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Ostrich nutrition: a review from a Zimbabwean perspective

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Summary
The ostrich is an important animal in many livestock industries and, in the developing world, the export of meat and skins is a valuable source of foreign currency. As the successful growth and reproductive performance of ostriches depends on good nutrition it is extremely important to provide the correct diet. Some researchers have incorrectly assumed that poultry diets are useful for ostriches, but the vitamin and mineral requirements of these birds are unique and their diets should never be substituted with poultry or other livestock feeds. Producers should be knowledgeable about how different ingredients provide the essential nutrients for growth and development. Adequate nutrition is key to good flock performance and more research into ostrich nutrition is required.
In Zimbabwe, one of the greatest costs involved in the keep of ostrich breeder birds is purchased feed, which can cost approximately US$ 4,555 for every 10 birds *per annum*. In order to cover these costs, the producer needs to ensure an adequate supply of birds for slaughter.

Keywords
Feed – Nutrition – Ostrich – Production – Ratite – Zimbabwe.

Introduction

The ostrich (*Struthio camelus* var. *domesticus*) is the largest of all birds and belongs to the order Ratitae, which also includes the emu, cassowary, rhea and kiwi (22). The healthy red meat and skins of ostriches make the animal very important for many livestock industries. The successful growth and reproductive performance of the ostrich depends on good nutrition and the ability of the bird to utilise the mineral and vitamin supplements therein. The successful raising of ostriches, from the egg to the breeder bird stage, requires high standards of nutrition management and the producer should be knowledgeable about the impact of the feed ingredients on growth and development, the capacity of the birds to utilise each nutrient, and expected performance outcomes. Correct nutrition of chicks is critical, as they are most vulnerable up to the age of three months (10). Breeder bird nutrition should cater for the increased calcium and phosphorus requirements of the egg production stage and should also include the correct amino acids, vitamins and carbohydrates for the maintenance of high fertility after the attainment of sexual maturity at 24 months of age (9). To understand the unique tolerances of these birds there is a need for additional research into the nutrition of ostriches, e.g. more collaborative studies and sponsoring researchers to study the subject in those countries actively engaged in ostrich production.

The literature provides a brief account of the protein, mineral, vitamin and other nutrient requirements of ostriches, depending on their physiological status, with respect to maintenance, growth and breeding (16). Erroneously, many researchers have assumed that poultry diets are useful for ostriches and have continued to rely on incorrect nutrition data when feeding their birds. Most of the published data on ostrich nutrition is of a semi-popular nature and producers use this data extensively. This paper attempts to condense and criticise recent, pertinent information on feed and feed management in ostriches, particularly in southern Africa. The authors also correct some of the errors contained in the published data and point out the problems that can occur as a result of relying on this misleading information.

Fig. 1
Ostrich embryo with an entirely unabsorbed yolk sac

The link between adequate nutrition and health

Adequate nutrition is essential for good ostrich productivity and an effective way of providing the required nutrients is by using mixed feed formulations with green feed and grit for efficient digestion (12). The authors agree with previous work which states that diets that approximate the following nutrient concentration are adequate for ostriches, emus and rheas: 16%-20% protein, ≤10% fat, ≤10% fibre, ~2.5% calcium and ~1.5% phosphorus (17). Up to the age of ten months, the food conversion of the ostrich is 6.5 kg of food/kg body weight (bwt) gained (20). According to Schmitt, unbalanced breeder or chick rations may increase the likelihood of the following (20):

– reluctance to eat (if chicks do not eat properly within the first week, health problems arise following consumption of the yolk sac, usually resulting in death within the first three weeks)

– bad food conversion and poor growth despite good food intake

– poor feather growth and loss

– leg problems occurring from one week to three months of age

– lowered immunity and increased stress levels.

Correct nutrition of chicks is important, as they are most vulnerable up to the age of three months (10). Unbalanced ostrich breeder nutrition results in multifaceted nutrient deficiencies in embryos, some of which are suspected to cause abnormal yolk sac conditions (15) (Figs 1 & 2). Some authors state that when egg production is forced by continually removing eggs, hens require increased calcium intakes that should be provided as a dietary inclusion of 16 g/kg with *ad libitum* access to granulated calcium carbonate or oyster shell (26). However, this value is too high. *Ad libitum* access to calcium may, in fact, result in excess ingestion of this mineral, leading to a reduction in the absorption and utilisation of zinc and, indeed,

Fig. 2
Ostrich embryos with almost completely absorbed yolk sacs

low-grade limestone sources of calcium potentially contain contaminant minerals that may interfere with the utilisation of other minerals in the ration.

Follicular growth in hens occurs for sixteen days, resulting in a demand for additional nutrients at eighteen days before the first egg is laid (23). The demand for extra nutrients by the hen increases in a sigmoid pattern and reaches a maximum approximately eight days before the first egg is laid. Thereafter, the nutrient requirements for egg production reach a plateau. Smith and Sales emphasise that cocks should not be permitted to consume layer diets, as ingestion of excess calcium leads to a reduction of zinc absorption, which can have adverse effects on sperm production. Furthermore, they suggest that cocks should be kept in adjacent paddocks and fed maintenance diets, and should only be introduced to hens for mating after the hens have consumed most of their daily rations (23). This, however, is not advisable, as it can interfere with the bonding and interrelationships of the birds and adversely affect breeder bird performance.

Feed is one of the largest running costs in an ostrich enterprise and may originate from an on-farm supply and/or from local feed manufacturers (15). On-farm evaluation of the production unit is a useful tool for improving productivity and potential income (14). As can be seen in Table I, which uses data taken from a study of the ostrich industry in Zimbabwe, the costs involved in sustaining an ostrich breeding flock are considerable (7, 8). Key assumptions in this study included an intensive system comprising one cock to two hen units. This is a unit of size, that is, a one acre fenced enclosure containing one cock and two hens. The hen (≥ 4 years old) lays about 44 eggs per year (July-November). No similar study has been reported elsewhere in southern Africa.

Table I
Mean costs and flock size of ostrich flocks raised in intensive systems in Zimbabwe (7)

Flock composition and size per annum

Bird category	Total number of birds on farm	Number of birds per bird unit (one acre)	Percentage of total number of birds
Cocks	24	1	4.17
Adult hens	27	2	7.41
Replacement cocks	4	2	50.00
Replacement hens	6	4	66.67
Total	**61**	**9**	**14.76**

Capital costs per annum

Costs	Total cost Z$	US$*
Fencing	75,000	1,976.29
Water reticulation	50,000	1,317.52
Pasture	10,000	263.51
Live bird purchases (50 birds)	250,000	6,587.62
Total	**385,000**	**10,144.94**

* US$1 = Z$ 37.95 (6)

Variable production costs per annum

Costs	Z$	US$
Replacements (4 cocks and 6 hens at Z$ 5,000 each)	50,000.00	1,317.52
Purchased feed		
Ostrich maintenance feed (non-breeding season)	32,579.25	858.48
Breeder nuts	140,300.00	3,696.97
Pasture	10,000.00	263.51
Labour (24 workers at Z$ 883.33 per month)	254,399.04	6,703.53
Veterinary fees	5,985.00	157.71
Transport	3,420.00	90.12
Fuel	3,990.00	105.14
Repair and maintenance	3,990.00	105.14
Miscellaneous	3,990.00	105.14
Total variable costs	**508,653.29**	**13,403.26**
Total variable costs per unit	**8,923.74**	**235.15**

Schmitt states that a pre-starter ration should be fed from day one up to eight weeks of age when the chicks weigh approximately 18 kg and that the ration must have a very high energy level, with ~55% grain and ~22% protein (20). Providing specific values should be cautioned against, as stating the sources of protein, i.e. grain or lucerne, and calculating the percentage of energy and protein each bird would derive from the consumption of a specific food is a far more valuable indicator. Schmitt affirms that sufficient quantities of essential amino acids such as lysine, methionine, arginine, cystine and trionine should be present, but his report does not say what constitutes 'sufficient quantities'. Schmitt also states that fibre should be omitted at this age. Fibre inclusion, however, is important for preventing impaction and should derive from a high quality source, such as chopped lucerne (7). Schmitt suggests, and the authors agree, that at eight weeks, a starter ration should be fed until the chicks reach sixteen weeks of age (45 kg bwt). This ration must be high in energy (~50% grain) and supplemented with ~20% protein. Due to greater food consumption at this age, up to 20% roughage may be included in the feed. A grower ration should be fed at 4 months old (45 kg bwt) and continued up to six months of age (65 kg bwt). The grower ration should have a medium energy level of ~40% grain and ~16% protein, which maximises body growth. A finishing ration should be given to birds aged about ten months (65 kg-95 kg bwt). The energy level of this ration should be medium to low, consisting of ~25% grain supplemented with 14% protein. Roughage inclusion should be ~70%. At 95 kg bwt, the growth rate of the birds declines. A cheaper, less concentrated ration, the slaughter ration, should be fed at this stage. This consists mainly of roughage (~90%), including lucerne, supplemented with 12% protein. Schmitt states that this ration should be fed until the bird attains a body mass of 110 kg (fourteen months old). However, slaughtering birds at this weight is not cost-effective because heavier birds take longer to skin and eviscerate; producers should, therefore, aim to slaughter their birds when they are between nine and twelve months old. A maintenance ration should be fed to birds with a body mass of 110 kg-120 kg during the non-breeding season (20). This ration consists mainly of roughage with a 10%-12% protein level. The birds should be given additional food for two months after their wing feathers have been cut (20).

Nutrient requirements and the capacity of ostriches to utilise those nutrients

Regression analysis comparing the true metabolisable energy corrected for nitrogen retention (TME_n) values of ostriches and poultry in relation to various foodstuff ingredients showed a highly significant relationship ($p < 0.001$) (4). The linear model offers the possibility of calculating TME_n values from poultry data until a fuller picture of foodstuffs for ostriches becomes apparent. The model is as follows:

ostrich $TME_n = 6.35 + 0.645$ poultry TME_n ($R^2 = 0.80$).

Molasses meal, for instance, has a TME_n value of 7.77 megajoules (MJ)/kg and is thus an inferior product compared to other food sources such as lucerne hay (8.91 MJ/kg), wheat bran (11.91 MJ/kg), grape residue (7.81 MJ/kg) and hominy chop (11.49 MJ/kg) (3). The use of plants such as *Phragmites australis* (common reed), *Atriplex nummularia* (salt bush) and *Agave americana* (alivera), which grow in arid areas of South Africa, as dietary supplements in ostrich feed has been investigated by Cilliers (2). Young salt bush and common reed plants were harvested, hammer-milled and pelleted. The TME_n values of common reed (8.67 MJ/kg) and salt bush (7.09 MJ/kg) compared favourably with the TME_n value of Lucerne (8.9 MJ/kg). Cilliers suggests that these ingredients could be used as supplementary sources of roughage in ostrich diets. The report, however, made no reference to the concentrations of nutrients in each food source and whether indeed these were adequate for maximum growth and development in the ostrich. Analysis of alivera leaves cut daily from the main plant and chopped into small blocks showed the TME_n value of this ingredient to be 12.2 MJ/kg, i.e. about 80% of the value of maize, which has a TME_n value of 15.22 MJ/kg. It has been suggested that in more extensive feeding conditions, alivera could be used as a feed supplement for maize in birds aged six months (3).

Dietary deficiencies

Several dietary deficiencies in ratites have been identified (17), several of which are described below.

Vitamin A deficiency has been associated with runny eyes, abscesses on the palate and stunted growth in rheas (17). Jensen *et al*. also link vitamin E and selenium deficiencies with muscle degeneration in four-month-old ostrich chicks fed a diet of crushed maize. In their tests on two birds, aspartate transaminase serum levels were elevated in both birds (300 IU/l; 1,600 IU/l), as were creatine kinase levels (18,200 IU/l; 69,600 IU/l). Both birds exhibited poor physical condition, had paresis and were unable to stand. Each bird received vitamin E and selenium injections and thereafter their condition improved. By 26 h post-injection, the least affected bird was regaining full mobility. The second chick showed increased muscle tone but remained recumbent even after the second injection and died five days after the second dose. Acute degeneration and necrosis of muscle fibres and arterioles were observed during histopathological examination. This report also provides details on pantothenic acid deficiency, a syndrome observed in ostriches that are fed all-maize diets.

Vitamin B deficiency affects epithelial tissues and causes curling of feathers and hyperkeratosis of the mouth and beak. Riboflavin deficiency causes a syndrome in domestic poultry referred to as 'curled toe paralysis'. Presumably, such a sign in ostrich chicks may also be associated with a lack of riboflavin. This deficiency, however, causes characteristic neural paralysis of the lower legs in poultry, which does not fit the description of digital deviation in ratites. Deviations of ratite toes may have traumatic or genetic causes or be the result of low incubation temperatures (17).

Diets deficient in calcium or with low calcium to phosphorus ratios are thought to cause long bone deviation in ratites. Jensen *et al.* suggest that maintaining calcium at 2.0%-2.5% and phosphorus at 1.0%-1.5% of the diet prevents deficiencies. This statement is too general, however, as the ingested concentrations of these minerals vary depending on their concentrations in drinking water and soil in a particular locality.

Vitamin D_3 deficiency is most likely to occur when the fat percentage in a diet is too high, as this vitamin is

Fig. 3
Ostrich chick with combined vitamin D_3 and selenium deficiency
Note the presence of a crooked beak and abnormal protrusion of the large intestine

Table II
True metabolisable energy corrected for nitrogen retention (TME_n) values of various foodstuffs as determined in ostriches and roosters on a 90% dry matter basis (3)

Foodstuff	Ostriches		Roosters	
	Mean	± SD	Mean	± SD
Yellow maize	15.06	0.228	14.42	0.057
Alfalfa hay	8.91	0.119	4.03	0.118
Malting barley	13.93	0.251	11.33	0.212
Oats	12.27	0.291	10.63	0.783
Triticale	13.21	0.241	11.82	0.224
Wheat bran	11.91	0.221	8.55	0.375
Sunflower oilcake meal	10.79	0.278	8.89	0.494
Soybean oilcake meal	13.44	0.173	9.04	0.165
Saltbush hay (*Atriplex nummularia*)	7.09	0.238	4.50	0.271
Common reed (*Phragmites australis*)	8.67	0.337	2.79	0.147
Sweet white lupinus albus (i.e. Buttercup)	14.61	0.340	9.40	0.642
Ostrich meat-and-bone-meal	12.81	0.203	8.34	0.126
Fish meal	15.13	0.315	13.95	0.190

SD: standard deviation

fat-soluble and therefore bound by excess dietary fat, resulting in improper absorption from the intestinal tract. This presumably also applies to vitamins A and E. Figure 3 shows a chick suffering from combined vitamin D_3 and selenium deficiency. Excess dietary fat will also bind calcium into a saponin that is highly indigestible (17). Fat contents over 10% should be considered excessive in the diets of ratites as they are likely to cause bone disease and death. The results from the research of Jensen *et al.* have led to the establishment of feed rations with low fat contents in southern Africa (7).

Rapid weight gain and lack of exercise are two additional factors that contribute to long bone torsion and porosis in ostriches. Diets high in balanced protein and energy provide optimum weight gain. Overweight chicks that have gained weight rapidly due to unbalanced rations may experience problems due to stress on their cartilaginous leg bones. Ratites have large cartilaginous cones in the distal and proximal tibiotarsal bone at birth and ostrich chicks retain these embryonic cones up to six weeks of age (19).

Fibre and fats in ostrich diets

Most ratite feeds are lucerne-based with additions of maize, wheat middling, oats, soybean hulls and brewers dried grains (19). The use of soybean meal yields good growth and reproductive performance in ostriches (11). There has been a move away from the inclusion of feed of animal origin in ostrich diets due to the possible threat of bovine spongiform encephalopathy contamination. Fibre is an important constituent of ostrich feed, normally ranging from between 6% and 18%, depending on the age of the bird. Most feeds contain between 15% and 24% crude protein (the need for protein is highest in young birds and decreases with age) (19). Specific nutrient requirements for achieving maximum growth rates on minimum balanced inputs were not documented in the past, but, recently, several studies have been performed on this subject. Major errors occurred in the past by presuming that the diet formulations given to poultry could be fed to ostriches, but researchers have now realised that this is not true.

In a 1988 study, Swart showed that volatile fatty acids, specifically acetate, were produced in the colon of immature growing birds (24). This same study showed that digestibility coefficients for hemicellulose and cellulose in feed containing 340 g lucerne meal/kg were 0.66 and 0.38, respectively (24). A 1998 report confirmed that ostriches digest plant fibre effectively, particularly hemicellulose (66%) and cellulose (38%), due to the presence of cellulose bacteria in the hindgut (3). Lucerne hay is a popular source of roughage in ostrich diets, although Cilliers suggests that wheat bran, with an improved TME_n value of 39%, could also be a useful alternative (2). However, this statement needs to be substantiated by more research.

The end products of fibre fermentation may provide approximately 76% of the metabolisable energy (ME) requirements of growing birds. Cilliers calculated the true ME differences between roosters and ostriches by means of regression methods and showed that the ostrich is more capable of digesting the fibrous contents of foodstuffs, including cellulose and hemicellulose (2) (Table II). Each diet was evaluated to compare theoretical values with practical values. For the test diets, theoretical values of 11.69 ± 0.189 and 8.28 ± 0.181 MJ TME_n/kg feed (90% dry matter [DM]) for ostriches and roosters, respectively, compared closely with experimentally determined values of 11.25 ± 0.0724 and 8.02 ± 0.445 MJ TME_n/kg feed (90% DM) (23).

Angel studied the effect of age on the ME value of foodstuffs and on the fibre and fat digestibilities of ostriches and the results are summarised in Table III. In this study, the feed contained 7.3% fat (soybean oil) and 33.9% neutral detergent fibre (NDF). The digestibilities of apparent ME, fat and NDF increased with age. Angel reported that the ability of the ostrich to digest NDF increases linearly up to ten weeks of age, slows and then reaches a plateau at seventeen weeks. In the study ostriches were fed a high fat, relatively high fibre diet, with a calculated ME value of 1,983 kcal/kg (1). However, others suggest that when using this information, poultry ME values used to formulate diets for adult ostriches may lead to the actual ME value of ostrich feed being underestimated by up to 41% (23). The data presented in Table III show that the ostrich is able to digest more than 50% of dietary NDF at ten weeks of age. In the adult ostrich, the measured ME content of the feed was more than 800 kcal/kg higher then the calculated ME content. The ostrich were therefore 40% more efficient than poultry in deriving energy from this feed. Ostrich chicks less than ten weeks old cannot utilise fibre as well as older birds, although fibre should be present in feed to promote healthy microflora development in the hindgut. By ten weeks of age, ostriches can digest fat efficiently. Although ostriches lack a gall bladder for storing fat-emulsifying bile, fat digestion is not impaired in older birds. Some authors suggest that the total fat content in the feed of young ostriches should be limited to between 6% and 8% (19). It has been argued, however, that this range is too high and that the fat content should be limited to around 3.5% (D. Holle, personal communication, 2001).

Water requirements

Shanawany claims that after hatching, the requirement of the ostrich chick for water is greater than the immediate requirement for food, as the chick can feed on the remainder of the yolk sac for the first seven to ten days (21). He suggests withholding feed for two to three days after hatching to ensure that the chicks find water and to allow them time to utilise their yolk sacs rapidly to prevent retention thereof. Such a statement is, however, erroneous, as water and feed should be introduced immediately to enable chicks to supplement their yolk sacs. Indeed, withholding feed may encourage the occurrence of ostrich chick fading syndrome (OCFS) (13), characterised by depression, anorexia and death three to five days after onset of clinical signs in ostriches less than three weeks old (25). El-Attrache *et al.*, isolated two group I avian adenoviruses in primary chicken embryo liver cells from ostrich chicks less than eight weeks old suffering from OCFS (13). These viruses were identified by virus neutralisation and further characterised by a pathogenicity trial in immature ostriches. The results showed that the isolates were non-pathogenic in ostrich chicks and presumably only become established in undernourished individual chicks.

It is essential that ostrich chicks have access to water troughs and the producer should ensure that they are drinking. Brooder light intensity or temperature may be adjusted to encourage drinking (21). The production of whitish urine is usually indicative of water deprivation. The normally copious, colourless urine changes to a thick white excretion after two days of dehydration and fluid excretion halts after three days.

Quantitative and qualitative feed restriction

The initial growth of ostriches should be controlled by restricting feed to avoid problems associated with rapid growth, such as leg and skeletal disorders (21). Quantitative restriction of feed involves offering chicks a pre-determined amount of food per day, either in one meal or divided into two or three meals. An inherent disadvantage of this method is that stronger, more aggressive chicks will consume more feed, resulting in poor flock uniformity. In qualitative restriction studies, chicks are offered *ad libitum* a diet with a low nutrient

Table III
Apparent metabolisable energy (ME) values and apparent neutral detergent fibre (NDF) and fat digestibilities as determined in ostriches of different ages

Age	Formulated poultry ME value (kcal/kg)	Measured ostrich ME value (kcal/kg)	NDF digestibility (%)	Fat digestibility (%)
Three weeks	1,983	1,731	6.5	44.1
Six weeks	1,983	2,337	27.9	74.3
Ten weeks	1,983	2,684	51.2	85.7
Thirty months	1,983	2,801	61.6	92.9
Standard error of means	–	75	4.5	3.7

Source: (1)

density. Care should be applied to avoid limiting the nutrients that are vital for proportional growth. Limiting the energy content of the feed to 9-10 ME/kg is usually sufficient to control body growth. The ability of ostrich chicks to digest fat early in life is low and Shanawany suggests that dietary fat inclusion should not exceed 5%. This value is, however, too specific and does not take into account the total nutrients in the ration. Food should initially be offered in crumb form and if floor brooding is used, the crumbs should be spread on paper or in egg cartons for one week and thereafter, feed troughs introduced. The energy and fibre intake should increase until the chicks are one year old (fibre should be increased at four to five months of age to approximately 10%-11%), at which point crude protein should begin to be gradually reduced to 15%-20% and feeding should be *ad libitum*. A balance between calcium and available phosphorus should be maintained at a ratio of 1.8-2.0 to 1 (21).

Breeding ostriches aged eighteen months should be fed a breeder ration. This ration should be energy- and protein-rich, and low in fibre. As ostrich eggs contain about 20% shell and calcium is the major constituent thereof, in hen diets at the onset of breeding or at eighteen months, calcium and phosphorus must be increased to at least 40 g/kg and 4.2 g/kg, respectively. Exclusion of these dietary components can result in poor laying rates and hatchability of fertile eggs and increases the production of soft-shelled or shell-less eggs.

Overfeeding is claimed as a common cause of obesity, while underfeeding delays sexual maturity and leads to poor performance. A combination of both quantitative and qualitative feed restriction by the use of a diet balanced in all vitamins and minerals, low in protein and energy and with a fibre content of ~15% is usually recommended.

Amino acid availability

Amino acid availability is the digested protein dietary fraction available for metabolism (23). Comparison of apparent and true amino acid availability in roosters and ostriches fed on a high protein (21% on a 90% DM basis) diet comprising seven foodstuffs indicated better digestibility of dietary amino acids in ostriches. Values derived from poultry underestimate the true amino acid availability in ostriches (3). Accurate measurements of the digestible amino acid content of raw material foodstuff inclusions are needed to formulate low-cost diets. However, it should be emphasised that amino acids require the support of other nutrients such as zinc and these interactions should also be studied. In a comparative study of the true and apparent amino acid digestibilities of mature ostriches and adult roosters, regression analysis was used to determine the content thereof in a high protein (209 g/kg) diet (5). The mean values for true digestibility were 0.837 (range 0.780-0.862) for ostriches and 0.795 (range 0.723-0.825) for roosters. True retention of dietary protein was 0.646 for ostriches and 0.609 for poultry. In the study, digestibility of all amino acids was higher in ostriches. For instance, arginine digestion in ostriches was 0.780, higher than that in poultry, with a value of 0.736. (Arginine is the most efficiently digested amino acid in de-hulled soybeans [93%] [11].)

The ostrich is able to obtain amino acids more efficiently from a diet than poultry and the net efficiency of amino acid utilisation varies between 0.569 (leucine and cystine) and 0.968 (alanine) (3). Cilliers reported that for lysine and methionine, amino acids that are often limited in raw matter inclusion in ostrich feed, the net efficiency was 0.733 and 0.780, respectively. In this study retention rates of amino acids in feathers, leather, thighs and bones were measured separately and these data were then proportionally pooled and combined as total growth and retention. During the latter part of the study, the hide to body weight ratio was found to increase with age in contrast to ratios of other components, such as the legs and feathers, which remained constant (3).

Ostrich energy requirements at different ages

In another study, Cilliers used carcass characteristics to estimate nutrient requirements for ostriches at different ages (day-old to 600-day-old birds) (2). Body mass was found to increase linearly with age from 1.8 kg (thirty-day olds) to 119.4 kg (600-day-olds). Feed intake increased linearly up to 390 days, and then remained constant at 2.50 kg/bird/day. Carcass energy gain increased from 2.400 MJ/day (thirty-day olds) to a peak of 9.599 MJ/day (180-day olds). Clearly, the ostrich chick is the stage where fastest growth occurs and where it is vital that feed formulations meet the needs of the growing birds. Indeed, energy requirements for growth peaked at 10.689 MJ/day in 180-day olds. Unsurprisingly, total energy requirement increases linearly and reaches a peak in 300-day olds (19.36 MJ/day). Furthermore, the TME_n was highest in day-old to 180-day-old birds. Thereafter, a steady decline in carcass energy gain was observed, dropping to 1.295 MJ/day (600-day olds). Maintenance energy requirements increase steadily from day-old (0.673 MJ/day) to 600-day-old birds (15.356 MJ/day). This is presumably associated with increased energy requirements for reproduction.

The role of vitamin E and selenium in ratite diets

Vitamin E and selenium play a unique role in ratite diets. Degenerative myopathy has been reported to be associated with deficiencies of these nutrients (18).

Vitamin E deposition in the egg is impaired at low dietary vitamin E concentrations (20-40 IU/kg). Ratite feeds therefore need to be fortified by including 80 IU/kg of vitamin E (1). Encephalomalacia in ratites caused by vitamin E deficiencies have also been reported (19). Veterinarians or producers may inadvertently increase the incidence of embryonic mortality and deformity if birds are given excess selenium. Most commercial ostrich feeds contain 1 ppm to 3 ppm of selenium, and in a 1993 report Angel states that this amount appeared to be adequate for their needs (1). This statement was, however, not supported by an investigation as to whether the concentration of this mineral was appropriate for ostrich health. Selective studies of birds in particular geographical areas should be carried out to determine the exact selenium requirements and dietary intake thereof.

In their 1994 report, Scheideler and Angel reported that one of four adult ostriches with sudden onset paresis, which were unable to stand up when disturbed, responded well to treatment with selenium and vitamin E. The others died and post-mortem examination revealed pale patches in the thigh muscles. Degeneration of skeletal muscles as observed in nutritional myopathy was demonstrated following histopathological examination. Further evidence of inadequate nutrition was seen in low serum selenium and vitamin E levels and high aspartate aminotransferase and creatinine kinase levels (19).

Conclusion

The successful raising of ostriches from the egg to the breeder bird stage requires high standards of nutrition and the producer should be knowledgeable about how different ingredients provide the essential nutrients for growth and development, the capacity of the birds to utilise each nutrient and expected performance outcomes. Good ostrich nutrition is vital for good flock productivity. As the mineral and vitamin requirements of ostriches are unique, their diets should never be substituted with poultry or other livestock feeds. Most performance problems in ostriches relating to fertility, hatching, chick survival, growth rates and deformities in the early weeks can usually be traced to inadequate breeder rations. Adequate nutrition is key to good flock performance and producers should keep detailed records of the following:

– in breeders: egg production, fertility, hatchability and infection

– in chicks and growers: feed conversion, weight gain, meat yields and conformation (muscle size, percentage of primary to secondary muscles and percentage of fat) and hide quality (quill cover, quill pattern, quill size and follicles).

Producers should be encouraged, within reasonable limits, to experiment with the diet of their birds to determine the most efficient, cost-effective nutritional balance.

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La nutrition des autruches : un bilan de la situation au Zimbabwe

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Résumé

L'autruche est un animal de grande importance pour de nombreux éleveurs. En outre, dans les pays en développement, l'exportation de viande et de peaux d'autruches représente une précieuse source de devises étrangères. Le régime diététique des autruches doit impérativement être adapté à leurs besoins car leur croissance et leurs performances de reproduction sont tributaires d'une bonne alimentation. Certains chercheurs ont commis l'erreur de croire que les régimes élaborés pour la volaille pouvaient être valables pour les autruches, alors que leurs exigences spécifiques en vitamines et en minéraux interdisent de remplacer leurs aliments par ceux des volailles ou d'autres animaux d'élevage. Il importe que les éleveurs comprennent le rôle joué par les divers ingrédients dans l'apport en nutriments essentiels à la croissance et au

développement. La réalisation d'études complémentaires sur la nutrition de l'autruche se justifie par l'importance capitale d'une nutrition adéquate sur la performance des bandes.
Au Zimbabwe, l'alimentation des autruches reproductrices constitue la première charge financière des élevages, qui peut atteindre quelque 4 555 $ US par an pour 10 oiseaux. Les éleveurs doivent donc assurer une production suffisante d'oiseaux de chair pour couvrir ces frais.

Mots-clés
Aliment pour animaux – Autruche – Nutrition – Production – Ratite – Zimbabwe.

Consideraciones sobre la alimentación de los avestruces desde el punto de vista de Zimbabue

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Resumen
El avestruz es un animal importante en muchos sectores ganaderos, y la exportación de su carne y su piel es una valiosa fuente de divisas para los países en desarrollo. Puesto que de la buena nutrición de los avestruces dependen su correcto crecimiento y buen rendimiento reproductor, es esencial suministrarles una alimentación adecuada. Algunos investigadores han supuesto erróneamente que el régimen alimenticio de las aves de corral vale también para el avestruz, olvidando que sus necesidades en vitaminas y minerales son distintas y que los productos para aves de corral u otros animales domésticos nunca son sustitutos adecuados para alimentar al avestruz. Los criadores deberían tener conocimientos sobre los nutrientes esenciales para el crecimiento y desarrollo del animal que contienen diversos alimentos. La nutrición correcta es fundamental para el buen rendimiento de la bandada, y por ello es necesario investigar más a fondo el tema de la nutrición del avestruz.
En Zimbabue, uno de los factores más onerosos de la cría de avestruces reproductores es la adquisición de alimentos, que puede elevarse a unos 4.555 dólares estadounidenses al año por cada 10 animales. Para amortizar esos costos, el criador debe asegurarse de que podrá enviar al matadero a un número suficiente de aves.

Palabras clave
Ave corredora – Avestruz – Nutrición – Pienso – Producción – Zimbabue.

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