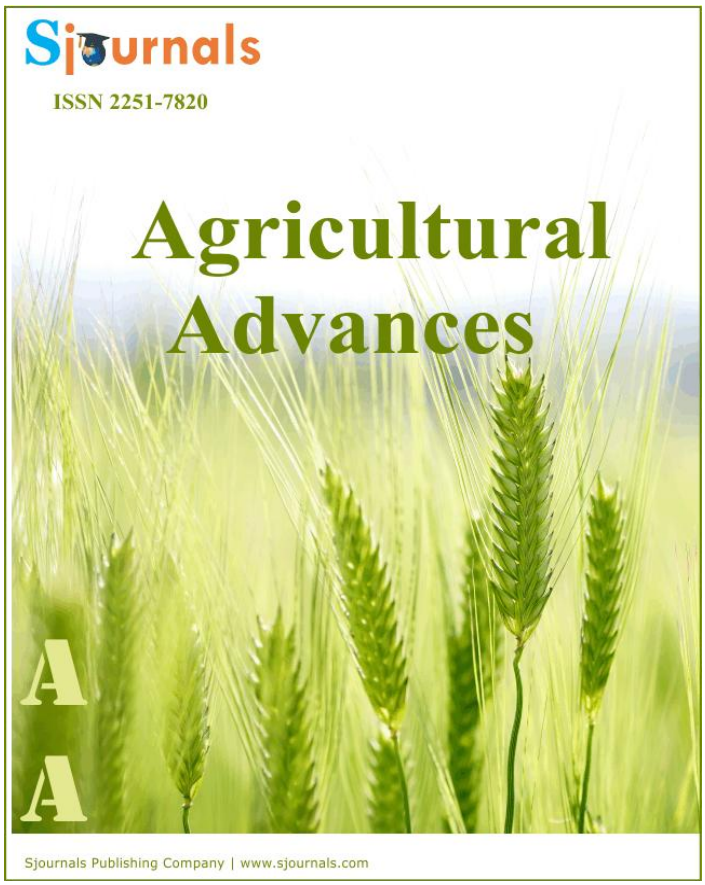
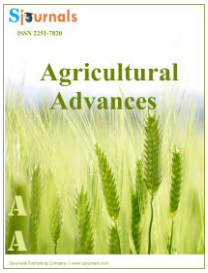


Sjournals
Scientific Journals
Agricultural Advances (2017) 6(9) 425-435
ISSN 2251-7820
doi: 10.14196/aa.v6i9.2463



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Review article

Consequences of nutritional programs and feeding strategies on growth traits, reproductive performance and mortality in rabbits

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ARTICLE INFO

Article history,
Received 17 August 2017
Accepted 03 September 2017
Available online 10 September 2017
iThenticate screening 19 August 2017
English editing 01 September 2017
Quality control 08 September 2017

Keywords,
Nutrition
Growth traits
Reproductive performance
Mortality
Rabbits

ABSTRACT

Nutritional programs and feeding patterns accounts for major production costs in a commercial rabbit enterprise. A successful rabbit enterprise is characterized by high feed consumption and adequate balanced essential nutrients to sustain the elevated nutritional requirements in support of intense productive animals. Rabbits improved growth pattern, efficient reproductive capacity and minimal kit mortality are closely associated with adequate nutrition. Enough energy dietary provision is required to mediate the nutrients metabolism for high production, while the protein component is the key factor in fueling tissue accretion (meat). In addition to energy and protein requirement, inclusion of dietary fiber is essential mainly because of its effects on the digestive transit and promotion of hind gut microbial activity where volatile fatty acids with high quality microbial protein can be recycled through caecotrophy benefiting the host animal. Inadequate dietary protein, energy and fiber levels have been associated with negative consequences on growth, reproduction and increased mortality. The nutritional value of feed resources and their constituents must be precisely balanced for optimum productive and reproductive performance to grantee economic viability and sustainability of a rabbit enterprise. On the other hand, any alternative feedstuff that might reduce variable costs are beneficial to the producer because apart from viability and sustainability can enhance profit margins in the long run. This implies that due to scarcity and the prohibitive cost of the commonly used classical

dietary protein sources in feed industry, chemical evaluation of available non-conventional feedstuff as potential sources of rabbits feed is crucial, if profits are going to be realized in commercial rabbit production, especially in developing countries. The preceding review looks at the effects of nutrition on growth traits, reproductive performance and mortality in rabbits.

1. Introduction

Feeding is the most critical component of a profitable rabbit enterprise due to its influence on enhanced productive traits (Agunbiade et al., 2002; Fotso et al., 2000), efficient reproductive performance (Smith and Somade, 1994) and reduced mortality (Tazzoli et al., 2013). Feeding accounts for almost 70% of production cost (Oliveira et al., 2013). Lebas et al. (1997) observed that rabbits have high reproductive potential and fast growth rates, which can be maintained taking advantage of their high feed utilization competence. The productivity effectiveness of farm animals such as rabbits is predominantly dependent on their reproductive achievement, and sizable positive and negative interaction between the reproductive performance and nutritional status (Castellini, 2007). Growing rabbits for meat production should be fed to appetite in order to maximize growth rate and final weight (Maertens, 2009). Slight feed restriction in rabbits foment sharp decline in daily growth however, a more severe dietary restriction is necessary to achieve substantial changes in body composition (Xiccato, 1999). Nutritional deficiency appears to be responsible for unsatisfactory reproductive efficiency (Castellini, 2007), production performance (Agunbiade et al., 2002; Sankhyan et al., 1991) and increased mortality (Tazzoli et al., 2013; Andrade, 1997). Rabbits have been found to give high performance when fed concentrates alone (Obinne, 2002). However, for efficient production roughage sources should constitute 35 to 40% of rabbit diet volume. Rabbits can survive on all forage diet, however optimum productivity can be only achieved through mixed feeding pattern, including both forage and formulated feeds (Arijeniwa, 2000). The provision of inexpensive dietary formulations which consider alternative cheap sources of nutrients can drastically reduce the production costs in rabbit production. Feed resources which have no direct nutritional value to humans, such as weeds, grass forage, vegetables, course grasses, house wastes as well as agricultural by products like rice straw, bean haulms, corn bran, etc. have a potential replacement value as effective supplements in rabbits' diets. This is on the backdrop that the potential of the rabbit meat production industry has been constrained due to reduced profitability as a result of the escalating cost of the manufactured conventional feed resources (Aduku and Olukosi, 1990) especially in developing countries.

2. Nutrition and growth traits

Observed growth rate performance of rabbits are determined by dietary crude protein levels (Obinne and Mmereole, 2010). Dietary protein level had an influence on growth in two commercial rabbit broilers (Berne and Gous, 2008). Okonkwo et al. (2010) feeding cassava leaf meal at 30% and 20.88% crude protein gave the optimum replacement value which sustained performance. In a separate study, Agunbiade et al. (2002) reported an average daily gain of 18.40 to 20.30g for rabbits fed diets containing 0 to 50% maize and varying proportion of dried cassava peel meal. Bhatt et al. (1999) working with Angora rabbits observed that feeding diets containing soy flakes at 9% and 16% (protein equivalent basis) improved rabbits' performance. Soybean meal (SB61) and sunflower meals fed as sources of protein resulted into distinguished growth performance and lowest mortality. This high performance was accredited to improved ileal digestibility (Gutierrez et al., 2003). Cheeke and Raharjo (1988) reported that tropical grasses were unfit as exclusive feed for rabbits due to their low digestibility (less than 10%). The growth rates under tropical environment are much lower and this is chiefly ascribable to inadequate nutrition (Rejadeven, 1984). Cotton seed meal fed as a key protein dietary source reduced growth rate in rabbits (Aganga et al., 1991), while in another study higher weight gains were observed when fish meal was the principal dietary protein source (Sankhyan et al., 1991). The satisfactory performance of rabbits fed fish meal as compared with cotton seed meal seems to be the plausible consequences of exceptional high amino acids of this protein

source (Mc Donald, 1973). In a similar study, Fotso et al. (2000) feeding fish meal resulted in improved feed/ gain ratio compared to offal meal, was in turn better than cotton seed meal and cassava leaf meal. Poor utilization of cassava leaf meal was associated with utilizing the sulphur amino acids to detoxify the residual hydrocyanic acid and therefore needed more to effect growth. Using cassava by products diets based on hay from the upper third of cacao variety cassava foliage and alfalfa hay resulted in reduced performance in does and growing rabbits (Machado et al., 2007). The unfavorable performance was associated with the low nutritional value of the cassava cultivar. Growth rates of 14.0g/d and 18.1g/d were reported for rabbits fed water spinach ad libitum and broken rice by Samkol (2005) and Phimmasan et al. (2004), respectively. In a similar study a high growth rate was observed of 31.4g/d when rabbits were supplemented with molasses block and concentrate at 2 and 3% dry matter of body weight, respectively (Chat et al., 2005). This is partly explained by the fact that diets that are efficiently utilized reflects the pattern that with a more balanced amino acids picture do support faster growth rate in rabbits.

Elsewhere, increasing protein level in rabbit diet improve production efficiency (Li et al., 2002). It has been ascertained that efficient dietary protein provision level in rabbits is about 15.5% (Blas and Wiseman, 2010). This value is slightly lower than the that reported by Fasaya and Ijarya (2002) who proclaimed that rabbits can perform better on weight gain basis when fed a diet constituting 16% crude protein. It has been observed that dietary protein percentages lower than 15% will reduce growth performance (de Blas and Mateos, 1998). A high density diet promoted lower feed intake while enhancing final weight and weight gain adjusted for constant intake (Teixeira et al., 2013). The results do not warrant the use of high density diet for growing rabbits does because it could have a negative impact during reproductive phase. A large reduction of dietary protein content has a negative consequence on growth performance (Carabano et al., 2000). Crude protein content of around 140g/kg do not impair growth performance if the ratio of digestible protein and digestible energy is maintained around 9.5 to 10g/MJ. This is only accomplished when the amino acid supply is adequate. The protein to energy ration is an appropriate and practical way of assessing dietary quality. Lactating does require higher dietary protein when they are concurrently pregnant. This intense demand for protein in does this period often result in a negative balance of protein in turn the does mobilizes protein from their own body reserves. It is imperative to provide adequate nutritional support in this phase in order to sustain pregnancy and lactation of kits and reduce pre-weaning losses. Higher protein levels of 17 to 18% in the diet will be adequate to sustain lactation and pregnancy (de Blas and Wiseman, 2003). From previous rabbit feeding studies, it can be deduced that the quality of protein visa vis amino acids balance should be taken into account. not just gross protein content.

The increase of dietary energy by concurrent increase of dietary starch and soluble fiber to take the place of insoluble fiber improves feed efficiency utilization (Tazzoli et al., 2015). Growing rabbits can favorably be reared on diets that are low in grain and significant amount of roughage (Cheeke, 1986). For maximum performance from growing rabbits the proportion of 100 to 200g and 40 to 60g of green roughage and concentrate mixtures, respectively, were suggested (Ranjhan, 1980). A high dietary energy supply influence does milk production capacity in rearing good performance litter, however, sometimes it impairs its potential benefits on maintaining does body condition (Pascual et al., 2000). In growing rabbits, the dietary digestible energy concentration clarifies a considerable part of the inconsistency in feed intake and feed conversion efficiency (Xiccato and Trocino, 2010). The same authors observed that energy concentration promote ingestion of dry matter and correspondingly utilization of other nutrients in form of protein, amino acids and minerals. The digestibility coefficient for energy decreases with increasing fiber content. Garcia et al. (1993) observed that an efficient replacement level of sugar beet pulp to barley grain was 15% without decreasing performance, however, energy and nitrogen utilization were reduced by 5%. Good growth and vitality was sustained in post weaning and finishing period at 14% dietary starch level (Volek et al., 2006). Energy concentration is the main responsible for ingestion of dry matter and consequently of the main nutrients like protein amino acids and minerals. The energy to protein ration was related to growth performance (de Bias et al., 1981).

Fiber is one of the essential dietary component of commercial formulated diets for intensively reared rabbits, which is normally included around one third of forage and fibrous by products (Wang et al., 2012). Agege (1994) observed that rabbits can make use of a moderate wide range of levels of dietary fiber between 10-22% crude fiber for growth and maintenance. However, fiber type is important since the molecular structure, physical and biological attributes of the cell wall differ immensely among fiber sources (Gidenne, 2003; Nicodemus et al., 2006). The different sources or constituents of dietary fiber affect nutrient digestibility in turn performance (Chio et al., 1998). The influence of fiber constituents on performance was more pronounced in a lignin supplemented group as compared to cellulose and pectin. Rearing rabbits on forages/fiber with an energy supplement has been observe

to be more applicable in under developed countries where commercial feeds are scarce or the cost is beyond most producers due to exorbitant cost (Linga and Lukefahr, 2000). It has been documented that different sources and different fiber components (cellulose, hemicellulose, lignin and pectin) influence nutrient digestibility, feed intake, rate of passage, hind gut fermentation and growth rate in various degree (Doug and Thu, 2007). The beneficial effects of the presence of dietary fiber in the rabbit gut is to promote a high rate of passage and avoid withholding of digesta in the caecum. Feed intake and growth may be negatively affected by reduced feed intake and digesta retention in the ceacum. Dietary fiber is broken down to supply essential nutrients in addition to maintaining the beneficial spectrum of microbiota that release high microbial protein within hind gut and consequently improving the productive performance (Gu, 2002). de Blas and Mateos (2010) observed that growing and lactating rabbit does may need comparatively high fiber content of 34 and 32% neutral detergent fiber, respectively, on a dry matter content basis g/kg. Rabbits have a unique sense of appetite, which makes them do well on a wide range of fresh or preserved grasses, shrubs and leaves as sources of fiber (Bumgbose et al., 2004). Fiber is a source of energy rich substrate which promote the co-existence of various intestinal microbiota populations in rabbit gut.

In comparison with other herbivores and ruminants' rabbits acquire limited digestive energy from roughage (Cheeke, 1987). Malted sorghum could effectively replace maize as a source of energy in diets for weaner rabbits without any adverse effect on performance. Malting increases, the protein, soluble sugars, lysine and reduces tannins levels of sorghum (FAO, 1995). Feeding wilted cassava and pelleted cassava resulted in weight loss in rabbits (Yono et al., 1986) which was attributable anti-nutritional factors. Omole and Onwuolike (1982) observed average weight gian of 15.6g for rabbits fed cassava root meal fortified with fish meal and palm oil. In similar studies, in response to maize diet weight gains of 12g and 13.4g were reported by Ekpenyo (1981) and Onifade and Tewe (1993), respectively. Several studies have established the prospects of incorporating different level of various fiber sources into balanced diets for rabbits without impairing growth performance. Masoero et al. (1984), Villamide et al. (1989) and Kasa et al. (1989) worked with wheat straw, wheat bran and rice by products, respectively, with few deleterious effect on growth performance. It has been noted that variable proportions of different sources of fiber influenced nutrient digestibility, nitrogen retention and the amount of volatile fatty acids differently (Doug and Thu, 2007). This is on the premise that dietary fiber promotes the caecal fermentative activity and bacteria fibrolytic activity (Gidenne et al., 2010). Dietary fiber levels alter the digestibility of other nutrients constituency in the diet and hence their influence on growth performance in rabbits (Gidenne and Garcia, 2006). The benefits of digestive fermentative activity and bacteria fibrolytic activity is that their by products, including volatile fatty acids with high quality microbial protein recycled through caecotrophy (Combes et al., 2013). Appropriate dietary fiber level is an avenue for regulating the digestive health (Gidenne, 1997) and caecal microbial activity (Bennegadi et al., 2003). It has been acknowledged that a severe decrease in dietary acid detergent fiber from 19 to 9%increases the risk of digestive disorders which in turn impact negatively on growth performance. Cutback of dietary fiber intake in rabbits has been implicated with poor growth performance and noticeable increase in health risk index. An inadequate supply of dietary fiber is the root cause of caeco-colic digestive disturbance resulting in diarrhea and mortality (Gidenne, 2003). However, an overload of dietary fiber restricts energy intake resulting in poor growth performance (Garcia et al., 1999). Tao and Li (2006) observed an increase in fibrolytic microbial activities with increase in the dietary NDF, while digestibility of crude protein, crude fiber and ether extract was depressed. The adjusting dietary fiber levels can explain caecal fermentation pattern and its implication for impaired growth and digestive health status. It is important to mention that the capacity of the microbial activities to provide 30 to 50% of maintenance requirements for an adult rabbits' point to the fact that fiber is a crucial component of the rabbit diet. As a result of microbial activity, the host rabbit benefits from the additional energy emanating from volatile fatty acids and recycled protein rich substrate from microbial protein synthesis through caecotrophy (Gidenne et al., 2010). The ideal level of dietary crude fiber for fattening growing rabbits to attain maximum growth rate and best feed utilization efficiency is 12.5% (Rabie et al., 2011). After 5 week feeding period, food intake and body weight gain increased with increasing in dietary fiber, while at 11.5% dietary level the highest feed conversion efficiency was observed (Yu and Chiou, 1996). Reduction in dietary level from 36-38% to 30-32% neutral detergent fiber resulted in improved performance on growth and feed efficiency (Alvarez et al., 2007). The ideal dietary fiber proportion for growing rabbits has been inconsistent and was dependent upon other factors for instant type of fiber, age and breed and/or energy density of the diet (Gidenne et al., 2010). de Blas et al. (1999) observed that disproportionate and inadequate dietary fiber content is associated with compromised rabbits' performance. Excessive dietary fiber levels result in low energy efficiency utilization and reduced net energy intake. The energy digestibility declined with increase in fiber level (de Bias et

al., 1981). In company with an optimal level of fiber, enough balance of digestible fiber and long sized particles is required to obtain an ideal performance. The impaired performance reported for high fiber diets is attributable to considerable fermentation losses and an inadequate glucose uptake to meet rabbits' nutritional needs.

Rajendra et al. (2003) observed that incorporation of mulberry leaves to replace lucerne hay at 15% inclusion level will improved total weight gain, average daily gain and feed efficiency in rabbits. However, feeding higher levels of 30 to 45% of mulberry leaves based complete feed was also encouraging. Exclusively feeding alfalfa or in combination with other ingredients, Cheeke et al. (1983) observed high daily gains of up to 35g. Other forage sources such as Desmodiumdistortum, Cassi fora and Clitoria ternate produced comparable results for weaning rabbits as alfalfa. Palm press fiber based diets fed to rabbits enhanced productivity and carcass quality in addition to keeping rabbits in good health conditions (Houndonougbo et al., 2012). The diet containing 20% groundnut haulms was appropriate for improving performance of weaner rabbits (Bawa et al., 2008). Feeding head lettuce residue, Mimosa pigra and water spinach resulted in higher growth rate and digestibility than feeding Ruzi grass and can be recommended as alternative feed source. Nakkitset et al. (2008) observed that apart from reducing costs water spinach foliage's potential supplement for rabbits and can replace guinea grass of 100% in the diet with higher live weight gain. Weight gains were comparable for iso-fiber diets of wheat, barley, maize and extruded maize varying in starch nature (Gidenne et al., 2005). Uko et al. (1999) observed that due to inadequate energy in maize and millet offals based diets, rabbits compensated for the low calorie content by consuming more feed and as a result deriving more digestible energy for improved weight gain. Working with mongrel rabbits Maidala et al. (2016) improved daily feed intake, daily weight gains and feed conversion efficiency feeding human used sugarcane bagasse as a source of fiber at different levels. The author noted that human used sugarcane bagasse can be effectively included in rabbits' diets at 80% replacement of wheat offals without any adverse effects on performance. The only difference was the rate of feed conversion efficiency, which was influenced by starch source. Maize seemed to be more resistant to intestinal digestion in comparison to barley and wheat. In contrary, Xiccato et al. (2002) observed a significant effect of barley versus maize as starch sources on growth performance, at neither low nor high inclusion levels. Artichoke bract was observed to be a potential feed ingredient due to its good chemical composition and has a potential as an effective supplement for rabbit to improve performance at levels of up to 100g/kg in the diet (Dabbou et al., 2014). Legume forages are rich in plant protein, which makes them a potential source as a feedstuff resource. Bamgboe et al. (2002) suggested that optimum performance of rabbits could be achieved if forage legumes were formulated in combination with small amounts of considerable concentrates. Weight gains reported on forage and concentrate mixture diets under tropical environment ranged from between 5-20g/g (Hongthong et al., 2004) and this is on the backdrop of average daily of 15-20g/d reported on common range in the tropics (Aduku and Olukosi, 1990). However, this performance was noted not only dependent on the diet, but also other fixed effects such as type of rabbits (weaners vs growers), forage type, state of forage (fresh vs hay) and environmental conditions.

The main thrust in legume forage utilization in rabbit production is to reduce feeding cost, enhance performance, reproduction and reduce mortality. However, the challenge in use of forage legumes is that they contain different levels of ant-nutritional factors. From various sources, anti-nutritional factors include phenolic compounds, phytate, tannins, saponins and oxalate. The major negative dietary effects of anti-nutritional factors are that they impair the availability of one or more dietary, reduce palatability and/or depress nutrients digestibility (Kaitho et al., 1998). Methods have been devised to lessen their activities in digestion, which include heating and boiling (Abbduirashid and Aqwunobi, 2009), biological treatment with fungi (Hassan et al., 2009) and use of inoculants in hay and silage making (Ben Salem et al., 2000).

3. Nutrition and reproductive performance

The productivity effectiveness of farm animals is predominantly dependent on their reproductive achievement, and sizable positive and negative interaction between the reproductive performance and nutritional status have been observed (Smith and Somade, 1994). Xiccato et al. (1992) suggested higher requirements for protein dietary supply of 20% to enhance reproductive performance than those needed for growth. During a three reproductive cycles rabbit females fed simplified diet had reduced feed intake correspondingly more reproductive defects (Oliveira et al., 2017). On the other hand, does fed half of the simplified diet exhibited an extended interval between first mating and the third weaning ascribable to the lower nutrient intake to meet the nutritional requirements of does kept under intense breeding plan. Andrade (1997) reported positive results on reproductive

performance as results of different substitution levels of commercial feed by cassava stem hay, cigana variety. A replacement rate of 30% of cassava stem hay gave a higher number of kits per litter, higher mean body mass of kits at birth and slaughter. Increase in protein level of the rabbit diet was reported to either or have no effect on total number of kits born per litter (Reharjo et al., 1986) or increase the total number of kits born (Omole, 1982). In contrary, Hammond (1965) observed a negative effect of low protein level on litter size and individual kit weight at birth. However, weaned kits per litter significantly decreased in does fed 10 to 14% protein level (Omole, 1982). Sanchez et al. (1985) noticed a slightly higher litter size as a result of increase in protein level in the diet. The low birth weight has been associated with low dietary protein level, which likely attributable to low nitrogen retention in does fed low protein diets (Odi, 1990). The current commercial levels of dietary protein for fatteners and reproductive does range from 16 to 18% CP (Carabano et al., 2009).

4. Nutrition and mortality

The feeding of balanced diet has been associated with reduced post weaning mortality by limiting pathogen microbiota population (Tazzoli et al., 2013). In the same study decreased protein level nearly halved mortality (Tazzoli et al., 2013). Holley et al. (1955) working with weanling broiler rabbits observed mortality rates of as high as 43.3%, when fed cotton seed meal at 20 to 40% inclusion level. The high mortality rate was probably a result of the daily dosage and accumulation of the dominant anti-nutritional factor (gossypol) in cotton meal based diets. At a digestible protein to digestible energy ration of 9.5, sustained by adequate amino acid supply, protein content around 14% fed to rabbits from weaning (35d old) to slaughter (2 to 2.7 kg) did not hinder growth performance (up to 55 g/d) (Garcia-Palomares et al., 2006). It was also observed that at this protein content N-excretion was reduced to 38% in fattening period (Maertens et al., 1997) and significantly reducing mortality. The association between growth traits with digestible energy intake reached optimal level at an energy protein ratio of about 23.5kcalDE/gCP at which mortality rate was minimum.

Soluble fiber may protect intestinal mucosa and reduce the presence of pathogenic bacteria and in turn minimizing mortality (Gomez-Conde et al., 2007). Dietary fiber fraction is very important in rabbit nutrition primarily because of its influence on rate of passage and promotion of microbial activity in the hindgut which in turn stabilizes gut ecosystem and health enhancing survivability (Soler et al., 2004). The same author observed that mortality rate during pre and post weaning period was to great extent dependent on diet, which decreased as digestibility of fiber to starch increased and also increasing with high level of animal fat. On the other hand, replacing with commercial feed contributed to mediating the differences associated with the digestible fiber/starch ratio and eliminated the effect of level of animal fat. Xiccato et al. (2003) observed inclusion of vegetable fat did not influence health status of rabbits consequently lowering mortality. Assessing mortality, Perez et al. (2000) reported an accelerated decline in mortality as digestibility fiber/starch ratio varied on fresh matter basis. The dietary starch origin did not influence mortality rate between weaning and 49 days of age during the finishing period (Gidenne et al., 2005).

Working with growing rabbits, feeding a soybean based diets showed a higher average daily gain and feed intake but a similar conversion ratio, and had a higher mortality than those fed on sunflower meal based diets (Gutierrez et al., 2003). The authors ascribed this to anti-nutritional activity as the major cause of higher mortality observed in soybean based diets than with low antigenic sources of protein in sunflower meal. Andrade (1997) observed lower neonatal mortality and mortality during nursing in rabbits fed different substitution levels of commercial feed by cassava stem hay, cigana variety. Higher ileal digestibility, low ileal flow and reduced mortality were reported in rabbits fed concentrated (ethanol treated) soybean protein or sunflower meal than those fed soybean meal or a mixture of soybean with potatoes (Carabano et al., 2000). Garcia-Ruiz (2006) observed a higher mortality with soybean meal with respect to rabbits fed sunflower. This was attributable to ant-nutritional factors in soybean meal which could have apply an added effect on mortality. The effects of maternal under nutrition in rabbits offspring have already been reported in terms of litter weights as well as offspring weight and survival rate (Matsuoka et al., 2006). The negative effects of simplified diet fed to does on the number of kits at weaning, body weight of kits at kindling, weaning weight gain of kits from birth to weaning and total body weight of kits at weaning resulted in increased overall mortality rate (Oliveira et al., 2017). In another study, highest and lowest mortality rates were observed in 60 and 50% inclusion of cowpea urea treated husks (Mohammed and Jamala, 2013). A sudden decline in mortality was observed under restricted feed intake and this was accompanied by favorable feed conversion efficiency which was 8% more (de Oliveira et al., 2012). A mixture of forage and

concentrates improved nutrient digestibility manifested in high milk production by does resulting in low mortality during the pre-weaning phase (Effiong and Wogar, 2007).

5. Implication

Nutritional programs and feeding patterns are modifiable risk variables that can be used in an effort to promote growth traits, reproductive performance and reduce mortality rates in rabbits. Attention has to be taken to adequately supply essential nutrients in order to optimize overall productivity and profitability. The indispensable components of rabbit diet (i.e. protein, fiber, fat and energy) should be maintained targeting the promotion growth traits, reproductive performance and reduced mortality rates. Nutrition is the major variable cost in commercial rabbit production, however, in response to the sharp rise in cost of conventional formulated feed, producers need to adopt cost saving nutritional programs and feeding patterns. Minimizing feed costs could be achieved in different ways, however, one of the promising strategies is the use of untraditional cheap feed ingredients which have shown the potential to enhance production, reproductive performance and reduce mortality. Different alternative feed resources have been evaluated these include types of weeds, shrubs and forages (grass and legumes), agricultural by products, agro industrial by products and kitchen waste etc. However, caution should be exercised in the event that non-conventional feedstuff is utilized in feed formulation because of the presence of anti-nutritional factors in some of these feedstuffs.

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How to cite this article: Assan, N., 2017. Consequences of nutritional programs and feeding strategies on growth traits, reproductive performance and mortality in rabbits. Agricultural Advances, 6(9), 425-435.