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Biological activity of Lysophospholipids in poultry and ruminants: A review

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Abstract

Lysophospholipids (LPL) are very important to the needs of the cells of living organisms, as they are an essential component of the cells as well as their major role in meeting the energy needs of the epithelial cells of the poultry intestine, and the chicks do not achieve maximum benefit from fat due to the lack of bile salts, so adding fat emulsions to the diet is very necessary to fill those Nutritional needs, in ruminants also lysophospholipids improve the production of cows and sheep. Many studies have indicated an improvement in the quality of milk and meat produced from both cows and sheep, as LPL allows ruminants to consume balanced food that meets all nutritional needs and thus stabilizes the rumen environment with fewer fluctuations in the pH value rumen, ammonia concentrate, and rumen fermentation to achieve a high yield, with no or little live weight loss over the lactation period and a low incidence of rumen acidosis. In addition to the great role of LPL in the metabolism of fats, proteins, and minerals, this review will highlight the studies that dealt with the effect of LPL in poultry and ruminants.

Keywords: poultry, ruminants, lysophospholipids, importance of phospholipids

Introduction

Improving dietary fat consumption is crucial for the broiler industry's cost-effective output. Bile salt acts as an emulsifier when dietary fat enters the aqueous gastrointestinal tract, breaking the lipids into droplets and enhancing the interaction of lipase with the fat. For lipids to pass through the colon and be absorbed, lipase hydrolyzes those (Khonyoung *et al*., 2015) [24]. Yet, due to inadequate bile salt output in young chicks, the use of fat is restricted (Noy and Sklan, 1998; Al-Marzooqi and Leeson, 1999) [33, 1]. Hence, one approach to address this issue is to provide exogenous emulsifiers in the diets. Phospholipase A2 cleaves one hydrophobic fatty acid off phospholipids to form lysophospholipids (LPL), also known as lysolecithin, enzymatically modified lecithin, and hydrolyzed lecithin (Joshi *et al*., 2006) [22]. Compared to popular emulsifiers like lecithin and bile salts, LPL has better hydrophilic characteristics and a higher hydrophilic-lipophilic balancing value. (Joshi, Paratkar and Thorat, 2006; Hasenhuettl and Hartel, 2008) [22, 17]. As a result, it improves the efficiency of fat digestion by reducing the size of fat droplets and stabilizing micelles in the small intestine while raising the bioavailability of fat in birds (Schwarzer and Adams, 1996) [37]. Moreover, the inclusion of LPL changes the permeability of cell bilayers and enlarges membranous pores in intestinal cell membranes, causing a larger influx of micro- and macro-molecules across the cell membrane (Lundbaek *et al*., 2010; Arouri and Mouritsen, 2013) [2]. LPL is the best-feed additive to improve nutrient transit and absorption because it combines the activities of emulsification and cell membrane modification, which results in improved nutrient digestibility. Increasing the surface area for nutrient absorption in the colon by raising villus height and minimizing cellular damage are just two of the benefits of LPL on nutrient utilization that are linked to improvements in gut health (Skoura and Hla, 2009; Boontiam *et al*., 2017) [40, 3].

One of the main energy sources for ruminants is lysophospholipids. It is crucial for the growth and supply of ruminal energy. Many studies have recently raised the subject of the value of forage feeding to produce more healthy beef (Cho *et al*., 2012) [10]. The study found that forage quality might affect meat quality, and that good forage could enhance carcass performance, meat color, and intramuscular fat deposition (Cho *et al*., 2012) [10]. Moreover, ruminal digestibility and animal performance are directly related to the quality of the forage. The bioavailability of nutrients in the diet was considered a key element in determining the income of farming households, Also, it is possible to assume that increasing the bioavailability of concentrate diets will increase the amount of forage in diets consumed during the fattening phase. Due to its low bioavailability, the forage diet could not be increased. It has been proposed that lysophospholipids (LPLs) may be a substance that activates biological membranes and increases the transport of macronutrients through the cell membrane (Koo and Noh, 2007) [26]. The remodeling of the membrane's lipid bilayer was proposed as the mechanism by which LPLs change the fluidity of the membrane and the permeability of nutrients through the membrane (Tagesson *et al*., 1985) [44]. There have been few types of research looking into how LPLs affect animal nutrition, and the majority of them focused on pigs and poultry (Xing *et al*., 2004) [48]. Investigations were done into LPLs' impact on in vitro rumen fermentation (Cho *et al*., 2013) [9]. However, there was little research that looked at how LPLs affected beef performance.

Phospholipids

Phospholipids are essential components of the majority of biological membranes; they are amphipathic and the subject of intense research into how they aggregate, phospholipids are distinguished from other lipid classes by having a polar head group that is linked to a glycerol backbone at the sn-3 carbon, moreover, the sn-1 and sn-2 carbons of two acyl residues produced from fatty acids are connected. Different polar head groups, fatty acid substituents, and their regioisomers are responsible for the structural variety of phospholipids. When assembled into ordered structures, they have three unique structural regions: (a) a polar hydrophilic headgroup that is located at the lipid-water interface; (b) an interfacial region of intermediate polarity; and (c) a hydrophobic tail region (D'Arrigo and Servi, 2010). The vital components of cellular membranes known as phospholipids have received extensive study and are the focus of numerous scientific research fields, customized glycerol-derived lipids are needed for recent developments in the fabrication of artificial cell membranes with particular biological activities. Phospholipids have a variety of practical purposes in addition to their biological function, such as emulsification in food and medicine, the creation of liposomes for cosmetics, and medication delivery (Stora *et al*., 2000: Uhumwangho and Okor, 2005) [43, 46].

Lysophospholipids

Lysophospholipids are glycerophospholipids in which one of the acyl chains is absent, and only one of the hydroxyl groups of the glycerol backbone is acylated. 1-Lysophospholipids keep the acyl chain in position 2, but 2-lysophospholipids only have acylation at position 1. LPLs are excellent synthetic intermediates for the synthesis of PLs for applications in foods, cosmetics, agrochemicals, and pharmaceuticals they are good emulsifying and solubilizing agents (Dennis *et al*., 2005). Lysophospholipids are membrane-derived signaling molecules created by phospholipases that exhibit a wide range of varied biological actions, but unlike Phospholipids, they are only found in very minute levels in biological cell membranes. The presence of lysophospholipids and their receptors in a variety of tissues and cell types indicates the significance of these molecules in a variety of physiological processes, such as vascular growth, nervous system development, and reproduction (Chun *et al*., 2005: Torkhovskaya *et al*., 2007: Parrill *et al*., 2008) [11, 45, 34]. They participate in numerous crucial but still poorly understood roles in both development and illness. In the past ten years, it has become abundantly clear that medically significant LPLs activities are mediated by particular G protein-coupled receptors (GPCR), implicating them in the etiology of an increasing number of diseases, including inflammation, autoimmune disorders, neuropathic pain, atherosclerosis, cancer, and obesity (Chun and Rosen, 2006) [12].

Due to its abundance in nature, 2-lysophosphatidylcholine is the LPL that has undergone the most research. Numerous reviews describe its regulatory effects. For instance, 2-LPC is directly involved in the signal transduction pathway through protein kinase C to induce long-term cellular responses; it accumulates in tissues during ischemia and in the plasma of inflammatory arthritis. It is involved in the regulation of gene transcription, mitogenesis, monocyte chemotaxis, smooth muscle relaxation, and platelet activation, lysophospholipase D transforms 2-LPC, which is released from the liver as a byproduct of phospholipase A2 hydrolysis or produced in the plasma by the enzyme lecithin/cholesterol acyl transferase, into lysophosphatidic acid (2-LPA, 1-O-acyl-sn-glycero-3-phosphate), a highly effective inducer of cell proliferation, migration, and survival (Van Leeuwen *et al*., 2003: Silliman *et al*., 2003) [47, 39]. Lysophosphatidic acid has been demonstrated to function as a crucial intermediate in transmembrane signal transduction processes as a platelet-activating factor and in the stimulation of cell proliferation. The recent identification and cloning of GPCRs with high affinity for LPA and another crucial LPL, sphingosine 1-phosphate (S1P), have enabled a greater mechanistic understanding of their varied roles in biological processes. LPA and S1P regulate the development of platelets (Karliner, 2002: Xu *et al*., 2003: Sengupta *et al*., 2004: Ren *et al*., 2006: Murph *et al*., 2007) [23, 49, 38, 32].

Bio ability of LPL

Enzymatic LPL synthesis provides numerous benefits over chemical approaches. A biocatalytic approach to structurally specified LPLs is actually preferred for a number of reasons: First, the selectivity or specificity of enzymes is discussed, second, the usage of less, frequently harmful and poisonous chemical reagents in the synthesis processes and under mild reaction conditions is discussed, the third justification is the purification process's simplicity as a result of the enzymatic catalysis's inherent selectivity and specificity, there will actually be fewer byproducts produced, another factor to take into account when purifying LPLs is the fact that in the event of an incomplete reaction, potential impurities in the finished product will be much more tolerable if the starting materials are substances that are already GRAS (generally regarded as safe), (Frohman and Morris, 1999) [15], as are natural PLs and enzymes, as opposed to residual chemical reagents, So, it would seem that synthesis, especially on an industrial scale, is quite interested in the possibilities of phospholipids modifying enzymes. The natural predecessors of LPLs are natural phospholipids, they have two phosphate ester linkages, as well as two carboxylic esters bonds, consequently, regio- and chemoselective characteristics, are necessary for selective recognition. Phospholipases are the enzymes that specifically catalyze the transformation of phospholipids, Phospholipases are essential for cellular control, phospholipid metabolism, and biosynthesis, one of the four ester linkages is specifically recognized by each of the four major phospholipases (Murakami and Kudo, 2002) [31] Phospholipases are common enzymes that can be found in both bacteria and animals. Around 100 phospholipases have currently been isolated, described, and cloned. Numerous more enzymes besides phospholipases can be utilized to modify phospholipids Lipases, which are non-specific enzymes with a wide range of substrate specificity, make up one of the major categories of these enzymes. Comparatively, to phospholipases, lipases have undergone more extensive theoretical and experimental development (Heinz *et al*., 1998) [19].

Effect of Lysophospholipids on Poultry

Lysolecithins are added to poultry diets to promote the intestinal absorption of nutrients, in particular dietary fats. Lysolecithins contain a mixture of phospho-and lysophospholipids and differ in composition depending on the conditions and source of the lecithin used for its production. Jansen *et al*., (2015) [21] used a basal diet with either soybean oil (5.3%) or pig lard (5.8%), each basal diet supplemented with 250 ppm soybean lysolecithin, and each basal diet supplemented with 250 ppm rapeseed lysolecithin. In vitro pig lard digestibility was significantly lower compared to soybean oil digestibility Although in vivo no significant difference was observed for crude fat digestibility, broilers fed the basal diet with pig lard had a lower digestibility, nitrogen retention, Lysolecithin supplementation showed a significant interaction with the fat type, both in vitro and in vivo, the in vitro hydrolysis of pig lard, but not of soybean oil. Polycarpo *et al*., (2016) [35] investigate three experiments with were conducted to evaluate maize-based diets for broilers containing different lipid sources soybean oil (S), or beef tallow (T), supplemented with or without lysophospholipids and organic acids on nutrient balance (Experiment I, evaluation period of 10-14 d), on liver concentration of fat-soluble vitamins, on jejunal microbiota an interaction between lipid sources and lysophospholipids was observed on faecal apparent digestibility of lipid (ADL), which improved with lysophospholipids addition in T diets Broilers fed on S had higher ADL and faecal apparent digestibility of nitrogen corrected gross energy (ADGEN), it was not possible to demonstrate a significant treatment effect on the liver concentration of vitamins A and E, even with the differences in fatty acid profile between S and T., enterobacteria values were below the detection threshold, lysophospholipid supplementation reduced gram-positive cocci in T-fed birds, S diets promoted lower total anaerobe counts compared with T diets, independent of additives, S diets increased BW gain and feed: gain ratio in all evaluation periods, lysophospholipids and organic acids improved feed:gain ratio at 1–21 d in T diets, furthermore, main effects were observed for lysophospholipids and organic acids at 1–42 d, which increased BW gain and improved feed: gain ratio, respectively. Zampiga *et al*., (2016) [50] used soy lecithin, One thousand seven hundred and fifty-five one-day-old male Ros 308 chicks were randomly divided into three experimental groups of nine replications each: control group (CON) fed a corn–soybean basal diet and two groups fed CON diet supplemented with constant (1 kg/ton) or variable (1–1.5 kg/ton) level of emulsifier (CONST and VARI, respectively), at the end of the trial (42 d), birds receiving the emulsifier had a statistically significant lower feed conversion rate compared to the control, body weight, and daily weight gain were only slightly influenced by lysophospholipids supplementation, while mortality and feed intake resulted similar among the groups, no statistically significant effect of the emulsifier was observed on nutrient digestibility as well as slaughtering yields, skin pigmentation and incidence of foot pad dermatitis. According to reports, broiler chicken performance has improved with the addition of lysolecithin to feed. Lecithin is hydrolyzed by phospholipase to produce lysolecithin. Lysophosphatidylcholine (LPC), one of the main products of the enzymatic reaction that changes different phospholipids into their matching lysophospholipids, is one of the end products. Brautigan *et al*., (2017) [6] noted no differences in weight gain during the starter period, a significant increase in average villus length with lysolecithin, and an increase in villus width with purified LPC, high throughput gene expression microarray analyses revealed many more genes were regulated in the epithelium of the jejunum by lysolecithin compared to purified LPC the most up-regulated genes and pathways were for collagen, extracellular matrix, and integrins. Staining sections of the jejunum with Picrosirius Red confirmed the increased deposition of collagen fibrils in the villi of broilers fed lysolecithin, but not purified LPC, thus, lysolecithin elicits gene expression in the intestinal epithelium, leading to enhanced collagen deposition and villus length. Zhao and Kim, (2017) [53] used (zero, 0.05, and 0.10% lysophospholipids), broilers fed basal diets had higher body weight gain (BWG, d zero to 14) and lower feed conversion ratio (FCR, d zero to 14 and d zero to 28) than those fed reduced energy diets, broilers fed LPL supplementation diets also had higher BWG (d zero to 14) and lower FCR (d zero to 14, d 15 to 28, and d zero to 28) than those fed without LPL supplementation diets, on d 14, the apparent total tract digestibility of dry matter, nitrogen, and gross energy was increased by LPL supplementation, the low-density lipoprotein cholesterol, total cholesterol, and triglycerides concentrations also were decreased by LPL supplementation on d 14, the relative weight of abdominal fat was higher in basal diet treatments, but lower in LPL supplementation treatments, in conclusion, LPL supplementation can increase growth performance and nutrient digestibility, decrease cholesterol and triglycerides concentration in the starter period, and decrease the abdominal fat percentage in broilers. Boontiam *et al*, (2017) [4] used five treatments: positive control without LPL supplementation and adequate in all nutrients, negative control without LPL, and reduced 150 kcal/kg of metabolizable energy and reduced 5 to 6% of crude protein and selected amino acids including Lys, Met, Thr, and Trp in a calculated amount relative to the PC, NC + 0.05% LPL (LPL05), NC + 0.10% LPL (LPL10), and NC + 0.15% LPL (LPL15). Feeding LPL linearly improved growth performance, feed conversion ratio, ether extract, and protein digestibility, LPL supplementation on low-energy and nitrogenous diets showed significant enhancements in metabolic profiles of blood glucose, protein utilization, and immune system functions, these improvements influenced carcass composition, especially in relative weights of pancreas and breast muscle. In contrast, LPL addition showed no significant effects on the relative weights of immune organs, gizzard, and abdominal fat, the negative control birds were more susceptible to inflammation via modulating the secretion of interleukin-1 (IL-1) and increasing crypt depth in the jejunal and duodenal segments, however, the inclusion of 0.05% LPL to the negative control diet could alleviate inflammation with increased jejunal villi height, a ratio of villi height to crypt depth and decreased IL-1 level, overall, LPL promotes growth performance, nutrient utilization, gut health, anti-inflammation, and muscle yields when applying to diets of broiler chickens with lower levels of energy, crude protein, and selected amino acids. Chauhan *et al*., (2019) [7] used two hundred and forty, newly hatched male chicks of a commercial strain, were randomly divided into four treatment groups, each treatment group had6 replicateswith10 birds in each group, birds were reared in separate pens as an experimental unit, two basal diets were formulated, one with a full energy diet which served as positive control and another was 80 Kcal/ kg less as compared to PC at each phase of the diet which served as a negative control, each of the diets was supplemented with 250 gm /ton of Lysophospholipids and Phospholipids blend emulsifier, and fed to birds from 0 to 35 days of age, at the end of the trial (35 d), birds that received the Lysophospholipids and Phospholipids blend emulsifier had a statistically significant higher body weight, lower feed conversion rate and better EEF as compared to the negative control, while mortality and feed intake was similar amongst control and treatment the groups, there was no statistically significant effect of the emulsifier on carcass traits and incidence of foot pad dermatitis. Boontiam *et al*., (2019) [5] investigated two experiments on the effects of lysophospholipid (LPL) supplementation on low-energy and low-nitrogenous diets for broilers, the treatments were: negative control was 150 kcal/kg of ME lower than PC, and LPL-05, LPL-10, and LPL-15 treatments were NC + 0.05%, 0.10%, and 0.15% of LPL supplementation, respectively, and experimental diet II included a positive control (PC) having a formulated amount of crude protein including Lys and Met + Cys that met the Ross 308 standards; negative control (NC) was 4% lower CP and AA than PC; other treatments were supplemented with LPL at 0.05% (LPL-05), 0.10% (LPL-10), and 0.15% (LPL-15) into the NC, respectively, an experiment I showed that growth performance linearly increased as the lysophospholipid It also showed a significant increase in feed consumption rate, feed conversion efficiency, protein digestibility coefficient, and amino acids. Chen *et al*, (2019) [8] found when to evaluate the effects of supplementing different levels of lysophospholipid (LPL) to normal or reduced energy diets on growth performance, carcass yield, intestinal morphology, and skeletal development in broilers, a total of 960 one-day-old Cobb 500 male birds were (NE: normal and RE: 100 kcal/kg metabolizable energy reduction) and 4 LPL supplement levels (0, 0.025, 0.050,and 0.075%), the results showed low metabolizable energy diets impaired bird's growth performance, intestine development, and bone quality, the 0.075% LPL supplement in NE improved BW, BW gain, and FI in the finisher and overall period compared with no LPL supplement in NE In RE, the 0.025% LPL supplement significantly improved growth performance compared to the other treatments in RE, The interactions on processing parameters were detected with LPL supplement in NE diets; 0.025, 0.05, and 0.075% LPL supplements significantly increased pectoral majorpercentages compared to the one without LPL supplement in NE, The 0.075% LPL supplement increased dressing percentage (cold carcass weight/live BW) compared with the others, the intestine morphology results showed LPL had positive effects on intestine development mainly during the early age (day 7) and claudin-3 expression at both day 7 and 21. Furthermore, the LPL supplement significantly increased the total Ca and P deposition and positively affected bone structure development. In summary, dietary LPL supplementation promoted growth performance, carcass yield, intestinal development, intestinal health, and bone quality. Movagharnejad *et al*., (2020) [30] used five treatments: positive control (PC) without LPL supplementation and adequate in all nutrients, negative control (NC) without LPL the reduced 150 kcal/kg of metabolizable energy, NC+ 0.15% LPL (LPL15), NC+ lipase (NCL), NC+ 0.15% LPL+ lipase (NCLL). Feeding LPL improved body weight gain and feed conversion ratio (FCR). In contrast, lipase supplementation showed no significant improvement in weight gain and FCR. Supplementation of LPL and lipase did not have a significant effect on immune organs, abdominal fat, and liver and thigh but decreased heart and gizzard and increased breast relative weight, digestibility of dry matter did not show a significant effect but crude protein and ether extract improved digestibility in LPL15 and NCLL group in contrast to NC group, the dietary treatment showed no significant improvement on the metabolic blood factors, the inclusion of LPL to negative diet (LPL15) and LPL+lipase to negative control diet raised villus height, a ratio of villi height to crypt depth and increased crypt depth, overall, LPL inclusion to the diet increased weight gain and improved FCR, crude protein, and fat digestibility, and improved villus height and the ratio of villi height to crypt depth to a control group.

Hettinger *et al*., (2021) used lysophospholipids at a concentration of 500 g/ton in one experiment, and in the second experiment, soybean oil was used as a source of rapidly decomposing phospholipids. It improved growth performance and protein digestion coefficient, but carcass characteristics were not affected, but the level of abdominal fat increased and the rate of digestion in the ileum improved. Solbi *et al*., (2021) [41] used broiler chickens fed diets supplemented with lysophospholipids (LPL) in combination with soybean (SO), flaxseed (FSO) or sesame seed (SSO) oil sources, a completely randomised design with a 2 3 factorial arrangement including two levels of LPL (0 or 0.1% Lipidol) and three different oil sources was used, a total of three hundred one-day-old were use, the results showed that body weight gain (BWG) and feed conversion ratio (FCR) significantly increased in broilers fed dietary LPL and SSO, there was a significant interaction between the oil sources and LPL supplementation on 10 days of age, inclusion of SSO to the diets increased villus width and villus surface area compared with SO diet, broilers fed LPL supplemented diets had lower crypt depth, while villus length to crypt depth ratio was greater in broilers fed LPL supplementation, lactobacillus population increased in broilers fed LPL supplemented diet compared to those without dietary LPL, inclusion of LPL increased ileal digestibility of dry matter, crude protein and ether extract, broiler fed SSO diets had greater digestibility coefficient for ether extract compared with SO group. The largemouth bass (Micropterus salmoides) (Lu *et al*., 2022) were fed diets with three experimental feeds, a control diet (Control, crude protein (CP): 54.52%, crude lipid (CL): 11.45%), a low-protein diet with lysophospholipid (LP-Ly, CP: 52.46%, CL: 11.36%), and a low-lipid diet with lysophospholipid (LL-Ly, CP: 54.43%, CL: 10.19%), respectively, the LP-Ly and LL-Ly groups represented the addition of 1 g/kg of lysophospholipids in the low-protein and low-lipid groups, respectively, after a 64-day feeding trial, the experimental results showed that the growth performance, hepatosomatic index, and viscerosomatic index of largemouth bass in both the LP-Ly and LL-Ly groups were not significantly different compared to those in the Control group, the condition factor and CP content of whole fish were significantly higher in the LP-Ly group than those in the Control group, compared with the Control group, the serum total cholesterol level and alanine aminotransferase enzyme activity were significantly lower in both the LP-Ly group and the LL-Ly group, the protease and lipase activities in the liver and intestine of both group LL-Ly and group LP-Ly were significantly higher than those of the Control group, compared to both the LL-Ly group and the LP-Ly group, significantly lower liver enzyme activities and gene expression of fatty acid synthase, hormone-sensitive lipase, and carnitine palmitoyltransferase 1 were found in the Control group, the addition of lysophospholipids increased the abundance of beneficial bacteria (Cetobacterium and Acinetobacter) and decreased the abundance of harmful bacteria (Mycoplasma) in the intestinal flora.

Lysophospholipids supplementation in ruminant

Song *et al*., (2015) investigated eight heifers assigned to each of 3 experimental groups (control, 0.3% LIPIDOLTM and 0.5% LIPIDOLTM), growth performance, nutrient digestibility, and carcass characteristics were investigated, significantly improved nutrient digestibility was found in the LIPIDOLTM treatment group compared to the control, no significant effect by LIPIDOLTM supplementation on growth performance was observed, however, interestingly, greater carcass weight was detected in the treatment of LIPIDOLTM where less daily gain was found, although not a significant effect, greatly decreased back-fat thickness and increased loin area were detected in the treatment of LIPIDOLTM, in meat characteristics, LIPIDOLTM increased intramuscular fat and tenderness, therefore, the present study results suggest that the inclusion of LIPIDOLTM in the diet of Hanwoo heifers can improve carcass performance and meat quality by increasing the carcass index and the meat quality index, the results also suggest that a level of 0.3% might be more efficient than 0.5% with regard to economic effectiveness. Huo *et al*., (2019) [20] noted Previous works showed that supplementation of lysophospholipid as a feed additive improves animal growth and milk yield in beef and dairy cattle production, However, its effects on fattening lambs have not been reported before, Huo *et al*., (2019) [20], feeding fattening lambs a diet with no or 0.5 g lysophospholipid in a kilogram of diet, we found that lysophospholipid did not or slightly improved the growth of fattening lambs. Feed digestibility, ruminal fermentation parameters, and rumen bacterial community were altered, which may be associated with decreased fiber digestion. However, lipase concentration in serum was decreased, which might enhance fat deposition in muscle and thus may increase meat quality, effects of lysophospholipid on sheep observed in this study are different from those on cattle. Lee *et al*., (2019) [27] recommended supplementation of a lactation diet with LPL increased milk yield and feed efficiency in a dose–response manner, and the positive production response was similar between LPL and MON, although more studies with large numbers of animals are needed to confirm, the increased production by LPL in the current study is in agreement with that found in nonruminant animals fed LPL however, the apparent digestibility of DM and OM tended to decrease with increasing LPL, which was not observed in nonruminant animals, a diet with LPL increased milk N secretion and decreased urinary N excretion with minimal effects of LPL on ruminal fermentation and bacterial populations although responses in production and dietary N utilization to LPL were similar to responses to MON, the mechanism between LPL and MON was likely different according to ruminal fermentation characteristics. Kim *et al*., (2020) [25] reported in an in vitro experiment on the use of lipolytic bacteria and their effect on lysophospholipids and reached the LPL supplementation had antimicrobial effects on several cellulolytic and lipolytic bacteria, with no significant difference in nutrient degradability (DM and neutral detergent fiber) and general bacterial counts, suggesting that LPL supplementation might increase the enzymatic activity of rumen bacteria, therefore, LPL supplementation may be more effective as an antimicrobial agent rather than as an emulsifier in the rumen. He *et al*., (2020) noted Dietary supplementation of lysophospholipids improves ruminant growth performance and may increase milk production in dairy cows, pelleted total mixed rations are increasingly used in ruminant production systems, however, the effects of lysophospholipid supplementation in a pelleted total mixed ration for dairy cows have not been reported before, in this study, we fed dairy cows pelleted total mixed rations containing 0 or 0.5 g of lysophospholipids in a kilogram of diet and found that lysophospholipids did not increase milk and nutrient yields or improve milk quality, although the feed additive altered certain plasma biochemical parameters, which may be beneficial for animal health. Farahmandpour *et al*., (2022) report that the addition of a lysophospholipid supplement to the diet of fattening lambs had a significant effect on daily feed intake, the use of 0.75% lysophospholipid supplement increased feed intake (1590g / day), the use of 0.75% of lysophospholipid supplement in the diet reduced the numerical value of feed conversion ratio, but this reduction was not significant, the final live weight was higher in the treatments of lysophospholipid supplementation than in the control group, also, the group that received 0.75% of the lysophospholipid supplement had a higher final weight (54.20 kg) than the control group as well as other groups, dry matter, and crude protein digestibility were not significantly different in the experimental groups. Zhang *et al*., (2022a) [52] used a total, of 40 Angus beef bulls were blocked for body weight (447 ± 9.64 kg) and age (420 ± 6.1 days) and randomly assigned to one of four treatments (10 beef cattle per treatment): (1) control (CON; basal diet); (2) LLPL (CON supplemented with 0.012% dietary LPL, dry matter (DM) basis); (3) MLPL (CON supplemented with 0.024% dietary LPL, DM basis); and (4) HLPL (CON supplemented with 0.048% dietary LPLs, DM basis), the results showed that dietary supplementation with LPLs linearly increased the average daily gain, digestibility of DM, crude protein, and ether extract, and decreased the feed conversion ratio, a linear increase in N retention, and a decrease in urinary, and fecal N levels were observed with increasing the supplemental doses of LPLs. Bulls fed LPLs showed a linear increase in glutathione peroxidase, and hepatic lipase, activity and a decrease in cholesterol, triglyceride, and malondialdehyde levels. Zhang *et al*., (2022b) [51] found supplementation of beef cattle diets with LPL could promote growth performance, feed efficiency, and apparent digestibility, which may be related to the change in the relative abundance of bacterial communities, total SCFAs concentration, and SCFAs profiles, the findings of the present study provide essential insights into the use of LPL as a growth promoter in beef cattle, and imply that manipulating the gut microbial community could be an efficient strategy for improving the finishing weight in the beef cattle industry. Furthermore, this study provides quantitative information that 0.75 g/kg LPL may be the optimal supplemental level for beef cattle finishing diets.

Conclusion

Through the review, it is clear that phosphorus fats and lysophospholipids had a major role in improving the productive and physiological performance of both poultry and ruminants, as they increased chicken productivity and improved the quality of meat, eggs, and even fish. Therefore, recommended to add them to diets, especially small birds and dairy animals.

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