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Research Article

Evaluation of macro, micro, and toxic minerals in Dates fodder in Basra, Southern Iraq

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Abstract
Mineral concentrations in plants are affected by a number of factors, which in turn affect the amounts available directly or indirectly to animals, so the concentration of some nutrients may be insufficient for the needs of animals. The article aimed to evaluate a wide variety of chemical elements in date fodder often used to feed cows, buffaloes, and sheep in Basra Governorate, Southern Iraq. In addition, it establishes the acceptability of chemical element concentrations in the dates, which included macro-minerals, micro-elements, and hazardous metals. The feed was prepared to be digested and then all minerals were analyzed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) equipment to determine the amounts of macro-minerals, micro-elements, and hazardous elements in the feed. Where macro-minerals included (calcium, magnesium, phosphorus, potassium, sodium, and sulfur) and micro-elements included (iron, copper, nickel, selenium, chromium, tin, silicon, vanadium, and molybdenum, while toxic elements included (aluminium, arsenic, cadmium, uranium, and lead). Most major and minor elements had low values compared to the critical level determined for their presence in fodders, as all elements did not reach the maximum tolerable(4.5% of macro-minerals and 40 ppm of micro-elements) and much less than the minimum limit(<0.06 of macro-minerals and <0.20ppm of micro-elements), whereas the toxic elements in the chosen dates fodder had low and acceptable concentrations compared to the risk index for their presence in fodder(100 mg Kg^{-1}). The current study helps farmers in Basra Governorate in their understanding of the mineral nutritional needs of cattle while relying significantly on this type of fodder.

Keywords: Dates Fodder, Macro, Micro, Minerals, Southern Iraq, Toxic

INTRODUCTION

Production, distribution, and consumption of feed all significantly contribute to global food security. Plant byproducts are a significant source of non-edible animal feed on a global scale (Salami *et al.*, 2019). The need for more sustainable production and consumption of animal-source food is central to the achievement of sustainable development goals (Van Zanten *et al.*, 2018). It is crucial to find more non-food plant resources to support the animal feed sector and boost livestock production because the cost of animal feed is continuously rising. Plant wastes may contaminate the air, land, and water. However, they may be valuable resources if they are wisely managed. Plant wastes are utilized as fertilizer and fodder for livestock. They are more beneficial than fertilizers when used as animal feed, though. These wastes are more valuable for feeding ruminants than poultry due to their high fiber and non-protein N content. The profitability of feed producers and the environmental quality could be improved by using plant wastes as feedstuffs. (Alagawany *et al.*, 2022).

Livestock systems are built on the foundation of animal feed and feeding. It has an impact on the whole livestock industry, linked services, and public goods and services, such as animal production, health and welfare, product quality and safety, land use and land-use change, and greenhouse gas emissions, directly or indirectly. Current cattle production practices need a lot of energy, land, chemicals, and water, all of which are becoming increasingly rare. In addition to presently recognized nutrition-based requirements for supplying commercially viable, safe animal products by creating safe feed, the suggested concept for sustainable animal diets incorporates the importance of efficient use of natural resources, environmental preservation, socio-cultural advantages, and ethical integrity. The concept's primary basic pieces are provided to reach a shared understanding of them and then prioritize them. All stakeholders must understand and participate to integrate this notion into appropriate management methods and contribute to long-term cattle production (Makkar, 2012).

Minerals are inorganic nutrients that are needed in modest amounts ranging from 1 to 2500 mg daily, depending on the mineral. Mineral needs differ per animal species, just as they do with vitamins and other necessary dietary elements. Humans and other vertebrates, for example, require a lot of calcium for bone formation and maintenance and adequate nerve and muscle function. Phosphorus is a key component of adenosine triphosphate (ATP) and nucleic acid, as well as a crucial component of acid-base balance and bone and tooth creation (KO *et al.*, 2010).

Minerals are inorganic compounds found in all biological tissues and fluids, and their presence is required to properly function certain physicochemical processes. Minerals are chemical components that the body uses in a variety of ways. Even though they produce no energy, they serve a crucial role in a variety of bodily functions (Eruvbetine, 2003). All biological things require certain inorganic elements or minerals (Özcan, 2004).

Minerals are categorized as either macro (large) or micro (trace) elements (Vaswani, 2020). The ultra-trace elements are the third type. Calcium, phosphorus, salt, and chloride are macro-minerals, whereas iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium, and sulfur are micro-minerals. (Eruvbetine, 2003). The most crucial element for the success of a dairy farm is the animal's productivity and reproductive efficiency. A dairy herd's reproductive and productive health depends critically on minerals. Less than 100 mg/kg dry matter of trace elements are needed, yet they play crucial roles in the immune system, oxidative metabolism, and energy metabolism of ruminants, all of which are directly or indirectly involved in growth, production, and reproduction. Any of these processes can suffer from a lack of trace minerals, which can also reduce growth efficiency. The majority of animal diets include organic or inorganic trace mineral supplements. (Bhalakiya *et al.*, 2019). Boron, silicon, arsenic, and nickel as examples of ultra-trace elements, have a beneficial role in some physiological processes in some species (National Academies of Sciences and Engineering, 2001). Some chemical elements, such as trace metals such as copper (Cu), zinc (Zn), manganese (Mn), nickel (Ni), and cobalt (Co), are essential for plant development, whereas others, such as lead (Pb) have no recognized biological role (Tangahu *et al.*, 2011).

Other than traffic volume and urbanization, multiple factors such as tire wear, brake wear, road abrasion, galvanized fuel tank parts, lubricant oil, exhaust gas, and worn-out engines made of metal alloys are some of the reasons attributed to mobility and elevated levels of heavy metals such as Pb, Cd, Cu, Zn, and Cr in the atmosphere (Yan *et al.*, 2012), which can cause accumulation of heavy metals in animals that consume polluted fodder. This is thought to substantially influence cattle health via long-term harmful consequences via metabolic interference (Gall *et al.*, 2015). Humans, as prospective eaters, are the most likely beneficiaries of its deleterious consequences (Kadhim *et al.*, 2022). Metals such as Cu, Ni, Cr, and Zn are known to have negative health consequences in humans, whereas Pb is designated as a human carcinogen (known or probable) by the United States Environmental Protection Agency and the International Agency for Research on Cancer (Singh *et al.*, 2011; Tchounwou *et al.*, 2012).

Animal feed additives are used of worldwide for various animals, including poultry, for various purposes, including providing important nutrients, increasing feed palatability, improving growth performance, and optimizing feed usage. Animals with strong growth performance require of good health, and adopting appropriate supplements is a major argument in such circumstances. With rising industry standards, customer knowledge, and a growing need for healthful animal-derived foods (Pandey *et al.*, 2019). Feed technology entails processing components and the creation of animal feeds, and it is an essential component of animal production systems to offer high-quality and nutritious food. The goal is to convert low-quality materials into higher-value feed components while also improving compound feed nutrient consumption. As a result, animal feed has a social obligation to help create more sustainable food production systems. A better knowledge of the structures and functional qualities of feed components, as well as how they vary at changing temperatures (der Poel *et al.*, 2020).

Minerals have an important role in the health and production of cattle. This aspect of nutrition, however, is frequently disregarded when evaluating nutritional requirements. Because Toxicities are more likely to arise than mineral shortages. Rations are frequently designed to surpass basic animal requirements easily. requirements. In these circumstances, it is critical to know whether Mineral concentrations in the diet exceed the maximum acceptable level. Cattle concentrations Mineral toxicity as a result of an oversupply of feed or water may result in noticeable consequences like a reduction in animal performance or a shift in animal behavior. Toxins may also have unintended or indirect consequences, such as build-up in meat or milk or environmental consequences as a result of higher mineral levels in the urine. Furthermore, mineral oversupply in cow diets is a needless and harmful practice. Cattle farmers may simply avoid this expenditure (Crawford, 2012). The study aimed to evaluate a wide variety of chemical elements in date fodder, which are widly utilized for cows, buffaloes, and sheep feeding in Basra Governorate, southern Iraq. This fodder is derived from dried dates and associated epicarp, mesocarp, endocarp and seeds. This also sought to determine the acceptability of chemical element concentrations, including macro-minerals, micro-elements, and toxic metals in that diet.

MATERIALS AND METHODS

Samples preparation and analysis of micro, macro and toxic minerals

The chosen feed source was sourced from date waste; the fodder was created from the remnants of date molasses as waste from the agricultural process industries, including dates in Basra, which are commonly used as fodder for cows, buffaloes, sheep, horses, etc. Following, the fodder was prepared for digestion using the digestion procedure (Binning and Baird, 2001). Then, samples were submitted randomly to the Zarazma Company for Mineral studies in the Islamic Republic of Iran. To measure the concentrations of macro-minerals, micro-elements, and toxic elements in the fodder, all the minerals were measured by an Inductively Coupled Plasma Mass Spectrometry (ICP-MS) device in Zarazma Company for Mineral studies. The macro-minerals included calcium (Ca), magnesium (Mg), phosphorus (P), potassium (K), sodium (Na), and sulfur (S) ; and micro-elements included manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), nickel (Ni), selenium (Se), chromium (Cr), tin (Sn), silicon (Si), vanadium (V), and molybdenum (Mo). On the other hand, the toxic elements included aluminium (Al), arsenic (As), cadmium (Cd), uranium (U), and lead (Pb).

Statistical analysis

The data were statistically evaluated using the program SPSS ver.23 by the analysis of variance (ANOVA) at the significant level of 0.05 and DUNCAN analysis.

RESULTS AND DISCUSSION

Macro, micro, and toxic minerals

The concentrations of macro-minerals (%) with the Critical level and Maximum tolerable concentrations in dates fodder are given in Table 1. The arithmetic mean of Ca 1.2% was higher than the lowest level (0.30), while the arithmetic mean of Mg was 0.71, which was lower than the lower limit (0.20%), while showing the arithmetic mean of P (0.06%). Moreover, the means of elements K, Na, and S showed values of 0.61 %, 0.186%, and 0.16%, respectively, which also all formed values less than the established minimum (Fig.1).

Moreover, the analysis of ANOVA (Table 2) showed significant differences between groups which was shown by the DUNCAN test after dividing the group into four levels (a, b, c, d), as group (a) represented the highest value, while group (d) represented the lowest value (Tables 2). The results of the arithmetic means of the micro-minerals showed that almost all of them were less than the Critical limit, as most of the minerals showed levels less than 0.003 ppm, which is considered a very small concentration compared to determinants for Critical limits (Binning and Baird, 2001) (Table 3). Furthermore, the analysis of ANOVA (Table 4) showed that there were significant differences between groups, which were divided into three levels (a, b, c) by the DUNCAN test, as a group (a) represented the highest value, while group (c) represented the lowest value. On the other hand, the arithmetic means measures of the selected toxic elements, which were represented by Aluminium, Arsenic, Cadmium, Uranium, and Lead, showed safe values less than the upper limit allowed according to (Crawford, 2012), as most of the elements showed an average of less than 0.003 mg Kg^{-1} (Table 5).

In the present study, the findings of the macro-minerals detection revealed significant differences between the components represented by calcium, magnesium, phosphorus, potassium, sodium, and sulfur. The calcium showed an acceptable concentration to suit cattle feeding according to National Research Council standards (Wild *et al*., 2021) and lower than the concentrations of Maximum tolerable according to Crawford (2012). Calcium is the most prevalent mineral in animals' bodies and plays a critical role in controlling various functions. Due to rising milk supplies and Ca need, maintaining Ca balance becomes more difficult, especially in lactating ruminants. Ca secretion via milk and Ca deposition in body tissues and conception products are added together to estimate the net Ca need. How-

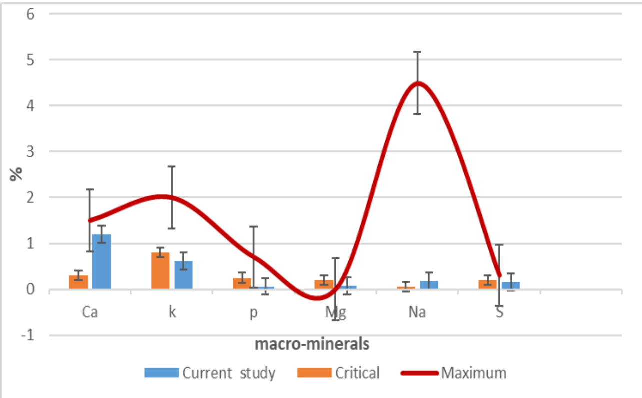

Fig. 1. *Arithmetic means (%) of macro-minerals in date fodder comparing with the Critical level (Saun, 2001) and Maximum tolerable concentrations (Crawford, 2012)*

Table 1 . Concentrations of macro-minerals (%) with the critical level and maximum tolerable concentrations in dates fodder

Chemical elements	N	Mean(%)	Std. Deviation	*Critical(%)	**Maximum(%)
Ca	3	1.20000±a	.020000	<0.30	1.5
Mg	3	.07100±d	.006000	<0.20	-
P	3	.06000±d	.010000	<0.25	0.7
K	3	.61000±b	.020000	<0.80	2
Na	3	.18667±c	.011547	<0.06	4.5
S	3	.16000±c	.026458	<0.20	0.3

N, Number of repeats; *According to (Saun, 2001), **According to (Crawford, 2012).

Table 2. ANOVA analysis and DUNCAN analysis of macro-minerals

ANOVA					
	Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Between Groups	3.027	5	.605	2052.873	.000
Within Groups	.004	12	.000		
Total	3.030	17			

Duncan				
Chemical elements	**Subset for alpha = 0.05**			
	1^d	**2^c**	**3^b**	**4^a**
P	.06000			
Mg	.07100			
S		.16000		
Na		.18667		
K			.61000	
Ca				1.20000
Sig.	.448	.081	1.000	1.000

df, Degrees of freedom; F, Fisher; Sig., Significant value; 1^d - 4^a, according to DUNCAN test (a) represented the highest value, while group (d) represented the lowest value.

ever, because dietary Ca is insufficient to meet the animal's net Ca need, a value for the efficiency of Ca utilization is used, which is the greatest proportion of Ca from the feed the animal may utilize to meet the net requirement. However, recent estimates of Ca use efficiency are inconclusive (Wild *et al*., 2021).

On the other hand, P, S, Mg and P showed a relatively low concentration according to National Research Council standards, while Na showed a high concentration based on the same scale. Despite the variance in macro-element proportions in the current study, the concentration of macro-elements in the fodder utilized in the study was accepted, which considered a nutrient-rich diet that was recently used in the growth and development of microorganisms (Alrubayae and Kadhim, 2020). Despite that, when comparing the concentration of calcium with some of the required minerals, we find significant differences between them. For example, in the current study, phosphorous concentration was relatively low. Phosphorus shortage is the most frequent and is generally linked to low soil phosphorus and a dry seasonal period, but calcium deficiency is less prevalent since plants, in general, contain more calcium than phosphorus, and Ca deficient soils are less common, as found in the current study. However, when ruminants are fed high grain diets, deficits such as poor development, bone deformities, and decreased milk output can result (Masters *et al.*, 1993). Over and above, sulfur is primarily connected with the essential amino acids methionine and cysteine, and a sulfur deficiency can result in impaired rumen roughage digestibility and nitrogen retention (Weston *et al.*, 1988). Deficiencies or changes in an animal's nutrition, such as minerals, can result in various illnesses and can occur in various ways (Hill and Shannon, 2019). When an element is missing, a distinctive symptom develops that reflects the nutrient's specialized activities in the animal's metabolism. Enzyme systems require elements to function properly. Mineral deficiency, whether simple or conditioned, significantly impacts metabolism and tissue structure. Information on the mineral element composition of foods, diets, and water is needed to determine dietary consumption and mineral adequacy (Simsek and Aykut, 2007).

Furthermore, the concentrations of poisonous elements in the fodder used for the study exhibited safe determinants since the toxic elements produced low values compared to the harmful determinants of these elements. Unwanted contaminants can contaminate animal feed and feed supplies, which might come from the environment and/or the manufacturing process. When production animals eat polluted feed, the pollutants can spread to animal-derived foods including liver, meat, and milk. Legislation to handle feed and feed material contamination exists in the European Union (EU) and much of the rest of the globe. Official limits and guidelines, generally by feed group, suggest acceptable amounts of each pollutant. Each EU member state creates a multi-annual control program for feed and feed ingredients in compliance with Regulation (EC) No. 882/2004. The program specifies the feed materials and contaminant combinations that will be tested and the frequency with which the controls will be applied. Feed-producing firms have contamination control programs in addition to European or national monitoring of feed and feed products. It is vital to have insight into the presence and quantity of contaminants in each feed component and animal feed to design such control pro-

Table 3. Comparing micro-minerals' concentrations (ppm) with the critical level and maximum tolerable concentrations in date fodder

Chemical elements	N	Mean (ppm)	Std. Deviation	*Critical (ppm)	**Maximum (ppm)
Mn	3	.3630000±b	.00700000	<40.0	-
Fe	3	<.0003967±c	.00001155	<50.0	-
Cu	3	<.0033000±c	.00000000	<8.0	40
Ni	3	<.0030000±c	.00000000	-	-
Se	3	<.0030000±c	.00000000	<0.20	5
Cr	3	<.0030000±c	.00000000	-	-
Sn	3	<.0030000±c	.00000000	-	-
Si	3	14.6500000±a	.04582576	-	-
Mo	3	<.0023000±c	.00000000	>6.0	5
V	3	<.0030000±c	.00000000	-	-

N, Number of repeats; *According to (Saun, 2001) **According to (Crawford, 2012).

Table 4. ANOVA analysis and DUNCAN analysis of micro-minerals

ANOVA					
	Sum of squares	df	Mean square	F	Sig.
Between Groups	576.449	9	64.050	298044.846	.000
Within Groups	.004	20	.000		
Total	576.453	29			

Duncan				
Chemical elements	N	Subset for alpha = 0.05		
		1^c	2^b	3^a
Fe	3	.0003967		
Mo	3	.0023000		
Ni	3	.0030000		
Se	3	.0030000		
Cu	3	.0030000		
Cr	3	.0030000		
Sn	3	.0030000		
V	3	.0030000		
Mn	3		.3630000	
Si	3			14.6500000
Sig.		.833	1.000	1.000

df, Degrees of freedom; F, Fisher; Sig., Significant value; N, Number of repeats; 1^c - 3^a, according to DUNCAN test (a) represented the highest value, while group (c) represented the lowest value.

Table 5. Comparing the concentrations of toxic minerals (mg Kg^{-1}) with the maximum tolerable concentrations in dates fodder

Chemical elements	N	Mean(mg Kg^{-1})	Std. Deviation	*Maximum Tolerable (mg Kg^{-1})
Al	3	.288000	.0298664	-
As	3	<.003000	.0000000	5
Cd	3	<.003000	.0000000	10
U	3	<.003000	.0000000	-
Pb	3	<.003000	.0000000	100

N, Number of repeats; * According to (Crawford, 2012) grams using a risk-based approach (Adamse *et al.*, 2017). Certain heavy metals and elements are one kind of contamination found in feed ingredients and animal diets. Mercury, cadmium, lead, and metalloid arsenic are hazardous because they are easily transported through food chains, have poisonous characteristics, and are not known to serve any biological role (Council, 2005; López-Alonso, 2012). In relation to the transmission of harmful substances to animal tissues and human tissues, the food chain generates possible health risks. Therefore, controlling health risks along the food chain can be accomplished by taking advantage of how animals feed themselves (Korish *et al.*, 2020). In general, pollution of the environment is mostly due to industrial and agricultural growth; however, some contamination comes from natural geological causes (López-Alonso, 2012; Rajaganapathy *et al.*, 2011). In general, farmers should be enriched with information about the nutritional needs of livestock and everything related to general information about the correct methods of raising livestock, as farmers in Basra Governorate lack a lot of information about the correct practices of raising livestock (Kadhim and Jasim, 2022).

Conclusion

The present study concluded that macro and microelements in date fodder in Basra had low concentrations compared to the critical index for their presence in fodder, as all did not exceed the maximum tolerated limit and were significantly less than the minimum limit (<0.06 of macro-minerals and <0.20ppm of microelements), whereas the toxic elements in the chosen diet had low and acceptable concentrations compared to the risk index for their presence in fodder.

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Conflict of interest

The authors declare that they have no conflict of interest.

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