وزارة التعليم العالي والبحث العلمي –اقليم كردستة
جامعة اربيل التقنية
كلية شقلاوة التقنية
قسم البيطرة
المرحلة الثانية / المسائي

Ministry of High Education and scientific research
Erbil polytechnic University
Shaqlawa technical college
Veterinary department
Stage Two/Evening

Trace element in ruminant nutrition

A research submitted to the Council of the Veterinary Department as part of obtaining a veterinary technical diploma

PREPEARED BY

Supervisor

Assistant Professor Dr. Hassan Abdullah Mohammed

2023

بسم الله الرحمن الرحيم

{ وَلَوْلَا أَن يَكُونَ النَّاسُ أُمَّةً وَاحِدَةً لَّجَعَلْنَا
لِمَن يَكْفُرُ بِالرَّحْمَنِ لِبُيُوتِهِمْ سُقُفًا مِّن فِضَّةٍ
وَمَعَارِجَ عَلَيْهَا يَظْهَرُونَ.} **صدق الله العظيم**

(الزخرف - 33)

Dedication

To the light that reveals the darkness of ignorance, the teacher of humanity....Muhammad (may God bless him and grant him peace) To the one who implanted in me the pulse of life and made my life a goal to which I strive...my father

To the world of tenderness, love, mercy, and a symbol of sacrifice....my dear mother

To those who have been the best help for me, my dearest brothers and sisters

To everyone who wanted me to succeed and good.....

we dedicate this fruit of my effort...

we dedicate to all of you the harvest of your planting and our humble effort

Research students

Acknowledgment

Praise be to God, who enlightened the hearts of His pious servants with the light of His clear Book, and made it a guidance and a mercy for the believers, and prayers and peace be upon the most honorable of messengers, our master Muhammad, the trustworthy Arab Prophet, lasting prayers and peace until the Day of Resurrection and Resurrection, and upon his immaculate family, his righteous companions, and those who followed them with kindness until the Day of Judgment. To proceed: I have the honor to extend my thanks, appreciation and gratitude to all my distinguished professors in the veterinary department, and our special thanks to our supervisor, Dr. Hassan Abdullah Muhammad, who provided us with the sources and supported us to complete the research.

We do not forget our families and their support and bear the trouble of studying with us........

Supervis val

I certify that this research decreed (Trace element in ruminant nutrition)

Submitted by students: ( )

It took place under my supervision at Shaqlawa Technical College as part of the requirements for obtaining a diploma in veterinary medicine.

Signature

Name: Asist. Proff.Dr. Hassan Abdullah Mohammed

Date:

Based on the available recommendations, I recommend the research for discussion .

Signature :

Head of Department :

Date:

Trace elements that are essential for the nutrition of animals are usually required in amounts ≤ 100 mg/kg in dietary dry matter. These elements include iron, zinc, copper, manganese, selenium, iodine, cobalt, molybdenum, and fluorine. This chapter provides a discussion on distribution in the animal body; absorption, storage, and excretion; essential functions in metabolism; deficiency and excess; interactions with other nutrients; and requirements, sources, and availability of these trace elements. Research with trace elements in the nutrition of animals that produce food for the diet of humans needs to be directed toward achieving four objectives. These include: to define dietary requirements of trace elements by food producing animals; to elucidate factors influencing enzyme systems in which trace elements are a vital component; to determine if trace elements are required by food-producing animals; and to determine the role that the trace elements have in immunocompetence of animals.

List of FIGURE

Tables list

1. Introduction

Trace minerals helps in improving the reproductive performance of cattle (Kumar *et al*., 2011; Grace and Knowles, 2012). Reports suggest that mineral deficiency greatly influence the ovarian activity in ruminants (Boland, 2003). Minerals are also involved in the synthesis of hormone essential for reproduction. Their deficiency will affect the production of both steroidal (Boland, 2003) and thyroid hormone (Abdollahi *et al*., 2011). The normal cellular functions of the body is unaffected if the required physiological concentrations of the mineral in present in the body (Ceylan *et al.*, 2008). In India, the main factor behind low production and suboptimal reproductive efficiency of our livestock is due to inadequate nutrition and that too particularly because of minerals deficiencies. Because of their role in follicular dynamics, ovarian activity and fertility, minerals are the integral component of production animal's diet (Boland, 2003). Reproductive failure may be induced by deficiencies of single or combined minerals or by their imbalances. This review will focus on the mechanism by which various minerals act and their daily requirements by the dairy cattle. Relationships between reproductive function and vitamins and minerals have long been recognized. In a general sense, all vitamins and essential minerals are required for reproduction because of their cellular roles in metabolism, maintenance, and growth. However, these nutrients also may have specific roles and requirements in reproductive tissues. The role or requirements of a vitamin or mineral in a reproductive tissue or cell type may change with the physiological state of the tissue during reproductive cycling and pregnancy most previous research in this area has been based upon nutrient deficiencies or excesses. Interpretation of much of that work is complicated by a limited base of knowledge on nutrient source and availability, nutrient absorption, transport and storage in the body, nutrient interactions, cellular uptake and utilization mechanisms, and metabolic interactions between physiological states of the animal such as growth, lactation, and reproduction.

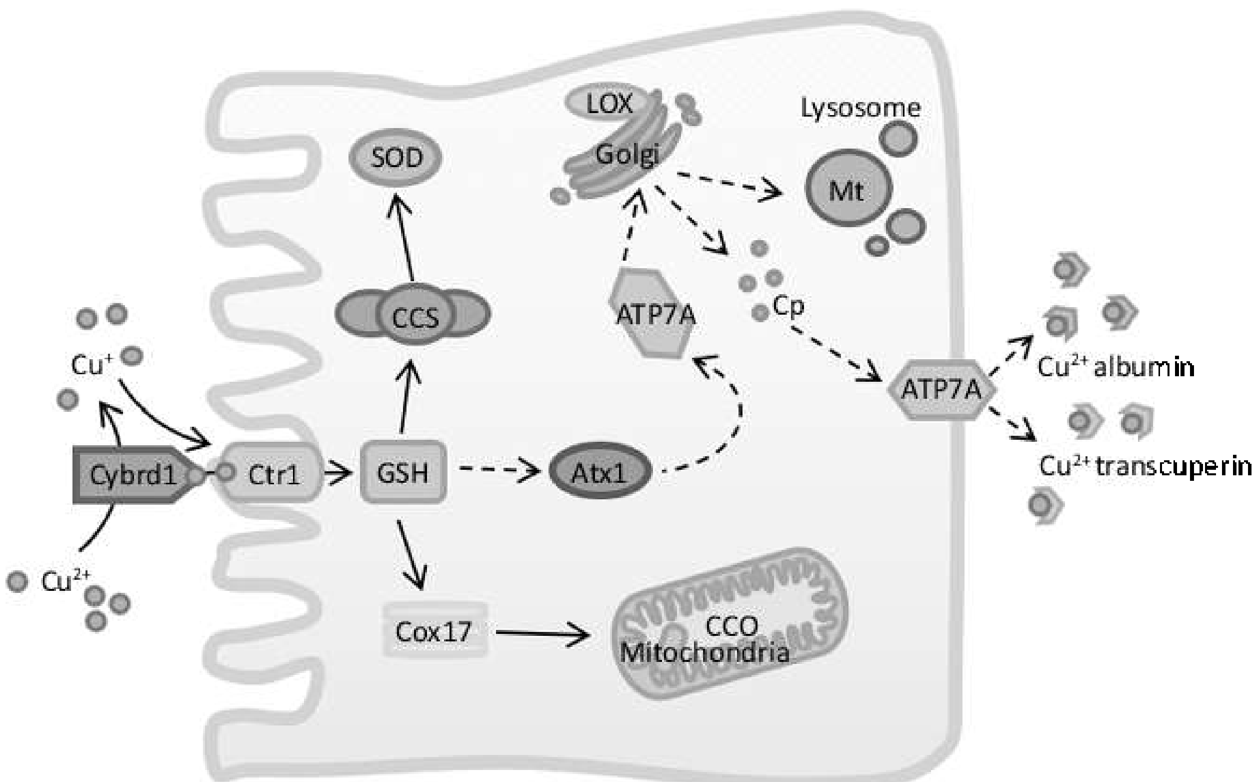
. This review will summarize the status of trace mineral nutrition and the effect of organically complexed trace minerals (mainly Cu, Fe, Mn and Zn) on broiler production. It will identify gaps in knowledge of inorganic and organic trace mineral nutrition for broiler birds and give some practical recommendations as to the use of organically complexed minerals in poultry diets.

2. Review literature

2.1. Trace Elements and Reproduction

2.2.1 Copper

Copper exerts its role as a cofactor in the activity of various enzymes and reactive proteins ceruloplasmin (Suttle, 2010).When the level of Cu is below physiological needs problems like early embryonic deaths, fetal resorption, necrosis and increased chances of retention of placenta develops. In dairy cows they may show delayed or suppressed estrous, impaired ovarian function and infertility. Adequate serum copper level of dairy cow have positive effect on reproductive health leading to less days to first service, fewer services per conception and fewer days to open. Deficiency of copper along with cobalt is having deleterious effect on the reproductive performance leading to delay in onset of puberty, low conception rate, early embryonic death and higher chances of retention of placenta (Nix, 2002). Copper is essential for the absorption and transport of iron necessary for hemoglobin synthesis, hence needed for erythrocyte production (Tuormaa, 2000). It is also necessary for melanin synthesis and interaction of copper and estrogen are also observed (Hidiroglou, 1979). Involvement of copper and zinc in the activity of super oxide dismutase helps in regulating the progesterone production by luteal cells (Sales et al., 2011). Copper and molybdenum act antagonistically as the crops grown on high organic matter (tert soils) are deficient in copper whereas levels of molybdenum are high. Following ratio of mineral combination is helpful in maintaining the normal copper level in blood, Zn: Cu 4:1, Cu: Mo 6:1 and Fe: Cu 40:1 (Hutjens, 2000). Chelates of amino acid with Cu, Mn and Zn have been described to reduce services per conception significantly in dairy cows . The normal body requirement of Cu in dairy cattle is 10 ppm but additional supplementation must be offered at various stage of life (Puls, 1994). Figure 1



2.2.2. Cobalt (Co)

Cobalt plays its role in the synthesis Vitamin B12 (Miller and Tillapaugh, 1967). Levels of Vitamin B12 are high in milk and colostrum which is required for the conversion of propionate into glucose and folic acid metabolism. Cobalt deficiency leads to reduce fertility and poor conditioning of the developing fetus. In dairy animal deficiency leads to prolonged uterine involution, irregular estrous cycle, lower conception rates and early calf mortality (Puls, 1994; Kumar, 2003). Deficiency of cobalt will in turn lead to Vitamin B12 deficiency. Manganese, zinc and iodine may reduce cobalt deficiency (Patterson et al., 2003). The dietary requirement of cobalt for dairy cattle is 0.11ppm (Miller et al., 1988).figure 2

2.2.3. Selenium

Selenium along with vitamin E acts as protective and anti-oxidant in the body by deleting the free radicals formed during peroxidation. In pregnant animal marginal deficiency of selenium leads to abortion, birth of weak calves that are unable to stand. Research indicates that selenium supplementation reduces the incidence of retained placentas, cystic ovaries, mastitis and metritis (Patterson et al., 2003). Being having direct link to the uterine involution selenium is important dietary mineral (Arthington, 2005). Chronic selenium toxicity leads to hoof problems mainly sore feet, lameness, deformed claws, and rocket shaped hoofs (Patterson et al., 2003). In herds where selenium levels are extremely low, injections are often required to rapidly return blood selenium levels to normal. After injection, feed supplements may provide enough selenium to maintain adequate blood levels in the cow. Among dairy animals, where subclinical selenium deficiency is there, reproductive performance may get retarded with delayed ovulation, increased services per conception and high incidence of mastitis (Goff, 2005). Selenium helps in enhancing the reproductive efficiency by increasing the activity of glutathione peroxidase in blood and tissues. Selenium easily crosses placenta whether fed as inorganic or organic food. It has been reported that selenium supplementation leads to improved conception rate at first service (McClure et al., 1986). In herds, supplementation of feed resources with selenium injection is helpful in maintaining the recommended blood level within normal range i.e. 8-10 mg/100 ml. Selenium injections prior to parturition helps in reducing the incidence of retained placenta in deficient animals. On dry matter basis the ration should contain 0.1 ppm selenium for ruminants (Miller et al., 1988).

2.2.4. Manganese (Mn)

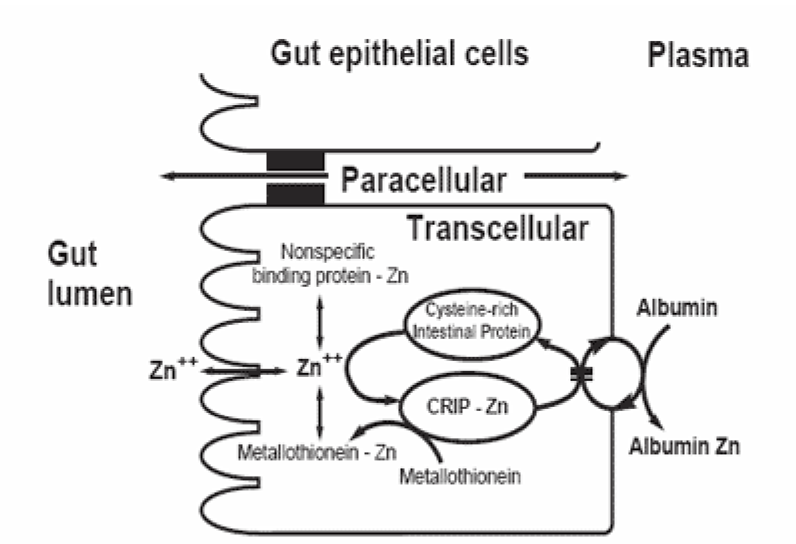
Manganese acts as activator of many enzyme systems that take part in metabolism of carbohydrate, fats, protein and nucleic acids (Patterson et al., 2003). It is required for the synthesis of cholesterol which is responsible for steroidal hormone synthesis like estrogen, progesterone and testosterone Decreased production of these steroid hormones will have effect on the reproductive performance by delaying the ovulation and disturbing the cyclicity of estrous. The corpus luteum, which is essential for maintaining the level of progesterone during pregnancy, has high level of manganese. Manganese acts as a co factor in the reaction for synthesizing cholesterol which acts as a precursor for estrogen, progesterone and other steroidal hormone (Karkoodi et al., 2011). Concentration of vaginal manganese in cyclic animal is higher than in non-cycling animal (Dutta et al., 2001). Manganese deficiency will lead to infertility, congenital limb defects in newborn, retarded fetal growth, cystic ovaries, poor follicular growth, delayed ovulation, increased embryonic mortality and lower conception rates (Kreplin, 1992, Corrah 1996, Patterson et al., 2003). Supplementation of manganese in feed helps in early postpartum estrous and higher conception rate in dairy animals

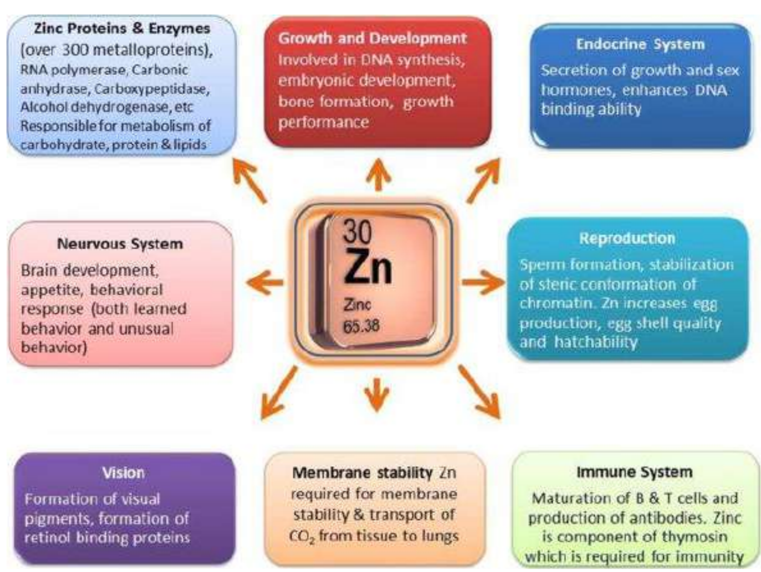
Table 1Requirements of Minerals in Non-Lactating Cow and Lactating Cows (NRC, 2001)

Mineral	Unit	Non lactating	Lactating cow
Calcium	%	0.70-.080	0.53-0.57
Phosphorus	%	0.36-0.40	0.33-0.37
Magnesium	%	0.22-0.27	0.18-0.21
Potassium	%	1.10-1.19	1.02-1.07
Sodium	%	0.26-0.31	0.19-0.20
Cobalt	ppm	0.11	0.11
Copper	ppm	12-15	9-11
Iodine	ppm	0.56-0.67	0.34-0.44
Iron	ppm	17-21	14-18
Manganese	ppm	15-19	12-13
Selenium	ppm	0.3	0.3
Zinc	ppm	56-67	45-54

2.2.5. Zinc

Zinc act as cofactor and coenzyme of many enzymes and various reproductive hormones. Zinc plays an essential role in the maintenance and repair of uterine lining after calving, helps in early involution. Abnormal levels of zinc is associated with decreased conception rate, abnormal estrous and abortion. Zinc as coenzyme, is involved in the formation of prostaglandins form arachidonic acid suggesting its profound effect on reproductive cycles and maintenance of pregnancy (Kumar *et al.*, 2011). Zinc also increases the plasma beta carotene level that has been directly correlated to higher conception rate and embryonic development (Staats *et al.*, 1988). Delayed puberty and low conception rates, failure of implantation and reduction of the litter size are also found in association with the zinc deficiency in feed. The recommended dietary requirement of zinc for dairy cattle lies between 18-73 ppm (Patterson *et al.*, 2003) depending upon the stage of the lifecycle and dry matter intake, whereas according to the feeding standards the requirement is 40 ppm (NRC, 2001). Apart from this, various other minerals like copper, cadmium, calcium and iron reduce zinc absorption and interfere with its metabolism (Patterson *et al.*, 2003). Figure 3





2.2.6. Iron

Iron is essential for the synthesis of hemoglobin and myoglobin and various other enzymes that help in formation of ATP through electron transport chain. It helps in transport of oxygen to tissues, maintenance of various oxidative enzyme systems (Khillare *et al.*, 2007). Deficiency is rare in adult animals due to its abundance in feed stuffs. But in cases where deficiencies are there, reproductive health is deteriorated due anemia, reduced appetite and poor body condition. Chances are there that deficient animal will become a repeat breeder and will require increased number of services per conception and may abort occasionally (Kumar *et al.*, 2011).

2.2.7. Iodine

Iodine due to its action on thyroid gland affects the reproduction. Iodine is regarded as essential for the developing fetus and maintaining the basal metabolic rate. Iodine through its effect on thyroid gland helps in secretion of gonadotropin by stimulating the anterior pituitary gland, thereby affects the estrous cycle (Khillare *et al.*, 2007). Deficiency of iodine affects the fertility and increases the abortion rate the incidence of retained placenta and post-partum uterine infections, respectively (Hemken, 1960). Conception rate and ovarian activity is reduced with the impaired thyroid functions. Thus iodine affects the reproduction in many ways and a recommended dose of 15-20 mg of iodine each day is necessary for a cow to have good reproduction status. Excess of iodine also have deleterious effect on reproductive health by inducing premature births of weak calves, abortions and lowers the immunity status of animal (Kumar *et al.*, 2011). Subclinical iodine deficiency is characterized by increased stillbirths, suppressed estrous, increased chances of retained placentas and prolonged gestation periods (Hess *et al.*, 2008). Normal plasma level of inorganic iodine in cows should be maintained between 100-300 ng/ml.

2.2.8. Chromium

Chromium is essential for carbohydrate metabolism (Tuormaa, 2000). It is present in nuclear protein in higher amount thus has a role in gametogenesis and for healthy fetal growth. It is also an integral part of the pregnancy specific protein that is secreted by uterine endometrium which helps in preventing the early embryonic mortality (Kumar *et al.,* 2011). It is having a crucial role in maturation of follicle thus maintaining the estrous cycle and also in LH release which triggers the ovulation. Deficiency of chromium will lead to irregular estrous cycle, delayed ovulation, early embryonic mortality and retarded fetal growth (Tuormaa, 2000). In lactating animals it may predispose the animal to ketosis and decreased milk production.

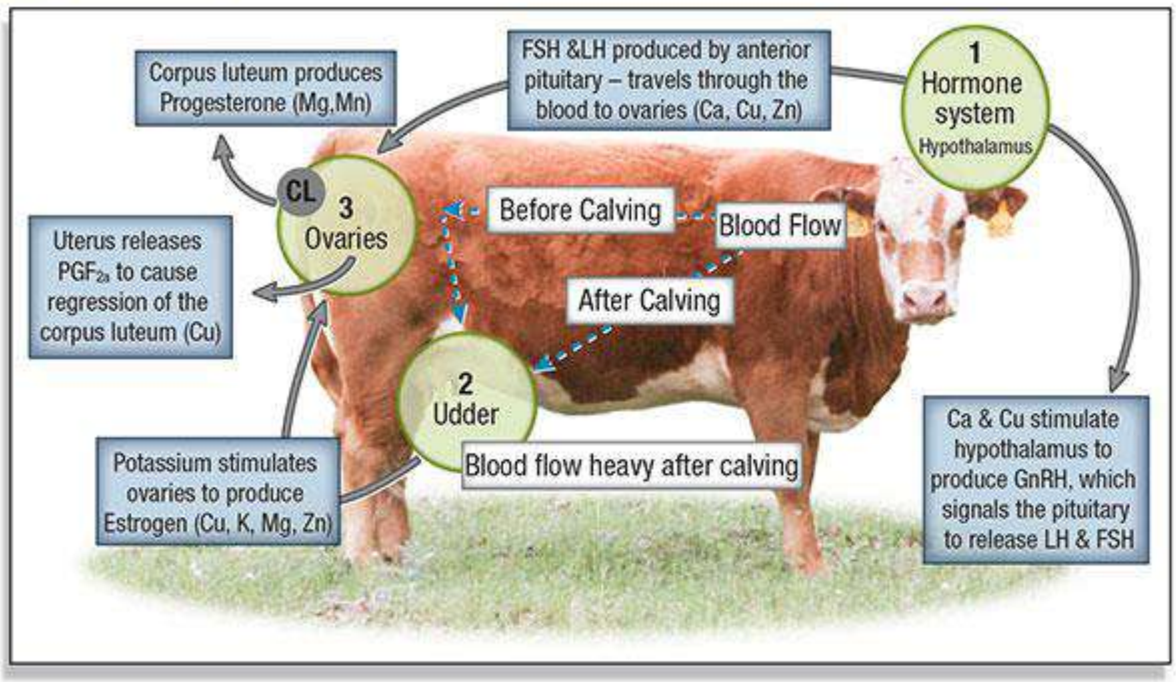
2.2.9. Molybdenum

Molybdenum deficiency in animals delays the onset of puberty, decreases conception rate and causes anestrus (Kumar, 2003). Molybdenum and copper are interlinked with each other as deficiency of one occurs in the presence of toxic levels of other. Therefore a proper balance in feeding the copper and molybdenum must be followed to avoid the reproductive problems (Randhawa and Randhawa, 1994).

Table 2Summarization of trace element Minerals in Dairy Rations

Iodine (I)	Synthesis of thyroxin	Big neck in calves, poor conception rates, abortions, longer gestation periods and the birth of dead, weak or hairless calves	Iodized salt, trace mineralized salt and commercial supplements
Iron (Fe)	Part of haemoglobin, part of many enzyme systems	Nutritional anaemia, pale mucus membrane	Forages, grains, trace mineralized salt, ethylene diamine dihydroiodine
Copper (Cu)	Needed for manufacture of haemoglobin, coenzyme	Severe diarrhoea, abnormal appetite, poor growth, coarse, bleached hair coat, repeat breeding, retained placentas, reduced libido and poor semen quality	Trace mineralized salt and commercial supplements
Cobalt (Co)	Part of vitamin B12, needed for growth of rumen microorganisms	Failure of appetite, anaemia, decreased, milk production, rough hair coat, low conception rates	Trace mineralized salt and commercial supplements
Manganese (Mn)	Growth, bone formation, enzyme activator	Delayed or decreased signs of oestrus, poor conception, higher abortion rates and low birth weight calves, weak calves with deformed or twisted legs and joints.	Trace mineralized salt and commercial supplements
Zinc (Zn)	Enzyme activator, wound healing	Decreased weight gains, lowered feed efficiency, skin/wound problems , low conception rates, slow calves growth rate and delayed onset of puberty, reduced sperm production and delays maturation of	Forages, trace mineralized salt, zinc methionine
Fluorine (F)	Not known if it is essential for ruminants, although essential for lab animals	Severe reduction in feed intake, stiffness in legs, enlarged bones	Rock phosphate mineral
Selenium (Se)	Functions with certain enzymes, , associated with vitamin E, immune system	White muscle disease, retained placenta, lessens subclinical mastitis, occasional abortions, premature or weak calves	Oil meals, alfalfa, wheat, oats, corn, commercial supplements
Molybdenum (Mo)	Part of the enzyme xanthine oxidase	Loss of weight, emaciation, diarrhea, decreased libido, reduced spermatogenesis and sterility in males and delayed puberty, reduced conception rate and anestrus in females	Widely distributed in feeds, deficiency rarely a problem

Figure 4 **Role hormones and minerals play in control of estrus cycle**



Source: NuTech Biosciences Inc.

2.3. Role of trace minerals in animal health.

The role of trace elements is well covered in the Compendium of Animal Health and Welfare in Organic Farming produced by the Organic Livestock Group, (2000) and by Underwood and Suttle (1999). In the hope that it might be more helpful in understanding the role of trace elements the approach taken here will be to consider their role in a number of ruminant disease/health problems. Many trace elements have very specific but often multiple roles, for example selenium. It has been known

for a considerable time to be necessary for growth and fertility in animals and for the prevention of a variety of disease conditions. More recently it has been established to form an integral part of a number of enzymes (selenoproteins) most of which function as antioxidants in the cellular cytoplasm in a range of situations. Others are involved in the conversion of Tetraiodothyronine (T4) to

Triiodothyronine (T3), the active form of the hormone thyroxin (a list of some of these enzymes and their function is given by Underwood & Suttle, (1999).

As well as individual trace elements having several functions several trace minerals and vitamins may be involved in a single function. For example it is well established that vitamins A and E as well as selenium, zinc and copper are all involved in immune function (see Meglia 2004)

Rather than consider the role of each trace element and vitamin it is felt that a review would be more helpful to consider the role of trace elements and vitamins in some of the more common problems encountered in ruminant livestock.

2.4. Immune competence and susceptibility to disease

It is well established that the incidence of infectious diseases such as mastitis and endometritis in dairy cows increases during the periparturient period with mastitis being the most common (Eberhart 1986, Grohn & Rajala-Schultz 2000 and Smith & Hogan 2001). Mismanagement of the dry period, particularly the transition period can predispose to both metabolic and infectious diseases (Ostergaard & Sorenson 1998, Rukkwamsuk et al 1999). In addition, a deficiency of micronutrients notably vitamins A and E, selenium and zinc have been associated with increased incidence of diseases (Kellog 1990, Hemingway 1999, Weiss 2002). The dry period should be used to assess the animals' trace element status and correct any deficits While the importance of vitamins and trace minerals is established it has also been noted by a number of workers (Johnston & Chew 1984, Oldham et al. 1991, Smith et al 1997, Meglia 2004) that levels of vitamin A and E and selenium and zinc vary with time in blood and milk, dropping towards the end of the dry period and around calving recovering during lactation. Indeed, Meglia (2004) showed that vitamin A and E levels dropped to critical levels in a proportion of the animals studied. It has also been noted that levels of glutathione peroxidase decrease at parturition and recover slowly during lactation (Tame 1995). Part of the explanation for this may be that colostrum contains more vitamins and selenium than milk (Goff & Stabel 1990, Underwood & Suttle 1999, Meglia 2004), part may be due to the decrease in DMI in the last 7-10 days prior to calving and part may be due to increased stress levels around calving.

Scaletti et al (2001) have shown that supplementing diets with 20 ppm copper reduces the severity of mastitis following *E. coli* challenge compared with diets containing only 7 ppm. A separate study showed that heifers fed 20 ppm supplemental copper from 84 days pre to 107 days post-partum compared with heifers fed no supplemental copper had fewer infected quarters (Harmon & Torre 1994). Again, copper is an integral part of a number of proteins that act as antioxidants (see Weiss 2005).

Zinc has also been shown to influence the incidence of infection and the recovery rate in both mastitis and somatic cell counts (see Weiss 2005). Tomlinson et al (2002) summarized the results of 12 experiments and reported an overall significant reduction in somatic cell count (SCC) when diets were supplemented with 200 mg zinc per day. On the other hand Whitaker et al (1997) reported no significant effect on infection rate, new infections clinical mastitis and SCC when similar levels of zinc supplementation either in the form of zinc proteinate or inorganic zinc or a combination of the two was used. Harmon (1998) has suggested that part of the effect of zinc may be related to skin integrity as a deficiency of zinc is known to be weaken skin and other stratified epithelia and the keratin lining of the mammary glad may physically trap bacteria and prevent migration into the mammary gland. It is also known to be involved in acute phase response to infection and inflammation (Prasad 1979) A study by Boland et al (1996) using a supplement containing copper, selenium and zinc as the bioplex showed that the reduction in SCC increased with time of lactation reaching as much as 52% by week 12. Questions have also been raised about the role of zinc in resistance to internal parasites in sheep. However,

studies have shown that appetite and growth rate are affected before there is any effect on resistance to internal parasites (Underwood and Suttle 1999) and it is possible that the effect is mediated through maintenance of the integrity of the cells lining the intestine and lungs.

2.5. Trace element status in ruminant livestock

Establishing the trace element status of ruminants is not straightforward. For example blood copper levels are not a good indicator of copper status as not all the copper is available to the animal. Levels can be influenced by antagonist such as molybdenum, sulphate, infection, trauma and stage of production (Puls, 1990), nor are serum copper levels highly correlated to liver copper levels (Clarke et al 1993). For example, cattle with low plasma copper levels had adequate liver copper levels (Mulryan and Mason 1992).

Swenson (1998) and Boland (2003) have also shown that liver copper levels vary with stage in the production cycle declining during the pre-parturient period reaching its lowest at calving and increasing post calving. It is also known that plasma levels of selenium change dropping markedly in the periparturient period and increasing slowly during lactation (Tame 1995).

Clearly the timing of any assessment in relation to the production cycle is very important.

2.6. Trace element requirements

For the UK trace element requirements of ruminant livestock are given in “Mineral, trace element and vitamin allowances for ruminant livestock” in ARC (1980) for the UK and in NRC Nutrient requirements of Dairy Cattle (2001) for the USA. The UK levels were drawn up in 1980 and some requirements, are based on rather sparse information. For the UK more recent suggestions have been made by Alderman (1993) and McDonald et al. (1995) for trace minerals and these differ from those given in ARC (1980).

The recommendations for livestock in the USA is perhaps more up to date being revised in 2001 (NRC 2001). However, Weiss (2002) suggests that these should be regarded as minimum requirements – as they do not included safety margins. The groups in both Ohio (Weiss, 2002) and Kentucky (Scaletti 1999) are offering very similar suggestions for feeding levels as follows:

Vitamin E 1,000 IU/day for dry cows

500IU/day for lactating cows

Selenium 0.3 ppm

Copper 20 ppm

Zinc 40-60

Though Weiss’ group goes on to note that as the dry matter intake falls in the last 2 weeks pre calving it will be necessary to increase the level per kg feed dry matter in order to maintain the 1,000 IU/day intake. While the UK recommendations do generally include a safety margin they do not take account of the presence of antagonists. For example vitamin E requirements increase in the presence of high levels of unsaturated fats and oils. Copper uptake is inhibited particularly by molybdenum but also by sulphur and to a lesser extent by iron (Underwood and Suttle 1999). There are also interactions between minerals for example high levels of calcium in the feed inhibit the uptake of zinc. It is also established that higher levels of copper are required in the presence of high levels of zinc and that animals under stress require higher levels of copper and zinc. There is also some evidence from personal observations (Tame 2006 and Measures 2006) that some deficits are associated with soil types, for example, deficiencies of selenium and zinc in livestock appear to be more common in animals foraging herbage from thin soils overlying chalk and limestone. Such interactions make it very difficult to set general requirements. Indeed, a more helpful approach would be to consider each situation in its own right.

Beck (1962) in a study in Australia states that copper deficiency diseases in ruminants occur when copper levels in pasture are 3 ppm or less and that above 6 ppm they did not occur. 3-6 ppm was regarded as marginal.

2.7. The extent of trace mineral deficiencies in organic ruminant livestock.

Whilst the author is not aware of any specific scientific studies in this area there is much information. For example, it is very well established that livestock grazed on the Somerset Levels rapidly exhibit the characteristic signs of severe copper deficiency as a result of very high molybdenum levels in the forages eaten.

Another example is parts of Derbyshire and Devon where livestock exhibit signs of iodine deficiency. In parts of Devon the iodine deficiency is complicated by selenium deficiencies.

Other examples are areas such as some parts of Dorset, Wiltshire, Gloucestershire and Lincolnshire where forages are growing on thin soils over either chalk or limestone brash where there appear to be deficiencies of selenium, copper and zinc (Tame 2003 personal observations).

Measures has also commented (Measures 2007) that there are deficiencies of selenium and cobalt in livestock grazing in the Herefordshire/Welsh border region.

It is also generally accepted that there are deficiencies of selenium and copper in the forage grown under conventional conditions over large areas of the country. There does not appear to be comparable information with regard to forages grown under organic husbandry. It is possible that trace mineral deficiencies may be less prevalent in organic systems for a number of reasons. In many cases production levels are lower so the daily trace mineral requirements are likely to be lower. In addition, higher levels of forages are usually fed and a higher proportion of the forages are from permanent pasture a proportion of which may contain herbs with a higher content of trace minerals.

2.8. Sources of trace elements and vitamins

There is a considerable amount of data collected over a long period of time on the trace element levels in forages, particularly from ryegrass based swards. However, the over-ridding feature of this data is the very wide range of values for each element. A tenfold or greater range between the lowest and highest values is not uncommon making the interpretation of the data extremely difficult. The problem is that no reference is made to the stage of growth, the ratio of leaf to stem to flower/seed head, at which the samples were harvested or to the weather conditions or light intensity under which the samples were harvested. It has been known for some time that values are different in leaf, stem and seed and even differ between young and old leaves (see review of Selenium in Higher Plants, Terry et al, 2000, and Goodwin-Jones 2007).

Thus a silage sample from a sward cut prior to heading will be expected to have a higher selenium level than a sward cut when it is in flower. Many organic farmers take only one cut of silage and to ensure that they have a sufficient quantity leave the sward to "bulk up". This usually means that the grasses have made the switch from vegetative to reproductive growth and this will have consequences for selenium content.

There is also evidence that the form in which selenium is available has a strong influence on the level of selenium in the plant (Terry et al, 2000).

It is likely that variations in the content of other trace minerals will be dependent on stage of growth, ratio of leaf to stem, weather conditions etc, may also apply to other trace minerals. While most of the trace elements are essential to plants this is not true of all of them. There is still a controversy as to whether selenium is essential to plants or not though it is know that there is a group of plants which appear to actively accumulate selenium (Parker and Page 1994).

There is also much anecdotal evidence that herbs such as ribgrass (Plantago lanceolata), yarrow (Achillea millefolium) and dandelion (Taraxacum officinale) etc. contain much higher levels of trace minerals. However, the same comments apply as made above. An additional comment is that there are only a small number of studies to date in which grasses, legumes and "pasture weeds" (herbs) have been grown under the same conditions and analysed for minerals and trace elements (Harrington et al., 2006, van Eckeren et al. 2006, Weller and Bowling, 2001). The Harrington study was conducted in New Zealand and samples were taken mid-summer though there is no comment about growth stage. Levels of both macro and micro nutrients were compared between ryegrass, Yorkshire fog, white clover, chicory, narrow leaved plantain, broad-leaved dock, and dandelion. The chicory and narrow leaved plantain had significantly higher levels of phosphorus, sulphur and sodium, chicory also had higher levels of magnesium and the narrow leaved plantain had higher levels of calcium. Dandelion had significantly higher levels of phosphorus magnesium and sodium. With regard to micro-nutrients Chicory had significantly higher levels of copper, zinc and boron, while narrow leaved plantain had higher levels of copper and cobalt. Dandelion had higher levels of copper, zinc and boron,. Yorkshire fog had a significantly higher content of molybdenum at a level likely to interfere with copper absorption.In the same study the levels of selenium were highest in white clover but also higher in the "weeds" than in the ryegrass though the difference between the "weeds" and ryegrass was not significant. This was despite the pasture having been treated with 27 kg/ha of Selenium Ultra the previous autumn.

The van Eckeren et al (2006) study compared ryegrass, white clover, chicory and plantain and was conducted on two different soil types, sandy and clay, though plantain was only grown on the sandy soils.

This study showed that calcium levels were very much higher in white clover and chicory on both soils and in plantain on the sandy soils. Sodium was higher in both chicory and plantain on the sandy soils and in chicory on the clay soils. Of the trace minerals copper was much higher in the chicory on both soils types than in the grass or clover. Zinc was higher in the chicory and the plantain than in grass and clover on the sandy soils and higher in the chicory on the clay soils. On the clay soils the chicory had higher contents of both cobalt and selenium than either grass or clover. There were no significant differences on the sandy soils.

Weller and Bowling (2001) have also shown that there were differences in the major minerals confirming that white clover and chicory had much higher levels of calcium, magnesium and sodium and ribgrass plantain had much higher levels of calcium and magnesium. Surprisingly, timothy was lower than ryegrass in both calcium and sodium. Clover was also lower in phosphorus and potassium. However, they also highlighted a significant complication by showing that the level of sodium varied through the season with, for example, ryegrass having levels of 997 mg/kg DM in May-June but 1,302 mg/kg DM in July-October.

The level of sodium in the ribgrass plantain, on the other hand varied in the opposite direction with 1,262 mg/kg DM in May - June but only 799 mg/kg DM in July - October. The levels in chicory were 7,193 mg/kg DM in May - June and 13, 885 mg/kg DM in July October. There also appeared to be a seasonal variation in magnesium content in ribgrass plantain. It is also well known that rapidly growing ryegrasses have lower levels of magnesium that can under some conditions result in staggers in cattle. Variations such as these only serve to highlight the difficulty of interpreting other data in the scientific literature. At present mineral analyses rarely note the stage of growth of the sward when the sample was taken. The question has to be asked as to whether there are seasonal variations in any of the other trace element levels in any or all of the herbs commonly present in swards? A further complication is that while chicory may be a very good source of sodium compared with ryegrass and ribgrass it’s proportion in the sward was quite low compared with either ryegrass or ribgrass but increased as the grass seed rate of the ryegrass decreased.

The proportion of ribgrass also increased as the grass seed rate decreased though the clover content remained fairly constant. The chicory, ribgrass and clover were all sown at a constant seed rate while that of the grass varied.

There is also some data on mineral composition of chicory and plantain by the group at the Appalachian Farming Systems Research Centre in the USA (Matt et al. 2003) citing both their work and that of others (Thomas et al 1952, Jung et al 1996 and

Belesky et al 1999) which shows that chicory and plantain generally have higher levels of calcium, magnesium, copper and zinc than orchard grass though there is a wide variation between the studies. Clearly this is a complicated area. The level of minerals not only varies from one plant species to another but also appears to depend on soil type and growth stage.

2.9. Strategies for assessing trace element status in ruminants

Clearly, in the light of the earlier findings detailed above, great care needs to be taken when assessing the trace element status of ruminant livestock. It appears that marginal trace element status often does not result in clearly defined symptoms.

Perhaps the best starting point for organic livestock is the forage, both grazed and conserved, as this has to provide a minimum of 60% of the daily dry matter intake in organic systems and in most cases provides considerably more. However, note should be made of the stage of growth, weather conditions, time of year, composition of the sward etc as these are all likely to affect trace mineral levels. Such analyses should give a good indication as to whether the animals is likely to have adequate, marginal or deficient levels of a particular trace element.

Assessment of the ruminant's trace element status is much more difficult. Account needs to be taken of its point in the production cycle, the level of stress imposed on the animal, the choice of analysis, the level of trace element antagonists as well as other trace elements in the feed and indeed the nature of any supplementary feeds used. At present the main strategy for improving trace element status in ruminants is to analyse the forages and possibly other feeds and to seek a derogation from the appropriate Sector Body to feed a tailor made mineral supplement or administer an injection of the appropriate trace element to overcome any deficits highlighted by the analyses. However, this should be regarded as a short-term measure as it is a largely conventional approach and not in keeping with organic philosophy. This poses the question of how can we devise a more “natural and sustainable” strategy

2.10. Effect of chemical/biological form of trace minerals on uptake

While the approach described above may be useful for some trace elements the indications are that it may only be partially effective for others, for example selenium. As pointed out above there is still controversy as to whether selenium is an essential element for plants or not (Terry et al., 2000). If it is not essential it will only be present in the plant as a contaminant and, consequently, may not reflect the soil selenium level. In addition, there is evidence that the form in which the selenium is presented to the animals is important. Grace et al, 1997 showed the there was no significant difference between the effects of giving the selenium either in the form of a selenium bolus or a barium selenate injection. Both forms resulted in a much higher blood selenium level as well as a much higher level in the milk from the treated animals. However, Givens et al, (2004) administered selenium at three different levels to dairy cows either in the form of sodium selenite, a chelated selenium product or a selenium yeast product. Significant increases were observed for all three sources though the selenium yeast gave a much greater response. They also commented that the efficiency with which the selenium was transferred to milk was much greater for the selenium yeast source.

Unfortunately, blood selenium levels were not measured in this study but it seems reasonable to assume, in the light of the Grace et al, (1997) study, that blood selenium levels were improved. It should be noted here that the uptake of selenium by plants appeared to be much higher if the selenium was in the form of selenate rather than selenite. This poses the question as to whether there may a similar difference in the uptake in ruminants.

Supplementation of trace elements in organic livestock is most commonly made through feed, rumen boluses and free access mineral blocks. There is also some use of trace element injections, particularly where local inhibitory factors are such as soil molybdenum affecting copper uptake. Injections have the disadvantage that the rumen is by-passed and consequently rumen microbes may not receive an adequate supply of trace elements for their critically important functions.

3. Conclusion and Recommendation

3.1. Conclusions.

There is a wealth of information on the vital role of trace minerals in ruminant health. This information gives some reasonable indications of the levels required by dairy and beef animals to maintain good health though there is much less information available for sheep. There is also a wealth of information available on the role played by trace elements in the major diseases of ruminants, particularly mastitis and the problem of high somatic cell counts. There is also information available on the effects of trace mineral supplementation on fertility and production.

This information should be used by organic farmers and their advisors to assess trace mineral status of animals under their care and to design strategies to help ensure that the trace element requirements of the ruminant are met and that good health status can be established and maintained. This should enable them to better resist the everyday challenges by pathogenic organisms responsible for many of the current infections such as mastitis. However, currently we only have enough information to be able to do this with any degree of certainty by using dietary supplementation with appropriate trace elements which is a conventional approach and does not sit well with organic philosophy. There are indications from a very small number of studies that there may be a more "sustainable, organic" way to achieve the same objective by increasing the diversity of the pastures used as the major food source for ruminant livestock. However, much more information is needed on the levels of trace elements present in these plants, how the level varies with soil trace element content and health status of the soil and how the level varies with stage of growth through the season. Only when we have this more detailed information can we design pastures that provide for the animal's requirements.

An additional benefit of such pastures is that they may result in a much greater diversity of wildlife.Attention also needs to be paid to the management and nutrition of the livestock in order to reduce both physical and nutritional stress to a minimum

3.2. Recommendations

The following are some suggestions for areas to be covered by future research projects. Their aim should be to gather information that will enable us to devise forage/herb mixes that will fully provide the trace mineral levels necessary to establish and maintain a good state of health including full immune competence in ruminants.

1) A comparison of the trace element and vitamin content of a range of grasses, legumes and herbs at various growth stages. A number of different trials need to be run on a range of soil types including soils known to be deficient in particular trace minerals and/or to result in trace element deficiencies in ryegrasses.

2) The effect of "trace element rich" forages on animal health with particular reference to mastitis and SCC.

3) A study needs to be undertaken on whether the various soil management strategies practiced at present do indeed enhance the trace mineral level of forages grown.

4. References

Abdollahi, E. Kohram, H. and Shahir, M.H. 2013. Plasma concentrations of essential trace microminerals and thyroid hormones during single or twin pregnancies in fat-tailed ewes. Small Ruminant Research. 113(2–3): 360–364.

Chaudhary, S. and Singh, A. 2004. : Role of Nutrition in Reproduction: A review. Intas Polivet. 5: 229-234.

Chester-Jones, H., Vermeire, D., Brommelsiek, W., Brokken, K., Marx, G. and Linn J. G. 2013. Effect of trace mineral source on reproduction and milk production in Holstein cows. Prof. Ani. Sci. 29: 289-297.

Corah, L. R. and Ives, S. 1991. The effects of essential trace minerals on reproduction in beef cattle. Vet Clin North Am Food Anim Pract. 7: 41-57.

Corrah, L. 1996. Trace mineral requirement of grazing cattle. Anim. Feed Sci. Tech. 59:61-70.

Cromwell, G. L. 1997. Handbook of copper compounds and applications. pp 177-202.

DeOndarza. and Mary, Beth. Minerals. www.milkproduction.com

Dutta, A., Baruah, B., Sarmah, B. C., Baruah, K. K. and Goswami, R. N. 200l. Micro-mineral levels in cycle, postpartum anestrus and repeat breeder local cows in lower brahmaputra valley of Assam. Indian J. of Anim. Sci. 70: 712-713.

Goff, J. P. 2005. Major advances in our understanding of with nutritional influences on bovine health. J. of Dairy Sci. 89:1272-1301.

Grace, N. D. 1983. Amounts and distribution of mineral elements associated with fleece-free body weight gains in grazing sheep. N.Z. J. Ag. Res. 26: 59– 70.

Grace, N.D. and Knowles, S.O. 2012. Trace Element Supplementation of Livestock in New Zealand: Meeting the Challenges of Free-Range Grazing Systems. Veterinary Medicine International. 12: 1-8.

Ansotegui, R. P., Bailey, J. D., Paterson, J. A., Hatfield, P. G. and Swenson, C. K. 1999. Effects of supplemental trace mineral form on copper status, estrus, ovulation rate, and fertility in beef heifers. Am Soc Anim Sci. 50: 189-192.

Hutjens, M. F. 2000. Feeding management of the 40,000 pound dairy herds. J. Dairy Sci., Vol. 83, No. 1, pp. 26 (Abstr., 108).

Arthington, J.D. 2005. Trace mineral nutrition and the immune response in cattle. Proc. 64

Kumar, S. 2003. Management of infertility due to mineral deficiency in dairy animals. In

Kumar, S., Pandey, A. K., Razzaque, W. A. A. and Dwivedi, D. K. 2011. Importance of micro minerals in reproductive performance of livestock. Veterinary World. 4 (5): 230-233.

McClure, T. J., Eamens, G. J. and Healy, P. J. 1986. Improved fertility in dairy cows after treatment with selenium pellets. Australian .Vet.J. 63:144-146.

Miller, J. K., Ramsy, N. and Madsen, F. C. 1988. The Ruminant Animal, In: Church D.C (Ed.), Prentice Hall, New Jersey. pp 342-400.

Nix, J. 2002. Trace Minerals Important for Goat Reproduction. Sweetlix Livestock Supplement System.www.sweetlix.com/media/ documents/articles/Goat/013.pdf

NRC. 2001. Nutrient requirements of Dairy cattle: 7th edn . National Acedemic press. pp: 105-1146.

Patterson, H. H., Adams, D. C., Klopfenstein, T. J., Clark, R. T. and Teichert, B. 2003. Supplementation to meet metabolizable protein requirements of primiparous beef heifers: II. Pregnancy and Economics. J. Anim. Sci. 81: 503-570.

Puls, R. 1994. Mineral Levels in Animal Health. Diagnostic Data, second Ed. Sherpa international, Clear brook, B. C. Canada.

Ceylan, A., Serin, I., Aksit, H. and Kamil, S. 2008. Concentrations of some Elements in Dairy Cows with Reproductive Disorders. Bull Vet Inst Pulawy 52: 109-112.

Boland, M. P. 2003. Trace minerals in production and reproduction in dairy cows. Adv Dairy Technol. 15: 319–330.

proceedings of ICAR summer school on “Advance diagnostic techniques and therapeutic approaches to metabolic and deficiency diseases.

پوختە

ئەو توخمە شوێنەوارییانەی کە پێویستن بۆ خۆراکدانی ئاژەڵان بەزۆری بە بڕی ≤ 100 میلیگرام/کیلۆگرام لە مادده وشکەکانی خۆراکدا پێویستن. ئەم توخمانە بریتین لە ئاسن، زینک، مس، مەنگەنیز، سیلینیۆم، یۆد، کۆبالت، مۆلیبدینیۆم و فلۆرین. ئەم بەشە باسێک لەسەر دابەشبوون لە جەستەی ئاژەڵەکاندا دەکات؛ هەڵمژینی و هەڵگرتن و دەردانی؛ ئەرکە سەرەکییەکان لە میتابۆلیزمدا؛ کەمیی و زیادەڕەوی؛ کارلێککردن لەگەڵ مادده خۆراکیەکانی تر؛ و پێداویستییەکان، سەرچاوەکان و بەردەستبوونی ئەم توخمە شوێنکەوتووانە. توێژینەوەکان بە توخمە شوێنکەوتووەکان لە خۆراکی ئەو ئاژەڵانەی کە خۆراک بۆ خۆراکی مرۆڤ بەرهەم دەهێنن، پێویستە ئاراستە بکرێت بەرەو گەیشتن بە چوار ئامانج. لەوانە: پێناسەکردنی پێداویستییە خۆراکییەکانی توخمە شوێنکەوتووەکان لەلایەن ئاژەڵە بەرهەمهێنەرەکانی خۆراکەوە؛ بۆ ڕوونکردنەوەی ئەو هۆکارانەی کە کاریگەرییان لەسەر سیستەمی ئەنزیمەکان هەیە کە تێیدا توخمە شوێنکەوتووەکان پێکهاتەیەکی گرنگن؛ بۆ دیاریکردنی ئەوەی کە ئایا توخمە شوێنەوارییەکان پێویستن لەلایەن ئاژەڵە بەرهەمهێنەرەکانی خۆراکەوە؛ و بۆ دیاریکردنی ئەو ڕۆڵەی کە توخمە شوێنکەوتووەکان لە توانای بەرگری ئاژەڵەکاندا هەیانە.