of exposure. An increase in cadmium concentration in milk is associated with a reduction in calcium concentration. (Fransson &

Lönnerdal, 1980) Research has demonstrated that the mammary gland and placenta impede the transfer of cadmium to the foetus and milk. Consequently, the presence of cadmium, even in a minute percentage, in breast milk is regarded as a severe case of poisoning, and the remaining symptoms of cadmium poisoning manifest, including vomiting, dry throat, headache and pulmonary haemorrhage in mothers who exhibit the presence of a percentage of cadmium in the milk (Mahabbis et al., 2009).

**Lead**

The human body is equipped with a number of mechanisms that facilitate the excretion of toxic metals, including the hair, nails, and milk produced by nursing mothers. A comparison of the level of lead in the blood of a nursing mother with its percentage in milk revealed a high probability of lead transfer from blood to milk (Nassir et al., 2013). In some studies, it has been demonstrated that lead poisoning in newborns may be caused by breastfeeding with milk containing high concentrations of lead. In a study conducted in Mexico to measure lead concentrations in blood and milk samples of nursing mothers, the results indicated a clear correlation between high concentrations in the blood and an increase in milk, and vice versa. The average results were 458.8 ppm and 24.7 ppm for blood and milk, respectively (Casey et al., 1989).

The lead concentrations found in the milk of nursing mothers are not solely due to the mother's exposure to lead during the breastfeeding period. Rather, they also result from lead stored in the mother's bones, given that it is structurally similar to calcium and may therefore be stored in the same way in the bones. During the two periods of pregnancy and lactation: In the event of a calcium deficiency, the mother's body will remove calcium from her bones in order to provide it for the formation of her foetus's bones. Similarly, the lead stored in the mother's bones is transferred to her foetus, and this phenomenon also occurs during lactation. The intake of sufficient quantities of calcium by the mother during the periods of pregnancy and lactation prevents the utilisation of her calcium reserves, thereby avoiding the transfer of the accumulated lead to these stores (Nassir et al., 2013; Mahabbis et al., 2009).

**Justifications For the Study**

The increase in the percentage of children who are fed artificial milk, which has reached 90% in some countries, has led to a debate about the advantages and disadvantages of breast milk and artificial milk. This research aims to compare and contrast the nutritional impact of natural and artificial milk on children.

- A paucity of awareness regarding the importance of healthy nutrition for the mother during the perinatal period.
- The increasing reliance on artificial nutrition.
- The plethora of artificial milk brands, with a wide range of price points and quality levels.

**Study hypotheses**

The research problem was identified, and the following hypotheses were formulated:

Does the nutritional value of mineral elements remain equal in the two types of natural and artificial milk that were studied, and can the level of minerals in both types be compared?

**Study objectives**

In light of the pivotal role of human milk as the primary source of nutrition for newborns, it was deemed imperative to undertake this research, which aims to:

The initial objective was to: The objective of this study is twofold: firstly, to determine the levels of certain mineral elements (iron, lead, cadmium, sodium, potassium, calcium and magnesium) in the milk of women who are breastfeeding, and secondly, to compare the composition of natural and artificial breast milk at two different stages of infant development: 0-6 months and 6-12 months.

**Study limits**

- The objective limits are as follows:
- A comparative analysis of natural and artificial milk in terms of their elemental and mineral composition.

Spatial limitations: The study was conducted in the city of Misurata, Libya.

- The limitations of the human body:
- The study was limited to breastfeeding mothers in some Misurata hospitals (Misurata Medical Centre).
- The temporal limits of the study are as follows:
- The study was conducted over a period of ten months, from March 2021 to October 2021.

**Literature review**

**Main components of infant formula**

The study conducted by Martin (2016) demonstrated that, the protein content of breast milk is 1 gram per 100ml, whereas that of formula milk is 3.5 grams per 100ml. Additionally, protein contains casein, with breast milk comprising 20% casein and formula milk comprising 50% casein. The fat content of breast milk is 4 grams per 100ml, in comparison to 3.8 grams per 100ml in formula milk. The proportion of energy derived from polyunsaturated fatty acids in breast milk is 6%, whereas in formula milk this figure is 0.5%. Additionally, carbohydrates (lactose) are present in breast milk at a concentration of 7.4 grams per 100ml, while in formula milk, they are present at a concentration of 4.5 grams per 100ml. The concentration of vitamin D in breast milk is 8 micrograms per 100ml, whereas the corresponding figure for formula milk is only 0.16 micrograms per 100ml, representing a fivefold reduction in vitamin D content. The concentration of vitamin B1 in breast milk is 10-20 micrograms/100ml, while that of vitamin B2 is 30 micrograms/100ml. With regard to minerals and salts, the percentage of sodium, potassium, calcium, magnesium, phosphorus and zinc is higher in formula milk, while the percentage of iron and copper is higher in breast milk.

This increase in the percentage of minerals has an effect on the child's body and the work of the internal organs. For example, sodium in breast milk is 7 mmol/L, whereas in formula milk it is 25 mmol/L. Similarly, calcium in breast milk is 34 mg/100 ml, whereas in formula milk it is 120 mg/100 ml. Furthermore, phosphorus in breast milk is 14 mg/ml, whereas in formula milk it is 95 mg/100 ml. A further study revealed that 25% of the disparity in fat concentration between mothers can be attributed to variations in dietary intake and protein consumption. Furthermore, the concentration of fatty acids in breast milk varies according to the maternal diet, with a notable distinction observed in the levels of long-chain unsaturated fatty acids. The study, conducted in Davis, California, elucidated the relationship between the behaviour and characteristics of mothers and the composition of human milk. It was determined that the concentration of the basic components four months after birth is associated with one or more of the following factors: body weight, protein intake, return of menstruation, and nursing frequency. Furthermore, it was determined that mothers who produce less milk exhibit lower protein and fat concentrations and higher lactose concentrations. Additionally, the protein content of milk obtained from mothers of preterm infants is observed to be higher than that of milk from mothers of full-term infants (9 months of pregnancy).

Goldsmith et al. (2015) indicated that breast milk provides nutrients along with a wide variety of non-nutritive bioactive components, including antibodies, glycans, bacteria and immune proteins. Furthermore, the presence of probiotics in breast milk has been shown to foster the development of a healthy gut microbiota in infants.

**Additional minerals and elements**

A number of studies have assessed the concentration of specific heavy metals in breast milk as potential biomarkers of maternal exposure. The concentration of selected heavy metals (Pb, Cd, Cr, Cu, Zn, Fe, As, Hg) in breast milk was analysed, and the results demonstrated a positive and significant correlation ($p < 0.01$) with the estimated daily intake of breast milk by the infant. The greatest daily intake of heavy metals, including lead, iron and cadmium, was observed in comparison to the other metals analysed. No significant correlation was identified between maternal diets and exposure to heavy metals, including copper, iron, and lead. Notably, none of the samples exceeded the national and international legal regulatory limits for AFM1 and selected heavy metals in breast milk, with the exception of chromium. Nevertheless, the presence of these pollutants continues to present a health risk to children, particularly at this early developmental stage. (2020 Al Ekeanyanwu et al.)

Another study indicated that there may be a potential risk of toxic metals, especially lead, for children in Hamadan city through the consumption of breast milk. (2019 Samiee et al.) In some studies, it was found that lead poisoning in newborns may be caused by breastfeeding with milk containing high concentrations of it.

In a study that analysed the essential and non-essential elements of samples of infant formula sold in Nigeria, the United Kingdom and the United States of America, the researchers observed that the highest levels of metals recorded in samples of soy milk as well as some brands were below the recommended nutritional allowances in North America (Ikem, A., et al., 2002).

The study conducted by Al-Saleh and colleagues (2003) demonstrated that... The objective was to determine the concentrations of lead, cadmium and mercury in the breast milk of lactating mothers from the Riyadh and Al-Ahsa regions in Saudi Arabia who were not occupationally exposed. The mean levels of cadmium, lead and mercury were found to be 1.732 µg/L, 31.671 µg/L and 3.100 µg/L, respectively. In contrast, mercury Gundacker et al. (2002) demonstrated that exposure to mercury (Hg) and lead (Pb) may result in neurotoxicity, renal failure and anaemia. Their tests indicated that the concentrations of mercury and lead did not exceed critical levels. Furthermore, the Codex Alimentarius Commission has adopted a recommendation that no more than 0.01 milligrams per kilogram (mg/kg) of lead be permitted in infant formula consumed in the marketplace. A cross-sectional study was conducted in the Iraqi city of Hillah on the milk of 68 healthy volunteer nursing mothers. The objective was twofold: firstly, to determine and measure lead and cadmium in the human milk of nursing mothers; and secondly, to clarify the relationship between the concentration of these elements and various factors.

In addition, the percentage of mothers with milk with high concentrations of these heavy elements was determined. The study demonstrated that the mean concentration of lead (in parts per billion, ppb) in the milk of nursing mothers was 25.9 ± 18.4, while the mean concentration of cadmium (in ppb) was 5.6 ± 1.77. These values are significantly higher than those reported in other international studies. The study identified a correlation between elevated lead and cadmium concentrations and residential proximity to urban streets and industrial areas, as well as the consumption of river water, particularly among younger nursing mothers (Fransson & Lönnerdal, 1983). A study conducted by Nassir and colleagues (2013) indicates that the percentage of lead and cadmium is higher in smokers than in non-smokers. This is due to the fact that one cigarette contains 0.1-0.2 µg of Cd. In a German study designed to quantify the concentration of cadmium in milk and to ascertain any potential correlation with maternal smoking habits, it was observed that there is a direct relationship between the number of cigarettes smoked by the mother per day and the level of cadmium present in her milk.

A study (Silvestre, et al., 2022) was conducted in Sweden, specifically in the city of Uppsala, to measure the concentrations of lead and cadmium in the milk of breastfeeding mothers. The concentrations were found to be 0.02 ppm and 0.001 ppm, respectively. In a study (Sternowsky & Wessolowski, 1985), samples were taken at the sixth week of birth from 75 nursing mothers, some of whom resided in proximity to copper and lead smelters, and mothers from other areas. The concentrations of lead and cadmium were quantified. The results indicated an increase in lead concentrations in the milk of the first group of samples, estimated at 0.009 ppm, while its concentration in the second group was 0.005 ppm. The concentration of cadmium in the milk of the second group of mothers was found to be higher than that of the first group, reaching 0.007 ppm and 0.005 ppm, respectively.

A study (Radisch et al., 1987) conducted on Indian, Malaysian and Chinese mothers revealed that the iron content in their milk differed according to their ethnic origins and appeared to be unrelated to the iron levels in their bodies. The iron concentration in the milk of breastfeeding mothers was found to remain constant despite fluctuations in iron levels in the body. Additionally, the iron content was observed to be unaffected by the use of contraceptive medication and smoking. However, the absorption of iron from breast milk was found to decline significantly following the introduction of solid foods to the infant.

In a study that measured the iron concentration in the milk of 101 breastfeeding mothers, the concentrations ranged between 1.4 and 0.5 ppm. (Al-Takrouri, 1989) Some studies have demonstrated that the concentration of iron in the milk of mothers who have breastfed premature infants is significantly higher, while in other studies the percentages were not significantly different (M. Rodr et al., 2000). The objective of the study was to analyse the content of calcium (Ca), magnesium (Mg), copper (Cu) and zinc (Zn) in the milk of Indian mothers. The milk samples were obtained from 14 mothers who had given birth to premature infants (gestational age less than 35 weeks) and 50 mothers who had given birth to full-term infants (gestational age 39 weeks) (Gupta et al., 1984). The mean levels of zinc, copper, and magnesium in the milk of mothers who had full-term pregnancies were found to be higher than those observed in the milk of mothers who gave birth to premature infants.

**Materials and Methods**

Seven samples of breast milk were randomly selected from the Misurata area and collected in polyethylene bottles. Subsequently, the samples were stored in a frozen state until analysis was conducted. With regard to the samples of industrial dried milk, ten types of milk available on the market in Misurata were selected for analysis. A questionnaire was constructed for the purposes of this research project, comprising 25 questions with multiple response options. The nine research papers were distributed, and all were duly received and their responses collated in a Microsoft Excel file (version 2010). This data was then used to generate the graphs.

The atomic absorption spectroscopy device was operated in accordance with the specifications provided by the manufacturer. The Agilent Technologies 200 Series AA, manufactured in the United States of America (USA), is available in two variants: a flame and a tube graphite atomiser. At the Food and Drug Control Centre in Misurata and the Quality Laboratory of the Libyan Iron and Steel Company in Misurata.

The estimation of specific elements in milk (Fa, Ca, Cd, Na, Mg, K, Pb) was conducted via wet digestion of milk using a mixture of concentrated nitric acid and hydrogen peroxide at a ratio of (1:3), in accordance with standardised methods (AOAC, 1997). This approach has been employed by numerous previous studies, including that of Saracoglu, S. et al. (2007). The methodology employed is outlined in the following section.

- A quantity of 5 grams of the milk sample is to be placed in a 250 ml cup. Subsequently, a mixture of 6 ml of concentrated nitric acid (HNO3, 69%) and 2 ml of hydrogen peroxide (H2O2, 30%) should be added. The solution should be heated for one hour in a water bath at a temperature of 70°C inside the gas cabinet.

- The mixture should then be cooled to a temperature slightly below that at which it was previously heated, and the same volume of the previous mixture should be added. The solution should be heated on an electric heater at a temperature not exceeding 130°C and maintained at this temperature for a period of two to three hours until the yellow vapours of nitrous oxide have been eliminated.
- Subsequently, the mixture should be cooled and 5ml of deionised water.
- The mixture should then be cooled and 5ml of deionised water added.

The solution was filtered into a standard flask with a volume of 25ml using an ashless filter paper (Wattman filter paper, Ash Less, No. 42), and the volume was completed with deionised water to the mark. The blank sample was subjected to the aforementioned steps in the absence of the sample itself (William, H., et al. 1980; Horwitz, W., et al. 1982).

**Statistical Analysis**

The SPSS statistical software was employed to perform the requisite calculations and to conduct the descriptive and inferential statistical analysis. This was achieved through:

1. the use of frequency tables, which illustrate the number of responses to each question in the questionnaire.
2. Tables of relative frequencies, indicating the percentage of respondents who selected each answer to each question in the questionnaire.
3. A pie chart is a graphical representation of data in which the areas of the slices are proportional to the frequencies of the categories represented.
4. The mean, standard deviation and standard error should be provided.
5. A t-test was employed for the purpose of comparing the two samples, with a view to establishing whether there were any significant differences between the elements in both types of breastfeeding.
6. The confidence interval for the mean represents the minimum and maximum values for each element in general for each group.

**Results and discussion**

**Results of the questionnaire for breastfeeding mothers**

In order to gain insight into the nutritional behaviour of mothers during the breastfeeding period and its impact on the components of the milk produced by the mother, as well as its effect on the health of the child, a questionnaire was designed and administered to the women who donated the study samples.

The study included nine women who completed the questionnaire, which was subsequently imported into Microsoft Excel (version 2010) for graph generation.

The results demonstrated a diversity of residential locations among the participants, with representation across the majority of Misurata city districts. Please refer to Figure 1. The results demonstrated a diverse range of age groups, with the 20-30 age group representing the largest proportion at 71.43%. In contrast, the 30-45 age group constituted a relatively smaller proportion at 28.57%. Additionally, the educational profile of the participants in the questionnaire revealed that the majority had attained intermediate education, either at the intermediate or secondary diploma level (22.2%), while a significant proportion had pursued higher education or university studies (77.8%). Please refer to Figure 2.

Most of the respondents were housewives (55.6%), while the next largest group were students (33.3%). Only a small number were employed (11.1%), Figure 3. The questionnaire also indicated that 42.9% of respondents observed differences between the various types of formula milk available on the market. It became evident that the most frequently utilized infant formula is the Primilac brand, with a percentage of 33.3%. The next most popular brand was My Boy, with a percentage of 22%, while 11% of respondents indicated that they do not adhere to a specific type. The percentage of those who do not use formula milk for breastfeeding was 22%.

Additionally, it was determined that 28% of mothers do not boil water prior to preparing the feeding bottle. Notably, the majority of mothers (71.4%) initiate formula milk use for breastfeeding during the first three months of pregnancy. This is particularly concerning given that 42.9% of women do not adhere to the recommended preparation method for milk. Figure 4 illustrates this finding. The findings also indicated that the majority of mothers do not adhere to a balanced diet during the breastfeeding period. Figure 5**,** Presents the amount of milk their children need per day Furthermore, only 33% of them expressed satisfaction with the use of nutritional supplements to compensate for the deficiency in nutrients and produce sufficient milk for their children according to their needs.

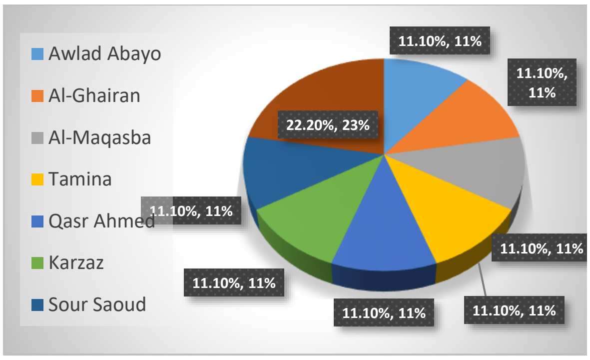


**Figure 1**. Place of residence of mothers participating in the questionnaire.

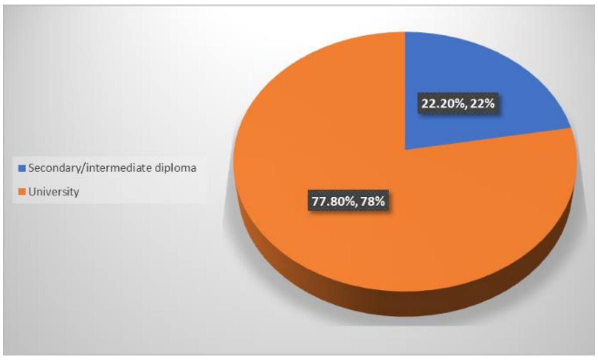


**Figure 2**. Educational level of mothers participating in the questionnaire.

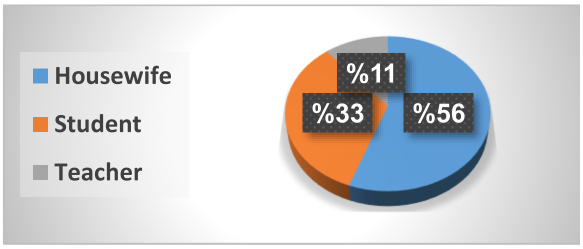


**Figure 3.** Occupation of mothers participating in the questionnaire.

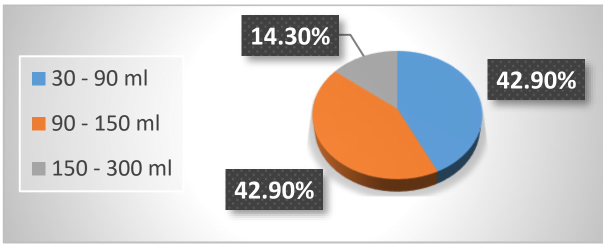


**Figure 4.** The period during which artificial breastfeeding was used in the study sample.

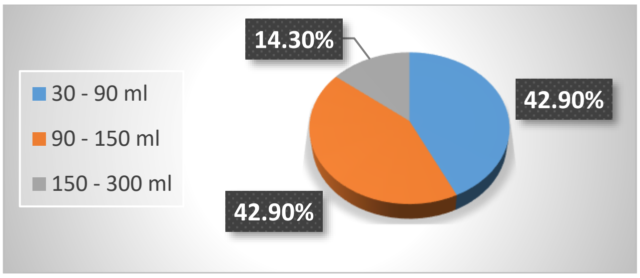


**Figure 5.** The amount of milk their children need per day.

**Estimation of essential elements and minerals**

**Estimation of mineral elements in breast milk samples**

Table 3 indicates that the mean concentration of essential elements in breast milk, expressed in milligrams per litre, is sodium (1.9 ± 14.4), potassium (1.07 ± 10.7), calcium (1.44 ± 31.7) and magnesium (0.11 ± 9.08). With regard to heavy elements, the mean concentrations in the aforementioned samples were as follows: iron (0.38 ± 2.6 mg/L), cadmium (0.006 ± 0.01 mg/L), and lead (0.01 ± 0.04 mg/L).

**Table 3.** The estimation of essential elements and minerals in breast milk samples.

| Type of milk | | Elements mg/L | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Sodium | Potassium | Calcium | Magnesium | Iron | Cadmium | Lead |
| Breast milk | 1 | 15.23 | 11.68 | 31 | 9.193 | 2.776 | 0.0121 | 0.0499 |
| | 2 | 16.21 | 10.89 | 34.01 | 9.151 | 2.678 | 0.0023 | 0.0398 |
| | 3 | 15.11 | 11.01 | 30.28 | 9.027 | 3.002 | 0.0123 | 0.0481 |
| | 4 | 12.26 | 8.79 | 33.01 | 9.213 | 2.920 | 0.0157 | 0.0451 |
| | 5 | 15.09 | 11.1 | 32 | 9.001 | 2.319 | 0.0023 | 0.0211 |
| | 6 | 16.17 | 10.08 | 30 | 9.113 | 2.085 | 0.0213 | 0.0501 |
| | 7 | 11.35 | 12 | 31.79 | 8.893 | 2.101 | 0.0127 | 0.0338 |
| Average | | 14.4885 | 10.7928 | 31.7271 | 9.0844 | 2.6972 | 0.0112 | 0.0411 |
| Standard deviation | | ±1.9 | ±1.07 | ±1.44 | ±0.11 | ±0.38 | ±0.006 | ±0.01 |

**Estimation of mineral elements in formula milk samples (0-6 months)**

Table 4 illustrates the mean concentration of essential elements in formula milk intended for children aged 0-6 months in mg/L. The mean concentration of sodium is 0.24±18.8, potassium is 0.52±11.5, and calcium is 3.90±62. The average concentrations of essential elements in the samples were as follows:

sodium (0.24±18.8), potassium (0.52±11.5), calcium (3.90±62.0). The average concentrations of heavy elements in the same samples were as follows: iron (0.50±2.39), cadmium (0.00±0.019), and lead (0.06±0.17).

**Table 4.** The estimation of essential elements and minerals in formula milk (0-6 months).

| Type of milk | | Elements mg/L | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Sodium | Potassium | Calcium | Magnesium | Iron | Cadmium | Lead |
| Formula milk (0 – 6) | Plasmon | 19.11 | 12.03 | 61.19 | 19.17 | 2.020 | 0.0159 | 0.1720 |
| | Primalac | 18.22 | 10.78 | 60.88 | 21.45 | 2.981 | 0.0310 | 0.1308 |
| | My boy | 18.68 | 11.31 | 61.08 | 16.28 | 1.816 | 0.015 | 0.2803 |
| | Liptomal | 19.33 | 11.99 | 69.53 | 16.02 | 2.333 | 0.0218 | 0.1351 |
| | Bebelace | 18.78 | 11.68 | 60.22 | 20.90 | 2.831 | 0.0150 | 0.1380 |
| Average | | 18.824 | 11.558 | 62.58 | 18.764 | 2.3962 | 0.01974 | 0.17124 |
| Standard deviation | | ±0.42 | ±0.52 | ±3.90 | ±2.53 | ±0.50 | ±0.00 | ±0.06 |

**Estimation of mineral elements in formula milk samples (6-12 months):**

Table 5 shows that the mean concentration of essential elements in formula milk intended for children aged 6-12 months is 2.2 ± 19.2 mg/L for sodium, 1.7 ± 11.2 mg/L for potassium, 3.5 ± 65.1 mg/L for calcium, and 3.4 ± 25.42 mg/L for magnesium. With regard to heavy elements, the mean concentrations in the aforementioned samples were as follows: iron (0.04 ± 3.3), cadmium (0.003 ± 0.017), and lead (0.2 ± 0.20), as illustrated in Table 5.

**Table 5.** The estimation of essential elements and minerals in formula milk (6-12 months).

| Type of milk | | Elements mg/L | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Sodium | Potassium | Calcium | Magnesium | Iron | Cadmium | Lead |
| Formula milk (6 – 12) | Primavita | 17.88 | 8.23 | 67.23 | 28.94 | 3.023 | 0.0121 | 0.0628 |
| | France lait | 19.05 | 11.15 | 60.92 | 20.14 | 3.188 | 0.0216 | 0.0779 |
| | Nido | 23 | 12.91 | 69.40 | 25.20 | 4.153 | 0.0197 | 0.1653 |
| | My boy | 19.2 | 11.68 | 62.14 | 27.85 | 3.167 | 0.0151 | 0.0228 |
| | Similac | 17.01 | 12.1 | 66.28 | 24.97 | 3.110 | 0.0187 | 0.7140 |
| Average | | 19.228 | 11.214 | 65.194 | 25.42 | 3.3282 | 0.01744 | 0.20856 |
| Standard deviation | | ±2.2 | 1.7± | 3.5± | 3.4± | 0.4± | 0.003± | 0.2± |

**Comparison Of the Content of Essential Elements and Minerals in Natural Milk with Artificial Milk**

**Essential elements:**

To ascertain the essential elements of breast milk in comparison with those found in artificial baby milk, the one-sample statistics test was employed to extract the level of significance P-value at a confidence level of 0.05. This determines the presence of significant statistical differences between the two groups. As evidenced in Table 6, there were notable disparities between breast milk and artificial milk with regard to the element's sodium, calcium, and magnesium. Conversely, no discernible differences were observed for the element potassium. It is noteworthy that the artificial milk sample exhibited considerably higher levels of sodium, reaching approximately double the concentrations of calcium and magnesium.

**Table 6.** The significant differences between breast milk and formula milk in terms of essential elements.

| Element | Breastfeeding type | NO | Mean | .Std Deviatio | Std. ErrorMean | P-value | Differences |
|---|---|---|---|---|---|---|---|
| Sodium | Breast milk | 7 | 15.012 | 1.443 | 0.589 | 0.000 | Have |
| | Infant milk | 10 | 18.824 | 0.426 | 0.190 | | |
| Potassium | Breast milk | 7 | 10.592 | 1.021 | 0.417 | 0.089 | Have not |
| | Infant milk | 10 | 11.558 | 0.522 | 0.234 | | |
| Calcium | Breast milk | 7 | 31.717 | 1.583 | 0.646 | 0.000 | Have |
| | Infant milk | 10 | 62.580 | 3.903 | 1.746 | | |
| Magnesium | Breast milk | 7 | 9.116 | 0.087 | 0.035 | 0.001 | Have |
| | Infant milk | 10 | 18.764 | 2.532 | 1.132 | | |

**Heavy metals**
A comparison of the levels of heavy metals in the two types of milk using the one-sample statistics test revealed significant differences between breast milk and formula milk for lead, due to its high level in breast milk. However, no significant differences were observed for iron and cadmium. These findings are presented in Table 7.

**Table 7.** The significant differences between breast milk and formula milk for heavy metals.

| Element | Breastfeeding type | NO | Mean | Std. Deviatio | Std. ErrorMean | P-value | Differences |
|---|---|---|---|---|---|---|---|
| Iron | Breast milk | 7 | 2.630 | 0.358 | 0.146 | 0.391 | Have |
| | Infant milk | 10 | 2.396 | 0.503 | 0.225 | | |
| Cadium | Breast milk | 7 | 0.011 | 0.008 | 0.003 | 0.078 | Have not |
| | Infant milk | 10 | 0.020 | 0.007 | 0.003 | | |
| Lead | Breast milk | 7 | 0.042 | 0.011 | 0.005 | 0.001 | Have |
| | Infant milk | 10 | 0.171 | 0.063 | 0.028 | | |

**Discussion**
The results demonstrate a clear tendency among mothers to opt for formula milk over breastfeeding, particularly during the initial months of the infant's life. However, high levels of nutrients such as sodium, magnesium and calcium may have an impact on the child's health. The incomplete functioning of the kidneys in children results in the inability of these organs to excrete the entirety of the sodium present in the body. This leads to an accumulation of sodium in the blood, which in turn causes the development of hydronephrosis. This issue is compounded when the mother fails to adhere to the preparation instructions set out in the product packaging. The water content in the formula may be insufficient, which increases the concentration of sodium. Additionally, the high calcium content is accompanied by the absence of vitamin D, which is necessary for calcium absorption. This has prompted milk manufacturers to add large amounts of vitamin D, which in turn increases calcium absorption and the likelihood of infection with kidney and bladder calcification in children.
Furthermore, the disadvantages of artificial baby milk are significant and cannot be overlooked. These include the potential for allergies in some children, the risk of exposing the child to quantities of mycotoxins, specifically aflatoxins M1 and M2, and instances of commercial fraud, particularly in cases where the milk is produced in countries with stringent manufacturing laws. In recent times, there has been a proliferation of methods employed with the objective of enhancing profitability. Among these are the utilisation of melamine and insulin-like growth factors (IGF), which are employed by certain companies with the intention of augmenting the production of cow's milk. The presence of elevated levels of lead in breast milk is a significant public health concern, as it is an indicator of potential contamination of food and water sources in the surrounding environment. A study conducted by Al-Kabeer (2018) in the city of Misurata on breast milk indicated high concentrations of iron and cadmium in comparison to the permissible rates. The prevalence of abnormally high concentrations of iron, cadmium and lead among breastfeeding mothers was 29%, 25% and 29%, respectively. This suggests contamination with these metals in the city's environment.
These elevated concentrations have an impact on children's health. While immediate effects may not be observed, cumulative exposure to low levels of lead can result in adverse outcomes over time. The developing brain is particularly vulnerable to the damaging effects of lead, with potential for irreversible impairment. Exposure to elevated levels of lead can result in damage to the kidneys and the nervous system, both in children and adults. Furthermore, exceedingly elevated levels of lead have been associated with the onset of seizures, loss of consciousness, and even mortality.
A new report released today by UNICEF and Pure Earth reveals. The report, the inaugural study of its kind, indicates that approximately one-third of children—up to 800 million globally—have blood lead levels exceeding 5 micrograms per deciliter, the threshold for intervention. Approximately half of these children reside in South Asia. "Lead poisoning has few early symptoms, but it has a significant and often insidious impact on children's health and development, with potentially deadly consequences," stated UNICEF Executive Director Henrietta Fore. In light of the pervasive prevalence of lead poisoning and its profound impact on the lives of individuals and communities, it is imperative to take immediate and decisive action to safeguard children from this threat. Furthermore, exposure to lead pollution during childhood has been linked to behavioural and mental health problems, as well as an increased prevalence of crime and violence. The report indicates that older children are also susceptible to significant adverse effects, including an elevated risk of developing kidney, heart, and other organ damage in later life (Rees, N., & Fuller, R., 2020).

**Conclusion**

The findings of this study, when considered alongside the results of numerous previous studies on infant nutrition, provide compelling evidence that breast milk is the most appropriate and optimal source of nutrition for infants. Breast milk provides infants with the necessary calories and essential nutrients in optimal proportions, making it the ideal choice for infant nutrition. There are significant differences between breast milk and infant formula produced from dried cow's milk. Such differences will undoubtedly have an impact on the child's physical, mental and psychological health. In addition to the aforementioned advantages for the infant, breastfeeding has several benefits for the mother.

The growing prevalence of mothers using dried milk during the initial stages of their children's lives will have ramifications for the future health and safety of subsequent generations. Furthermore, the elevated levels of heavy metals in our bodies serve as a cautionary signal, underscoring the importance of mindful dietary choices and environmental hygiene.

**Recommendations**

- The study proposes that mothers should exclusively breastfeed their infants for the first six months of the child's life in order to facilitate optimal growth, development and health. In order to meet their advanced nutritional requirements, infants should be provided with nutritionally appropriate, safe, and complementary foods while continuing to breastfeed until the age of two years.
- It is recommended that mothers consume a balanced diet during pregnancy and breastfeeding to ensure the provision of essential nutrients for their child's growth and development.
- It is recommended that the levels of heavy metals in imported baby formula and the drinking water used in preparing baby food be continuously measured.
- It is recommended that mothers be educated about the importance of natural milk for the child's immunity against disease and normal growth.
- It is recommended that mothers be educated about the role of breastfeeding in weight loss, maintenance of fitness, and prevention of pregnancy.
- It is imperative to enhance the awareness of all mothers regarding the advantages of breastfeeding for both the mother and the infant.

In the event that artificial milk is utilised, it is advised that:

- The users are informed that the product is not sterile. Furthermore, it should be noted that the product may be contaminated with pathogens that may cause serious diseases. The likelihood of infection can be diminished by ensuring that the formula is prepared and handled in an appropriate manner.
- It is recommended that the Food Control Centre implement measures to prevent the circulation of PIF types that do not comply with the international specifications set by the World Health Organization (WHO). Additionally, it is essential to ensure that the method of preparing the meal is conducted in a safe manner.
- It is recommended that a specific type of milk be used in accordance with the child's medical requirements.
- It is imperative to educate mothers on the necessity of sterilising the feeding bottle before each use, as well as accurately adding the appropriate amount and ensuring that the product used has not exceeded its expiration date.
- The obligation of husbands to facilitate the natural breastfeeding of their healthy wives.

**Referances**


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