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REVIEW ARTICLE

Probiotic Supplementation in the Diet of Rabbits - A Review

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Abstract

Probiotic are advocated as an alternative to antibiotic for growth promotion. They are live culture of non pathogenic organisms which are administered orally and are defined as live microbial feed supplements, which beneficially affect the host by improving its intestinal balance. Probiotic products are available in the form of oral paste, water feed additives and include microbial cell, microbial culture and microbial metabolites. Most probiotic get destroyed by up to 80 percent in the presence of antibiotics or when mixed with antimycoplasma drug in the feed. The term "pronutrient" is used in place of probiotic. The US food and drug administration used the term Direct Feed Microbiotics' (DFM) instead of probiotics and the manufactures were directed to write DFM on their products. Micro-organisms used in animal feeds are mainly bacterial strains belonging to different genera and microscopic fungi. A dose of 10^6 to 10^7 CFU/gm of feed administered continuously is necessary to obtain a balance between probiotic micro-organisms and bacteria of resident micro-flora in the gut. The microbial species used in the probiotic preparation include *Lactobacillus acidophilus, L. bifidus, L. bulgarians, L. casie, L. lactis, Streptococcus faecium, Bifidobacterium bifidum, Aspergillus oryzae and L. ruminis*. Probiotic strains had positive effect on animals and result as bio-regulators of the intestinal micro-flora and reinforcing the host's natural defences. Probiotic represents addition of live micro-organisms in feed showing positive effects by maintaining eubiosis. Normal gut micro-flora provides normal mucosal function, increase digestibility and stimulates motility and immunity. The use of probiotics had many potential benefits and included: modified host metabolism, immune-stimulation, anti-inflammatory reactions, exclusion and killing of pathogens in the intestinal tract, reduced bacterial contamination on processed broiler carcasses, enhanced nutrient absorption and performance and ultimately decreased human health risk.

Key words: Probiotic, Pronutrient, Direct feed microbiotics, Antibiotics.

1. Introduction

Rabbit is considered as superior to the other livestock because it is one of the fast growing and its high prolificacy. It has a high production capacity and high feed conversion efficiency when compared to the other meat animals. Rabbits attain a slaughter age of 18-20 weeks normally when their body weight is of 3 kg. Rabbit meat is most delicious, low in fat and cholesterol (4%), easily digestible, high in protein content (25%) and low in caloric value (160 Kcal/100 g meat). Therefore, it can be consumed by heart patient and children. India is facing acute meat shortage i.e. less than 30g per capita against the recommended 125g by Nutritional Advisory Committee of Indian Council of Medical Research. This animal species has vast potential in improving the rural economy of the country by providing employment and generating income for the farmers having low and marginal land holding. In addition to these, it also plays a significant role for supply of animal protein at a cheaper cost for the overgrowing human population of the country. The importance and potential of this small versatile animal has been realized by the planners decades back, however, the development pertaining to research, extension and popularization of the species did not reach up to the expected mark. Recent Indian reports also highlight the importance of this species for rural development programme (Das *et al*., 2005; Risam *et al.,* 2005). The potential of rabbit to improve food security and nutrition has been amplified by Food and Agricultural Organisation and has proposed to promote rabbit farming in the various livestock projects all over the world. Rabbit production can serve as a vehicle to foster human development through the all elevation of poverty (Lukefahr, 1998). Rabbit are fragile animal and therefore the digestive process is very complex. That is why rabbits are sensitive to enteric diseases and especially when they are exposed to negative impacts. These problems can be avoided by antibiotics. Probiotics that contain yeast, live bacteria or bacterial spores can also prevent enteric disease of the rabbits. Instead of growth promoters with antibiotics that kill some of the rabbit own gastrointestinal flora, probiotic promote gut colonisation and stabilize eubiosis by competitive growth against harmful micro-organism reducing the intestinal pH with production of lactic acid and encouraging digestion by producing enzyme and vitamins. This function strengthen the animals own new specific immune defence (Fortun-LaMothe and Drouet-Viard, 2002). Dietary administered probiotic bacteria were effective in preventing the growth of *E. coli* 0157: H7 in the intestine of neonatal rabbits (Tachikawa *et al.,* 1998). Hamarany *et al.* (2000) found a dose-dependent positive effect of probiotic bacterium on *E. coli* occurrence in the caecum and small intestine in young rabbit. Parker coined the term "Probiotic" in 1974 and defined it as "Organism and substance which contributes intestinal microbial balance." The term probiotic means "for life" and has a contrast with the term antibiotic means 'against life'. Probiotic are advocated as an alternative to antibiotic for growth promotion. Probiotic are live culture of non pathogenic organisms which are administered orally. Again, probiotic are defined as "live microbial feed supplements, which beneficially affect the host by improving its intestinal balance" (Fuller, 1989). Probiotic products are available in the form of oral paste, water feed additives and include microbial cell, microbial culture and microbial metabolites. Most probiotic get destroyed by up to 80 percent in the presence of antibiotics or when mixed with antimycoplasma drug in the feed. The term "pronutrient" is used in place of probiotic. The US food and drug administration used the term Direct Feed Microbiotics' (DFM) instead of probiotics and the manufactures were directed to write DFM on their products. Micro-organisms used in animal feeds are mainly bacterial strains belonging to different genera and microscopic fungi. A dose of 10^6 to 10^7 CFU/gm of feed administered continuously is necessary to obtain a balance between probiotic micro-organisms and bacteria of resident micro-flora in the gut. The microbial species used in the probiotic preparation include *Lactobacillus acidophilus, L. bifidus, L. bulgarians, L. casie, L. lactis, Streptococcus faecium, Bifidobacterium bifidum, Aspergillus oryzae and L. ruminis*. Probiotic strains should have the following desirable properties (Mathur *et al.,* 2003; Jadhav *et al.,* 2015).

i. Viability of probiotic organisms: Probiotic bacteria must be viable and available at high concentration, typically 10^6 CFU/gm of a probiotic. The probiotic strain in use should be resistant to stomach acidity, pancreatic secretion and bile.
ii. Bio-safety: The probiotic strain should be safe with regards to animal and human health.
iii. Adherence properties: The adherence, colonization and multiplication in the intestine are most important selection criteria for a probiotic culture.
iv. Other properties: Each probiotic strain must be host specific, i.e. they should colonise the compatible host.

Different mechanisms of probiotic action have been suggested, but most are hypothetical. The positive effect on animals can result either from a direct nutritional effect of the probiotic, or a 'health effect', with probiotic acting as bio-regulators of the intestinal micro-flora and reinforcing the host's natural defenses (Guillot, 2003). Probiotic represents addition of live micro-organisms in feed showing positive effects by maintaining eubiosis (Sinovec, 2001). Normal gut micro-flora provides normal mucosal function, increase digestibility and stimulates motility and immunity. The mechanisms involved in such effects are still the matter of discussion but the most important could be so-called 'competitive exclusion' (CE) meaning prevention of entry and gut colonization by non-desirable bacterial populations. The importance of this stimulator lies in the fact that only healthy animals could fully express productive potential. The use of probiotics had many potential benefits and included: modified host metabolism, immune-stimulation, anti-inflammatory reactions, exclusion and killing of pathogens in the intestinal tract, reduced bacterial contamination on processed broiler carcasses, enhanced nutrient absorption and performance, and ultimately decreased human health risk (Edens, 2003; Patil *et al.,* 2015). Consumption of fermented foods had been associated with improved health and lactic acid bacteria (*lactobacillus and Bifidobacteria*) had been implicated as the causative agents for this improved health. Research over the last century had shown that lactic acid bacteria and certain other microorganisms can increase resistance to diseases. Establishment of *L. acidophilus* in the GIT helps in increasing the resistance to *Salmonella* and *E. coli* colonization (Panda *et al.*, 2000) and may even have a possible role in competitive exclusion by elimination of pathogenic organisms from the gut. The effect of probiotics had been shown to be influenced by various factors like: level of incorporation (Jadhav *et al.*, 1992), product composition and location. Probiotic generally show low efficiency under controlled experimental conditions, the activities of some probiotic seem better when the micro-flora is unbalanced (Guillot, 2003). They are also active against a wider range of condition when multiple-strain preparations are used. The available literature reveals that the response of probiotics is variable and that the key factor in successful use of probiotics has been the presence of viable bacteria in sufficient number with the capacity to colonize the GIT. One of the problems in probiotic manufacture is the practical handling of pure bacterial culture. Other factors resulting in the loss of viability during refrigeration, level of oxygen in products, oxygen permeation through the package and sensitivity to the antimicrobial substances (Dave and Shah, 1997). Usage of growth stimulators offers a certain degree of control and modification of gut population (eubiosis) whose importance in maintaining the normal health and productivity is unquestionable. After the biological (antibiotics) and technical (disinfection) era, the new ecological era is introduced in pathogen control by the use of probiotics. Ecological control of pathogenic micro-organisms through the usage of alternative growth stimulators becomes more and more the custom choice in animal husbandry and disease prevention. Therefore, more research works needs to be carried out to guarantee the safety of probiotics besides identification and characterization of active principles of them. The ultimate commercial values of probiotics however will also depend upon economical consideration. Keeping the above mentioned facts in view, the probiotic supplementation and performance of rabbits is described in this review.

2. Body Weight and Growth Rate

Csikvary *et al.* (1990) reported that 6 week old New Zealand White rabbits when supplemented with a probiotic (Lactifern) at 0, 0.2 and 0.8 g each every second day with drinking water gained 30.9, 31.9 and 32.6 g daily; however, when the same diet supplemented with another probiotic (Paciflor) to litter mates at 0, 50,100 and 150 mg/kg feed, the average daily gain was 30.15, 29.87, 30.32 and 30.71 g. The values in both conditions did not vary significantly. Blast *et al*. (1991) revealed that average daily gain increased significantly ($P<0.05$) in the rabbits (NZW X California) received pelleted diet with probiotic (Paciflor reg composed of Bacillus CIP 5832 spores at 10^6/g) than without probiotic. Gippert *et al.* (1992) reported that body weight gain of the rabbit increased by 3-6 percent when the probiotic (Lacto- Saac) was added to the diet at 1.0 g/ton as compared to the non-added groups. Maertens (1992) reported that when rabbits were reared with zero and 0.15% Biosaf granules (*Saccharomyces cerevisiae concentration* 5×10^9/g) weighed 2419 and 2359 g in control and 2490 and 2460 g in probiotic group under strict sanitary and normal conditions, respectively. Zoccarato *et al.* (1995) reported that body weight gain of growing rabbits was 33, 31, 34 and 29 g/day when they were given mixed feed with antibiotic (bambermycin at 4 mg/kg), sporigen probiotic (9.6×10^9 CFU/g composed of *Bacillus subtilis* + *Bacillus licheniformis* the ratio of 50:50), antibiotic + probiotic (bambermycin at 2 mg plus probiotic at 200 mg/kg) and basal (control) diet, respectively and antibiotic and probiotic significantly ($P<0.05$) increased weight gain. Ayyat *et al.* (1996) observed that addition of Lacto- sacc (probiotic at 0.1 percent level) significantly ($P<0.05$) increased the body weight of rabbits (NZW) at 12 week and average daily gain at 8-12 week of age at protein level of 16.3 percent than that of the other protein level (18.4 percent) and age interaction. Kamra *et al.* (1996) observed that there was no difference in the live weight gain of the New Zealand White rabbits on either common pelleted diet or diet supplemented with lactic acid producing bacteria (*Lacto* at 5×10^8 cells/rabbit) or equal amount of *Lacto* and *Saccharomyces cerevisiae.* (Sacc at 5×10^8 cells/rabbit). Ahmed *et al.* (1997) revealed that growth performance of New Zealand White rabbits improved significantly when they were reared with two levels of proteins (14, 16%) and supplemented with probiotics (N-FAC 1000 at 1.0 g and CYC-100) at 2.0 g/kg feed. Lower level of protein and N-FAC 1000 exhibited more improvement than CYC-100. Kermauner and Stuklec (1998) postulated that litter weight at weaning and litter gain were significantly ($P<0.05$) higher in New Zealand White male rabbits following the addition of probiotic (2% kanne produced from fermentation of cereal mix-wheat, rye and oats than control group. Bonanno *et al.* (1999) revealed that weight of young rabbits (Hyla multiparous) was 992, 1061 and 1053 g at the age of 14 weeks when they were provided commercial feed along with a probiotic (containing 3×109 spores/g of *Bacillus licheniformis* and *B. Subtilis* in 1:1 ratio at a concentration of 600 mg/kg diet) at zero level (without probiotic), probiotic given up to 9 weeks and probiotic given up to 14 week, respectively. El- Adway *et al*. (2000) postulated the final body weight and daily gain of New Zealand White rabbits increased significantly ($P<0.01$) upon the addition of addition of either 0.1 or 0.2 percent probiotic (Lact-A-Bac) or 0.05, 0.1 or 0.2 percent antibiotic (Stafac *20) than the rabbit of control group. Matusevicius *et al*. (2003) observed that the rabbit weight increased significantly ($P<0.05$) by 16.7-18.0 percent after supplementing the ration of rabbits aged 1-60 days with a probiotic preparation, i.e. control, probiotic (yeasture) at 1.5 and 2.0 kg/ton of the mixture respectively. Abdel-Azeem *et al.* (2004a) observed that New Zealand White rabbit fed with high starch diet plus 0.20 or 0.30 percent Yea-Sacc (probiotic) significantly ($P<0.05$) increased in final body weight and daily weight gain than those rabbits with probiotic supplementation. Abdel-Azeem *et al* (2004b) revealed that final body weight and daily weight gain improved significantly ($P<0.05$) when the New Zealand White rabbits (35 days aged) received diet supplemented with 20 mg virginiamycin, 100 mg zinc bacitracin, 1 g bioaction (probiotic) 1.5 g and 3.0 g yeast culture (*Saccharomyces cerevisiae)* per kg diet as growth promoters than the control group. Amber *et al.* (2004) observed that Yucca schidigera extract at the rate of 250 mg/kg feed or Lact-A-Bac (probiotic) at the rate of 0.5 g/kg feed when added increased the daily weight gain significantly ($P<0.05$) by 12.1 per cent or 9.6 percent in 5-13 week of age rabbits, respectively. Matusevicius *et al.* (2004) showed that the live weight of rabbits supplemented with yeasture probiotics increased significantly ($P<0.05$) by 16.7-18.0 percent when control ration was supplemented with 1.5 and 2.0 kg probiotic/ ton, respectively. Surdjiska *et al*. (2004) studied of adding 0.05 and 0.08 percent Lactina (pure culture of *Lactobacillus bulgaricus, L. acidophillus, L. helveticus, L. lactis, Streptococcus thermophillus and E. faecium with a total number of* 1×10^8/g micro-organism) in the New Zealand White rabbit diets and observed the addition of 0.05 percent Lactina increased the average daily gain by 11.7 percent and higher dose (0.08%) did not favour better biological results. Al-Sultan (2005) observed that the body weight of rabbit was significantly ($P<0.05$) improved in the rabbit group fed 0.75 g probiotic (Tri-Mic) per 10 litre of drinking water that of either 0, 0.25, 0.50, 1.00, 1.25 or 1.50 g level. Kustos *et al.* (2004) reported no difference in body weight and daily weight gain in Pannon White rabbits (2434 vs 2427 g and 34.4 vs 34.4 g) when received diet without probiotic (control) or with probiotic (Bioplus-2B Reg at 400 mg/kg diet). Das and Das (2006) observed that probiotic supplementation (Biovet YC at 0.2% of feed) had significantly ($P<0.05$) higher effect on final live weight and average daily gain in Soviet Chinchilla and Meghalaya local breeds of rabbits; however, the effect was insignificant ($P>0.05$) in case of all traits of New Zealand White. Matusevicius *et al.* (2006) revealed that dietary inclusion of probiotic (at 400 mg/kg BioPlus 2B corresponding to 1.28×10^6 colony forming units-cfu/g feed stuff, i.e. 6.4×10^5 cfu/g of *Bacillus licheniformis* and 6.4×10^5 cfu/g of *B. subtilis* pelleting) in the diet of rabbits (35 day old) did not affect body weight (77 day old) and daily weight gain (2427g and 34.4 g/day) as compared to the control rabbits (2434g and 34.4 g/day). Eiben *et al*. (2008) revealed that live weight of New Zealand White rabbits at 63 days tended to be higher both in prebiotic (0.3% inulin) and tannin (0.3%) group (2043 and 2051g), intermediate in control and probiotic (1000 mg/kg of probiotic bacteria of *B. subtilis* and *B. Licheniformis)* groups (1990 and 1996 g) and lower in 0.3 percent organic acid group. The impact of probiotic was ambiguous. Pascual *et al.* (2008) revealed that dietary inclusion of the probiotic Toyocerin Reg (1×10^9 spores of *Bacillus cereus* var toyoi per g*)* did not affect the Epizootic rabbit growth rate when compared with control diet without probiotic. Wang *et al.* (2008) observed that the average daily weight gain was significantly ($P<0.05$) higher by 15 percent in probiotics processing water group (P), 6 percent in nanometer implement processing water group (N) and 23.9 percent in P×N group as compared to control. Abdel-Azeem *et al*. (2009) reported that the highest final body weight and daily weight gain of the New Zealand White rabbits (5 weeks old) were recorded with supplementation of 200 mg Bioplus 2B (probiotic) or 400 mg Bioplus 2B per kg diet than either supplementing 200 mg per kg linofeed (antibiotic) or without supplementation. Copeland *et al*. (2009) observed that the addition of *Lactococcus lactis* to the diet resulted in the appropriate growth of the body without any colonization or translocation of probiotic outside the G.I. tract than the control group without probiotic. Yang *et al.* (2009) reported that use of *Clostridium botlinum* probiotic had growth promoting property. Zonato *et al*. (2009) studied of addition of growth factor, i.e. control, antibiotic (0.05% zinc bacitracin) probiotic (0.15% *Bacillus subtilis* at 10^9 cfu/g) prebiotic (0.15% phosphorylated mannan oligosaccharides at 30%) and symbiotic (probiotic+ prebiotic) in the diet of growing New Zealand White rabbits and concluded that addition of prebiotic or probiotic did not improve the weight gain of rabbits. Chrastinova *et al.* (2010) revealed that application of probiotic strain *E. faecium* AL41 strain (10^9 cfu/ml, 500 ml, animal/day) had highest body weight gain than that of either sage (*Salvia officinalis* at 10 ml/animal/day) or *Eleutherococcus senticosus* (Ginseng dry extract at 30 g/100 kg feed) or control diet without any supplements in drinking water. Dimitrova *et al.* (2010) observed that average live weight and gain in weight were better in rabbits received lucerne hay and commercial pellets and probiotic with biotin (Probikan with biotin) than those with probiotic without biotin (Probikan without biotin) or with coccidiostat eSb3 or control group. Further, the highest average daily gain and live weight were detected in rabbits breed Vesselina while the lowest in the animals of Californian breed. Onu and Oboke (2010) showed that rabbits fed 50 percent maize processing waste based diet (MPW) supplemented with 200 mg of enzyme (grindazym) or 200 mg probiotic (yeast) per kg feed had significantly ($P<0.05$) superior body weight gain as compared to MPW or non-MPW diet without supplementation. El-Katcha *et al.* (2011) reported that the influence of dietary supplementation of probiotic at 0.1 or 0.15 g/kg diet from *E. faecum* containing products (Protexin) had non-significant ($P<0.05$) improvement in body weight by about 3.3 and 4.9 percent while probiotic at 0.3 or 0.35 g/kg diet from *Lacto bacillus acidophilus* and other *L. strain* with enzyme (AM Phi-Bact) had reduced body weight gain by about 14.5 and 9.5 % respectively when compared with control. Ezema and Eze (2012) observed that inclusion of Bio-active yeast (probiotic) at a level of 0.12 g yeast/kg of diet *Saccharomyces cerevisiae)* had a significantly ($P<0.05$) higher weight gain than that of those rabbits supplemented with either 0.08 or 0.16 or zero gram yeast/kg diet. Khalil (2012) observed that rabbit fed with low protein diet and supplemented with 0.10 or 0.15 g multi-strain probiotics (protexien)/kg diet recorded 7.02 and 7.86 percent growth rate than the rabbits fed normal protein diet without protexin supplementation. Lam Phuoc Thanh and Jamikom (2012) observed that average daily gain was increased significantly ($P<0.05$) in New Zealand White rabbits from 24.0 g/day in control group to 28.1 and 27.9 g/day in 1×10^7 cfu/g *Lactobacillus acidophilus* group and 0.5×10^7 cfu/g *L. acidophilus* plus 0.5×10^6 cfu/g *Bacillus subtilis* group. Shehata *et al.* (2012) postulated that addition of amino-yeast at 0.25, 0.50 and 0.75 percent significantly ($P<0.05$) increased the daily body weight gain of the male New Zealand White rabbits as compared to control; however, the improvement was 31, 15 and 17 percent higher in the supplemented group as compared to control, respectively. Wallace *et al.* (2012) revealed that supplementation of probiotic (RE3) either at 1.0 or 1.5 ml per kg feed in the diet of heterogeneous population of California White, New Zealand White and Chinchilla weaner cross-bred rabbits had no influence on live weight as compared to the control group. Brzozowski and Strzemecki (2013) observed that there was positive impact of probiotic (*Bacillus cereus* var toyoi) at 400 mg/kg of probiotic preparation on body weight and weight gain in young rabbits than the control group without probiotic. El-deek *et al.* (2013) observed that dietary supplementation of 0.2 percent Super Action Probiotic (SAP) showed significantly ($P<0.01$) the highest final body weight and daily weight gain in 14 week old male New Zealand White rabbit as compared to those group reared on diet supplemented with either zero or 0.1 percent SAP. Oso *et al.* (2013) observed that growing rabbits fed diet containing Prebiotic (MOS at 1.0 g/kg feed) showed highest ($P<0.05$) final live weight and weight gain as compared to either those rabbits fed on arabixonylans oligosaccharides (Axe 1.0 g/kg feed) or Probiotic (Prediococcus acidilactis as 1×10^{10} cfu/g; 0.5 g/kg feed or Bacillus Cereus as 1×10^9 cfu/g @ 0.5 g/kg feed) or even other dietary combinations. Simonova *et al*. (2013) observed the highest average daily gain in the rabbits fed on commercial diet along with *Enterococcus faecium* CCM7420 (EF) than either with *E. senticocus* extract (ES) or their combination (EF+ES) or control group. Amber *et al*. (2014) observed that the rabbits (at the age of 3 weeks) when fed basal diet supplemented with MIX1 (mixture of prebiotic i.e. Bio-MOS Reg; mannan oligosaccharide at 1g/kg diet and a probiotic i.e. Bio-Plus Reg.2B, *Bacillus subtilis* and *Bacillus licheniformis at* 0.4 g/kg diet) attained significantly ($P<0.05$) higher body weight than those rabbits supplemented with either prebiotic (Bio-MOS,MOS1), probiotic (Bio-Plus, PLUS1) or control group. They further reported that body weight of rabbits were significantly ($P<0.05$) higher for MIX1 than MIX2 (mixture of MOS and PLUS and supplemented to rabbits at 5 weeks of age); however, there was non-significant difference between the body weight values of MIX1 and MOS1. El-Maksoud *et al.* (2014) reported that live body weight and total body weight gain were significantly ($P<0.01$) the highest with New Zealand White rabbits group that were supplement Probiotics in drinking water during 8-12 week period than that of either 6-10, 10-14 or 12-14 weeks period (2187.75g vs 1451.50g). Sevidoglu and Galip (2014) observed that final body weight and total weight gain did not differ significantly ($P>0.05$) when male New Zealand White rabbits (aged 5-6 weeks) were reared on basal diet (control) or supplemented with live yeast culture, i.e. *Saccharomyces cerevisae* (SC at 3.0 g/kg diet), *Spirulina plantesis* (SP at 3.0 g/kg diet) or SC and SP (at 3.0 g/kg diet SC; at 5% diet SP) for a period of 90 days.

3. Feed Intake and Feed Conversion Efficiency

Csikvary *et al*. (1990) reported that 6 week old New Zealand White rabbits when commercial mixed pelleted diet supplemented with a probiotic (Lactifern) at 0, 0.2 and 0.8 g each every second day mixed with drinking water feed conversion efficiency. Zoccarato *et* *al*. (1995) reported that growing rabbits when they were given mixed feed with antibiotic (bambermycin at 4 mg/kg) sporigen probiotic (9.6×10^9 CFU/g composed of *Bacillus Subtilis* + *Bacillus Licheniformism* in the ratio of 50:50), antibiotic + probiotic (bambermycin at 2 mg plus probiotic at 200 mg/kg) and basal (control) diet was (4.5, 4.7, 4.4 vs 4.9) respectively and antibiotic and probiotic significantly (P<0.05) increased feed conversion efficiency without modifying feed intake. Beilanski *et al*. (1998) reported that supplementation of Bb probiotic in complete diet on 35 days old rabbit decreased feed intake by 0.1 kg per Kg weight gain. Bonanno *et al*. (1999) observed that in the growth phase of rabbit (*Hyla multiparous*), from 6 to 9 weeks, when they were provided commercial feed along with a probiotic (containing 3×109 spores/g of *Bacillus Licheniformis* and *B. Subtilis* in 1:1 ratio at a concentration of 600 mg/kg diet) at zero level (without probiotic), gave better feed conversion efficiency (3.9 vs 3.4 vs 3.4). Abdel-Azeem *et al*. (2004b) revealed that feed conversion efficiency was improved significantly (P<0.05) when the New Zealand White rabbits (35 days aged) received diet supplemented with 20 mg virginiamycin, 100 mg zinc bacitracin, 1 g bioaction (probiotic), 1.5 g and 3.0 g yeast culture (*Saccharomyces cerevisiae)* per kg diet when compared to the control group. Matusevicius *et al*. (2004) showed that the feed conversion efficiency of rabbits supplemented with Yeasture probiotics decreased significantly (P<0.05) by 7.2-18.4 percent when control ration was supplemented with 1.5 and 2.0 kg probiotic/ ton, respectively. Amber *et al*. (2004) observed that Yucca schidigera extract at the rate of 250 mg/kg feed or Lact-A-Bac (probiotic) at the rate of 0.5 g/kg feed when added increased the feed conversion efficiency significantly (P<0.01) by 3.62 for probiotic treated and 3.87 for control group in 5-13 week of age rabbits, respectively. Das and Das (2006) observed that probiotic supplementation (Biovet YC at 0.2% of feed) had significantly (P<0.05) higher effect on feed conversion ratio in Soviet Chinchilla and Meghalaya local breeds of rabbits. Kristas *et al*. (2008) reported that rabbits treated with Probiotic (containing *B. licheniformis and B. subtilis*) at the age of 41 to 88 days had a significantly (P<0.05) better feed conversion ratio. Wang *et al*. (2008) observed that the feed conversion ratio was significantly (P<0.05) higher by 12.7 percent in probiotics processing water group (P), 12.7 percent in nanometre implement processing water group (N) and 18.1 percent in P×N group as compared to control. Onu and Oboke (2010) showed that rabbits fed 50 percent maize processing waste based diet (MPW) supplemented with 200 mg of enzyme (grindazym) or 200 mg probiotic (yeast) per kg feed had significantly (P<0.05) superior feed conversion ratio as compared to MPW or non-MPW diet without supplementation. El-Katcha *et al*. (2011) reported that the influence of dietary supplementation of probiotic at 0.1 or 0.15 g/kg diet from *E. faecum* containing products (Protexin) and *Lacto bacillus acidophilus* and other *L. strain* with enzyme (AM Phi-Bact) had reduced daily feed intake by 9.1 percent, 7.6 percent, 16.2 percent and 11.3 percent, respectively when compared with control. Dietary supplementation of *E. faecum* containing products (Protexin) significantly (P<=0.05) improved feed conversion ratio by 13.0 percent and 13.1 percent. Wallace *et al*. (2012) revealed that supplementation of probiotic (RE3) either at 1.0 or 1.5 ml per kg feed in the diet of heterogeneous population of California White, New Zealand White and Chinchilla weaner cross-bred rabbits had no influence feed intake but demonstrated a significant improvement (P<0.05) in feed conversion efficiency. Simonova *et al*. (2013) observed better feed conversion efficiency in the rabbits fed on commercial diet along with *Enterococcus faecium* CCM7420 (EF) than *E. senticocus* extract (ES) or their combination (EF+ES) or control group. Amber *et al*. (2014) observed that the rabbits (at the age of 3 weeks) when fed basal diet supplemented with MIX1 (mixture of prebiotic i.e. Bio-MOS Reg; mannan oligosaccharide at 1 g/kg diet and a probiotic i.e. Bio-Plus Reg.2B, *Bacillus subtilis* and *Bacillus licheniformis at* 0.4 g/kg diet) significantly (P<0.05) increased feed intake (P<0.05).

4. Mortality / Livability and Performance Index

Gippert *et al*. (1992) observed that supplementation of probiotic Lacto-saac to the diet at 1g/ton on 4-12 week aged rabbit decreased mortality by 3 to 6 per cent. Bielanski *et al*. (1998) observed that feeding complete diet with Bb probiotic to 35 days old rabbit reduced mortality. Kustos *et al*. (2004) observed that supplementation of Bioplus 2B Reg at 400 mg/kg to Pannon White rabbits lowered the mortality rate by 17 per cent and morbidity by 3 per cent resulting in a 20 percent decrease (P<0.01) in sanitary risk (morbidity and mortality) during fattening period. Matusevicius *et al*. (2006) revealed that dietary inclusion of probiotic (at 400 mg/kg BioPlus 2B corresponding to 1.28×10^6 cfu/g feed stuff, i.e. 6.4×10^5 cfu/g of *Bacillus licheniformis* and 6.4×10^5 cfu/g of *B. subtilis* pelleting) in the diet rabbits (35 day old) the morbidity and mortality rate were 3 and 17 per cent lower (P<0.01) during fattening period. Kristas *et al*. (2008) reported that rabbits treated with Probiotic (containing *B. licheniformis and B. subtilis*) at the age of 41 to 88 days significantly (P<0.05) decreased in the mortality rate when compared to the control group.

Pascaul *et al.* (2008) observed that dietary supplementation with 1000 ppm Toyocerin Reg. (1× 10^9 spores of *Bacillus cereus* var toyoi per g) reduced the mortality and sanitary risk index of rabbit during fattening period. Chrastinova *et al.* (2010) revealed that application of probiotic strain *E. faecium* AL41 strain (10^9 cfu/ml, 500 ml, animal /day) influenced mortality and energetic meat value. El-deek *et al.* (2013) reported that performance index of male New Zealand White rabbits at 14 weeks of aged were significantly (P<0.01) improved by diets supplementation with 0.2% Super Action Probiotic. Simonova *et al.* (2013) observed that dietary supplementation with *Enterococcus faecium* CCM7420 (EF) and *E. senticosus* extract (ES) or their combination (EF+ES) stimulated the leukocytes phagocytosis and reduced the pathogen in rabbit's digestive tract without oxidative stress. Amber *et al.* (2014) observed that the rabbits (at the age of 3 weeks) when fed basal diet supplemented with MIX1 (mixture of prebiotic i.e. Bio-MOS Reg; mannan oligosaccharide at 1 g/kg diet and a probiotic i.e. Bio-Plus Reg. 2B, *Bacillus subtilis* and *Bacillus licheniformis at* 0.4 g/kg diet) reduced mortality.

5. Dressing Percentage and Carcass Quality/Yield

Blast *et al.* (1991) observed that supplementation of probiotic Paciflor Reg at 10^6/g through two consecutive period at 23^0 C - 28^0 C and 18^0 C – 22^0 C, until rabbit reached 2 kg live weight, the average daily gain during fattening period was increased by 2g/day (P<0.05). Kermauner and Struklec (1996) observed that addition of probiotic Acid-Pack-4-way (AP4W) on the diet of rabbit increased (P<0.05) the dressing percentage and carcass weight. Ahmed *et al.* (1997) reported that addition of probiotic N-FAC 1000 (1 g/kg feed) and CYC-100 (2 g/kg feed) with two dietary protein level (14 and 16 per cent) improved carcass weight, protein content and water holding capacity. Abdel-Azeem *et al.* (2004b) revealed that New Zealand White rabbits (35 days aged) when received diet supplemented with 20 mg virginiamycin, 100 mg zinc bacitracin, 1 g bioaction (probiotic) 1.5 g and 3.0 g yeast culture (*Saccharomyces cerevisiae)* significantly (P<0.05) increased dressing percentage and carcass weight percentage. Matusevicius *et al.* (2004) observed that the live weight of rabbit supplemented with Yeasture probiotic at 1.5 and 2.0 kg probiotic/ton increased significantly (P<0.05) meat protein content by 1.8 per cent and 4.1 per cent and fat content by 0.2 per cent and 0.7 per cent, respectively. Al-Sultan (2005) reported that supplementation of probiotic (Tri-Mic) at 0.75g probiotic/10 liters of drinking water on rabbits does not affect the carcass weight. Lui *et al.* (2005) reported that inclusion of probiotic (containing *Lactobacillus acidophilus, L. casie, Bifidobacterium bifidum, Streptococcus salivarius, Enterococcus faecium, Bacillus subtilis, B. toyoi and Saccharomyces cerevisiae)* at a level of 0.00, 0.01, 0.02 and 0.03% in the diet of growing rabbits had no significant effect (P>0.05) on performance and carcass yield. Abdel-Azeem *et al*. (2009) reported that with supplementation of 200 mg Bioplus 2B (probiotic) or 400 mg Bioplus 2B per kg feed on the diet of rabbit increased the dressing percentage, Heart weight percentage increased while kidney fat weight percentage decreased. Zonato *et al.* (2009) studied of addition of growth factor, i.e. control, antibiotic (0.05% zinc bacitracin) probiotic (0.15% *Bacillus subtilis* at 109 cfu/g) prebiotic (0.15% phosphorylated mannan oligosaccharides at 30%) and symbiotic (probiotic+ prebiotic) in the diet of growing New Zealand White rabbits and concluded that addition of prebiotic or probiotic does not improve carcass weight, kidney, liver, lungs, hearth, etc. Dimitrova *et al.* (2010) observed that average carcass weight were better in rabbits received lucerne hay and commercial pellets and probiotic with biotin (Probikan with biotin) than those with probiotic without biotin (Probikan without biotin) or with coccidiostat eSb3 or control group. Wallace *et al.* (2012) revealed that supplementation of probiotic (RE3) either at 1.0 or 1.5 ml per kg feed in the diet of heterogeneous population of California White, New Zealand White and chinchilla weaner cross-bred rabbits had no influence on live weight, full stomach, full gastro intestinal and carcass length. However it causes changes in the warm and chilled dress weight. Brzozowski and Strezemacki (2013) observed that addition of Bacillus Cereus Var. Toyoi, as probiotic factor on young rabbit's diet at a level of 400 mg/kg of probiotic preparation showed positive result during fattening and dressing percentage.

6. Economy of Feeding Probiotics

Zoccarato *et al.* (1995) observed that with the addition of antibiotic (bambermycin at 4 mg/kg) sporigen probiotic ($9.6×10^9$ CFU/g composed of *Bacillus Subtilis + Bacillus Licheniformism in* the ratio of 50:50), antibiotic + probiotic (bambermycin at 2 mg plus probiotic at 200 mg/kg) reduced feed cost by 6.7 per cent. El-Adawy *et al.* (2000) recorded the highest economical efficiency value with the addition of either 0.1 or 0.2 percent probiotic (Lact-A-Bac) or 0.05, 0.1 or 0.2 percent antibiotic (Stafac *20). Surdjiska *et al.* (2004) reported that higher doses of probiotic (0.08%) did not favour better economical result and concluded that 0.05% was recommended dose for rabbits. Abdel-Azeem *et al.* (2009) observed the best net return, percentage of economic efficiency; relative economic efficiency and performance index were obtained by supplementing 400 mg Bioplus 2B on diet of the rabbits. Onu and Oboke (2010) observed that supplementation of 50 per cent Maize Processing Waste (MPW) with 200 mg of enzyme (grindazym) or 200 mg probiotic (yeast) enhanced the rabbit performance and successfully reduced feed cost of maize. El *et al*. (2011) recorded that dietary supplementation of probiotic at 0.1 or 0.15 g/kg diet from *E. faecum* containing products (Protexin) improve economical efficiency percent by about 64.9% and 49.7% on two different groups. Shahata *et al*. (2012) studied the effect by addition of amino-yeast at 0.25, 0.50 and 0.75 percent on the diet of growing rabbit and concluded that there was an improvement in carcass trait and economic efficiency. El-deek *et al*. (2013) observed that dietary supplementation of 0.2 percent Super Action Probiotic (SAP) on the diet of 14 week old male New Zealand White rabbits improved economic efficiency.

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