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Review

Use of Distillery Yeast Sludge in Poultry: A Review

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Nutrition contributes 65 to 70 % of the total production cost in poultry. Various protein sources like soybean meal, canola meal, sunflower meal and cotton seed meal are being used for ration formulation which is very costly. Cost of production can be reduced by using alternative low price protein sources in the diet. Several microbes like algae, bacteria, yeast and fungus act as protein producers and can be used in the diet of poultry. Of these microbes, yeast is mainly used in single cell protein production. It can also be produced using other sources i.e. sugars, starch, pectin and cellulosic material, fruit wastes and alcohols. Its production plays important role in waste management as waste materials are used as substrate. Yeast contains high concentration of protein with crude protein from 21 to 27 % and true protein from 18 to 20 %. It also contains some essential amino acids which are necessary for proper growth and health of birds. Due to low fiber and excellent nutritional profile, distillery yeast sludge is a potential ingredient for poultry diet. Its inclusion in the diet results in higher weight gain, lower feed intake and better feed conversion ratio comparatively at cheaper rates. This is because yeast enhances health of intestinal lumen which improves breakdown and absorption of diet particles, improving bird's performance. It also decreases abdominal fat and E. coli due to its binding ability with E. coli. Yeast supplementation improves quality of meat because of higher amount of vitamin B_6, Zn and Se present in it. It also enhances the health of intestinal lumen which improves breakdown and absorption of diet particles, resulting in better bird's performance. In conclusion, yeast can be used as protein source for economical poultry production without any adverse effect on bird's performance.

Key words: Yeast, protein, poultry, growth, economics.

INTRODUCTION

Nutrition is backbone of poultry industry because it contributes 65 to 70 % of the total production cost (Esonu *et al.,* 2006). Natural resources are limited which causes shortage and high prices of feed ingredients especially protein sources like soybean meal, canola meal sunflower meal and cotton seed meal. Using alternative low price protein sources in the diet could be a suitable option for reducing the cost. Several microbes like algae, bacteria, yeast and fungus act as protein producers (Azam *et al.* 2014) and can be used in the diet of poultry. Of these microbes, yeast is mainly used in single cell protein (SCP) production. This is because of its rapid growth rate and high efficiency to convert carbon source into protein (Glazer and Nikaido, 2007). Yeast and yeast products produced from agro-industrial by products are rich in protein contents (Silva *et al.,* 2009). Molasses fermented by *Saccharomyces* (Ergun and Mutlu, 2000) and its waste products can be used in the diet of poultry. Similarly, yeast sludge (product of distillery industry) contains crude protein (27-29 %; Ali, 2004) and can be used in poultry diet (Verma and Sundar, 1988). It also contains some essential amino acids which are necessary for proper growth and health of birds (Rameshwari and Karthikeyan, 2005).

Yeast sludge refers to surplus yeast at the bottom of fermentation tank in the form of sludge during the fermentation process of sugar and distillery industries. It is also named as spent yeast, yeast slurry and trub. It is considered as a waste product and it is difficult to manage and dispose it (Bustamante *et al.,* 2008). About 1,300 tons distillery yeast sludge (DYS) is produced and wasted annually in Pakistan (Khan, 2001). Yeast has

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been successfully used as a protein source in the diet of broiler (Shahryar *et al.,* 2012) and in quail diet (Yalcin *et al.,* 2008).

REVIEW OF LITERATURE

History of Japanese quails

The Japanese quail belongs to the order Galliformes and the family Phasianidae. It is considered a separate species from the common quail (*Coturnix coturnix*), which migrates throughout Europe, Asia, Africa and India. It is believed that migratory common quail were domesticated in China during the 11th century and subsequently brought to Japan in the 12th century. For hundreds of years, these quail were bred in Japan primarily for their song and were later introduced into China, Korea, Taiwan, Hong Kong and Indochina. During the 1900s, Japanese quails were bred for egg and meat production. During second world war many of species were lost. After that new strains were reestablished. All established domesticated lines are derived from post-war populations (Mills *et al.,* 1997). Japanese quails have been used as an animal model in laboratories all over the world for many years. The Japanese quail was used as laboratory animal for the study of avian development and it was firstly described as research model by Padgett and Ivey (1959). These researchers later prepared a detailed developmental atlas of the quails that was based on the 1951 chicken staging system of Hamburger and Hamilton (Hamburger *et al.,* 1951). This atlas, along with that published by Zacchei in 1961 (Zacchei *et al.,* 1961), continues to serve as the gold standard for staging quail development. An exhaustive study of the anatomy and histology of the Japanese quail was published by Fitzgerald in 1969 (Fitzgerald *et al.,* 1969). In 1985, Ratnamohan reviewed the management of Japanese quail in the laboratory as well as the many uses of this species in virological research (Ratnamohan, 1985).

Discovery of alternate protein sources

Conventional agriculture may not be able to meet human requirements for protein due to increasing population. This problem of low protein sources has led to search for substantial high microbial protein source. Single cell protein production was the choice. Initially, SCP field focused of using various species of yeast. *Saccharomyces cerevisiae, Torula sp.* and *Candida utilis* were the common yeast that used in protein production. Afterward using bacteria and filamentous fungi became an interest subject (Barnell, 1974; Wiebe, 2002).

Many reasons make the microbes prime candidate for SCP production. Some of those reasons are the high growth rate under optimum conditions and high feed efficiency, which is expressed as gram protein produced/kg feed consumed. Moreover, microorganisms are more easily modified genetically than plants or animals. Furthermore, microorganisms can be grown in a vast number in relatively small continuous fermentation processes using small land area and also independent of climate (Riviere, 1977). Various cheaper substrates were investigated like dairy by-products such as cheese whey, molasses, starch, methanol, hydrocarbon substrates and spent sulfite liquor were used for commercial process. Surplus waste product consumption added a new economic incentive to SCP production, as the idea of low cost substrates. Using a waste product in SCP production has contributed in the preservation of the environment rather than food production. Carbohydrates can be transformed to SCP with different nutritional values based upon the variety of microorganisms used. Single cell protein can be used in human food or in the feed of animals (Basil, 1979).

Single cell protein definition and uses

Single cell protein is the term used to describe microbial cells which are grown and harvested primarily for use as human or animal feed. The SCP contains carbohydrate cell wall material, nucleic acids, lipids, vitamins and minerals. Microbial cells are produced as protein source for food or feed. Some edible eaten foods are in fact micro-organisms. Good examples for these are blue green algae which were collected from lakes in Mexico, edible fungi which have been collected from the wild and yeast which were grown on a large scale in Germany and used as food and feed (Barnell, 1974; Reed and Warr, 1985; Sivasanker, 2002). Microbial cells are rich in protein because they can produce protein from inorganic nitrogen i.e. ammonia. Microorganisms can use alternative carbon sources i.e. CO2 as by algae. Organic carbon is another carbon source that be used in wide range like waste products from industries or agriculture. The SCP production plants are efficient in space and microorganisms grow much more rapidly than plants or animals which have given usage of microbial cells another advantages. But beside these advantages there are some disadvantages. The leak of sufficient quantities of essential amino acids like methionine in algal, little taste or smell, digestibility problem of some of microbial cell kinds, adverse effects in humans, limitation of range of microorganism's kinds because of pathogenic or toxicity and the high content of nucleic acid RNA (Murray, 2004).

High nucleic acids content causes gout and kidney stones because of accumulation of purine which is production from the breakdown of RNA. This will raise uric acid concentration. However, in large animal bodies, high concentration of nucleic acids had no adverse effect on their health because uric acid is changed into

allantoin, which is excreted via urine. Therefore, human intake of nucleic acid has to be limited to 2g/day. Nucleic acid content of SCP from fungal renders it as a food factor. Yeast and fugal SCP have been included in animal feeds. Fish has digested SCP of fungal origin well **(**Halasz and Anna, 2000).

Nutritional advantages of single cell protein

Single cell protein consists of water, fats, protein, carbohydrates, ash and other elements like potassium and phosphorous (Jamel *et al.,* 2008). Aside from the nutritional benefits of SCP, another benefit of SCP technology is their throughout the year production. Also, it plays its role in waste management as waste materials are used as substrate. Small area of land is required and SCP is made in less time. To access nutritional value of SCP, many factors must be considered which include nutritive value, amino acids, vitamin and nucleic acid content as well as different gastrointestinal and allergies effects. To access toxicological and carcinogenic affects, long term feeding trails are also required. A process (drying, harvesting and processing) has a main effect on the nutritional composition of the final products (Bhalla *et al.,* 2007). The composition of SCP is influenced by the nature of substrate and organism used. Proteins not only provide nutritional value but also involve in number of other functions (Mahajan and Dua, 1995). Single cell protein from yeast and fungi has 50-55% protein it has high protein carbohydrates ratio (Mchoi and park, 2003). It contains more lysine less amount of methionine and cysteine. Its amino acid profile is good and it contains higher B complex vitamins which are more suitable for poultry feed. Some yeast strains having probiotic properties such as *Saccharomyces cerisiae* and *Debaryomyces hansenii* improve the growth of beneficial microbes of GIT tract (Burgents *et al.,* 2004). Single cell proteins produced by using bacteria contain more than 80% protein although they have small amount of sulphur containing amino acids and high in NA content (Attia *et al.,* 2003). Single cell proteins from yeast origin have been added to aquaculture diets as the replacement for fish meal (Gao *et al.,* 2008). The concept behind the production of SCP protein is to help the developing countries in future food shortage. For this purpose different researches and projects are planned.

Production of single cell protein from different sources

Many processes of SCP production have been developed by utilizing different sources of carbon. Feed processes have been developed mainly in Europe, Japan and other countries, where feedstuffs are in short supply.

Processes have not generally been successful due to unfavorable economics (rising substrate costs and decreasing cost of Soya). For food, SCP has been produced on a smaller scale and is mainly limited to yeasts, the use of which in food has been traditional. The exception is myco-protein, which is being promoted as a health food, rich in protein and lacking animal fat and which can be used as meat substitutes in high-value vegetarian convenience foods (Burgents *et al.,* 2004).

Single cell protein production from fruit wastes

Mondal *et al.* (2012) used fruit wastes as SCP in order to produce an economical product. They produced SCP from the fruit wastes using *Saccharomyces cerevisiae* by fermentation. They concluded that SCP from fruit wastes was easy to hydrolyze generates higher amount of protein. Dhanasekaran *et al.* (2011) studied the use of pineapple waste in fermentation media of different strain specially yeast. They showed that biomass yield and protein formation was increased by the use of pineapple hydrolysate. Also, the cost of using yeast strain was less as compared to others.

Single cell protein from carbohydrates

Carbohydrates are renewable source. A carbohydrate is an excellent substrate for SCP production by heterotrophs. Many forms of carbohydrates can be found such as sugars, starch, pectin and cellulosic material. Yeasts can utilize many kinds of sugar. Therefore, it was used widespread in production of SCP. Each process differs slightly according to the nature of the substrate and the organism used. Hydrolysis of starch can be carried out by chemical or enzymatic treatment to produce sugars for a fermentation medium. Cellulosic material is solid and is normally used in solid-substrate fermentations. Cellulosic materials require hydrolysis to sugars before they are available for cell uptake and use (Marx, 1989).

Single cell protein from Molasses

Molasses is by-product of sugar manufacturing process, mostly from beet or cane and contains 35-50% sucrose and small quantities of nitrogen. It is used as a fermentation medium for the synthesis of baker's yeast, ethanol and other products. Baker's yeast was produced firstly in aerobic fermentation on molasses. For SCP production, the molasses is diluted to 44% sucrose, supplemented with phosphate and sterilized by continuous heat sterilization. Continuous processes are run in aerated fermenters with ammonia addition, producing food-grade *Candida utilis* and *Sacchmomyces cerevisiae*. Yeasts are recovered by centrifugation, washed, dried by drum or spray drying and packaged.

The product contains about 45% protein and is used as a high protein food supplement, particularly in Taiwan

and South Africa (Oura, 1983; Chen and Chinger, 1985).

Single cell protein from Starches

Effluents from the processing of starchy vegetables such as potatoes, cassava, rice or corn (maize) have been the substrates for commercially operated SCP processes. The Symba process was established in Sweden to produce SCP for animal feed from the wastes of potato processing. The Symba process is a two-stage continuous process based on a symbiotic culture of the yeasts (Morgan *et al.,* 2001).

Single cell protein from hydrocarbons and derivatives

Using hydrocarbon as a carbon source for producing SCP is not devoid from complications because of low solubility in water and high aeration rate. Many disadvantages accompany such process such as raising of costs because of high aeration and cost of cooling, as the oxidation process is exothermic. Toxicity can be obtained with small traces of alkanes (Faust and Prave, 1983).

Single cell protein from n-alkanes

Alkanes were also used as an attractive substrate for SCP production. Many processes were developed such by British petroleum, in Italy, France and in the former Soviet Union, where the shortage of feed protein was compensated by oil availability. Microorganisms include yeasts and filamentous fungi are able to assimilate n-alkanes and n-alkenes in liquid culture. Processes have been developed to production scale growing yeasts, for feed, on purified C10-C23 n-alkanes (such n-paraffins being liquid at normal ambient temperatures). The process was developed to production scale with a capacity of 200,000 tonnes per year. This process, developed by British Petroleum, was one of several in Europe and Japan that was ever operated commercially. This was due to sharply increased substrate costs in 1973 and social pressures against the use of petroleum-based substrates (possibly contaminated with carcinogenic or toxic compounds). However, most of these processes have ceased because of the suspected health hazard. Japan was the first country decided to ban any protein from petrochemicals (Riviere, 1977; Morgan, *et al.* 2001; Pandey, 2004; Smith, 2004).

Single cell protein from ethanol

Ethanol based SCP production is suitable source if the SCP intended for human consumption. Single cell protein production from ethanol has been started by many companies such as Amoco in USA, Mitsubishi petrochemical co. in Japan and Exxon-nestle project in Switzerland. A few processes operate in the USA using ethanol to produce food-grade Candida utilizes, with capacity of about 7,000 tonnes per year. The technology is similar to that already described for SCP from sugars. On ethanol, the yield is about 0.65 kg dry wt per kg ethanol used. But the rising of ethanol price will limit the ethanol based SCP production (Arora *et al.* 1991; Smith, 2004; Pandey, 2004).

Single cell protein from methanol

Methanol is petrochemical industry by-product. Methanol has many advantages over other hydrocarbons in SCP production. Methane and other hydrocarbon are slightly soluble in water. Methanol demands low oxygen rate in comparison with methane, which means lowering in cooling cost. Methanol can be produced by the oxidation of methane. Methane can be chemically oxidized to methanol relatively cheaply. The heat liberated during such oxidation is higher grade than that liberated by biological conversion and is thus easier to recover and use elsewhere. It was expected that using methanol as a fermentation substrate would, having by-passed the energy inefficient methane oxidation step, lead to higher yield and lower the oxygen and cooling requirement. Methanol has the added advantage of being very much more soluble in water and easier to handle than methane.

Several processes have been developed to produce feed-grade SCP using methanol as a substrate. In the late 1960s, Imperial Chemical Industries (ICI) in the UK was interested in developing an SCP process using abundant and cheap methane from newly developed sources in the North Sea. In this process an air-lift pressure-cycle bioreactor was chosen. Despite optimized culture conditions, yield coefficients for methanol were lower than the expected level of about 0.5. Yields were, in fact, lower than those achieved routinely with the lm3 fermentation system The problem was traced to the cyclical nature of the pressure cycle system, which, due to introduction of air, ammonia, methanol and other nutrients at single points, leads to cyclical changes in nutrient concentrations as well as changes in pH, temperature and hydrostatic pressure. These parameters change in cycles as the medium flows around the reactor. Such changes do not occur in stirred vessels, accounting for differences in yield observed in comparison with those in the 1 m^3 system (Faust and Prave, 1983; David, 1972; Pandey, 2004).

Single cell protein production from microorganisms

Single cell protein from bacteria

Rapid growth rate and short generation time (20 minutes)

make the bacteria suitable for the production of SCP. They have ability to grow on wide range of raw materials that range from carbohydrates (starch and sugars) to petrochemicals (methanol and ethanol) (Bamberg, 2000) and nitrogen sources which are beneficial for bacterial growth comprise nitrates, ammonia, urea, organic nitrogen and ammonium salts in wastes. It is suggested to add some mineral nutrient supplement to the culture medium of bacteria to fulfill shortage of nutrients. Sometime these nutrients are absent in water which sufficient to maintain growth. Potential phototrophic bacterial strains are recommended for SCP production. Some researchers also suggest use of methanotrophic and other bacterial species for SCP production (Arora *et al.,* 1991). Large quantities of SCP for animal feed can be produced via bacteria like *Brevibacterium* (Adedayo *et al.,* 2011). *Lactobacillus species, Cellulomonas species, Methylomonas methylotrophu*s (Piper, 2004)*, capsulate, Flavobacterium species* (Dhanasekaran *et al.,* 2011)*.*

Single cell protein from algae

Since ancient times, *Spirulina* was cultivated by people in Africa and Mexico. They used it as a food after drying it. *Spirulina* is the most widely used algae so much that even astronauts take it to space during their space travel. Similarly, biomass obtained from *Chlorella* and *Senedessmus* has been harvested and used as source of food in many parts of the world. Alga is used as a food in many different ways and its advantages like faster growth, simple cultivation, high protein content and effective utilization of sun light. The algae *Spirulina* has been considered for use as a supplementary protein (Raja *et al.,* 2008). It is concluded that the use of *Spirulina* should be encouraged in patients suffering from malnutrition, immune suppression, hepatic and neural compromise, etc. although further investigations on the antiviral effects of this alga and its clinical implications are strongly needed. Five strains of *Chlorella* species (isolated from different environments) are used for the production of SCP and were studied under different environmental factors (Mahasneh, 2005).

Single cell protein from fungi

Many species of fungal are used as a source of protein in animal feed (Bhalla *et al*, 2007). Many other filamentous species are also used as source of SCP. During World War II, trials were conducted to cultures the *Fusarium* and *Rhizopus* species (Yousuf, 2012). High amount of fungal biomass is produced as a result of growth. Mycelia yield vary greatly which depends upon organisms and substrates. Very recently, SCP technology is using fungal species for bioconversion of lignocellulosic wastes (Lenihan *et al*, 2010). The filamentous fungi that have been used include *Chaetomium celluloliticum,* (Zubi, 2005)*, Cephalosporium cichorniae, Penicillium cyclopium, Rhizopuschinensis, Scytalidum aciduphlium* and *Tricoderma viridae* (Jaganmohan *et al.,* 2013).

Single cell protein from yeast

Yeast belongs to kingdom fungi and is unicellular microorganism of varying diameter from 3-40µm. Yeast acts as a biological product, which increases the defensive system against pathogenic bacteria especially Salmonella and E-coli (Ghadban, 2002). Lactic-acid producing bacteria also increased by yeast supplementation (Flemming *et al.,* 2004) with decreased mortality (Kralik *et al.,* 2004). It has several species but *Saccharomyces cerevisiae is* considered to be ideal for further culture production because of its peculiar metabolic characteristics and growth (Panda *et al.,* 2011).

Yeast SCP is a high nutrient feed substitute (Burgents *et al*, 2004). Among these, most popular are yeast species *Candida* (Bozakouk, 2002), *Torulopsis, Pitchia, Hansenula* and *Saccharomyces*. The production of SCP varies using *Saccharomyces cerevisiae* grown on various fruit waste (Tanveer, 2010). The typical oily yeasts genera include *Candida, Yarrowia, Rhodosporidium, Rhodotorula, Trichosporon, Cryptococcus and Lipomyces*. Orange peels and cucumber were used for the production of SCP using yeast (*Saccharomyces cerevisiae)* by fermentation (Sengupta *et al.,* 2006).

Yeast was extracted from grapes and has been used in the diet of animals since the time of Romans (Onifade *et al.,* 1996). About 1200 species of yeast are present but the yeast which is most commonly used is called *Saccharomyces cervices*. It is eukaryotic organism that reproduces by the process of cell division. Its diameter is less than 10 µm and round to oval in shape. Yeast has many uses containing baking and also called baker's yeast (Brake, 1997). Distillery yeast sludge is rich source of *Saccharomyces cervices;* it is a protein source of high biological value. The cell wall of *Saccharomyces cervices* contains MOS and B-glucans which are involved in the binding of toxins and maintain the normal gut micro flora. Yeast (*Saccharomyces cervices*) contain higher CP (40 to 45%), vitamin B-complex, pantothenic acid, niacin, biotin and thiamin (Abaza *et al.,* 2008). Yeast cell walls and yeast products have been improve growth and absorption of intestinal tract of turkey (Santos *et al.,* 2007) and broiler (Lopez *et al.,* 2009).

The nutritional Significance of the yeast

Yeast improved live weight and feed efficiency in a low protein diet fed bird with appreciable contribution to enhancing carcass characteristics and organ weights at an optimum level of 0.08 percent dietary inclusion (Adejumo *et al.,* 2004). Koc *et al.* (2010) showed that that addition of *Saccharomyces cerevisiae* with/without MOS.

Table 1. Nutritional value of distillery yeast sludge

References	DM	CP	TP	CF	EE	NFE	Ash	ME (kcal/kg)
Sharif *et al.* (2012)	--	27.4	19.1	0.0	1.1	49.5	22.1	2200
Haider (2010)	--	29	--	3.0	1.0	44	15	2230
Sattar *et al.* (2008)	27.8	26.3	--	0.0	1.1	41.1	31.6	-
Rameshwari (2005)	85 (dried)	21	--	5.5	--	--	56	--
Ali (2004)	26.2	29.6	20.8	0.0	1.2	39.23	30	1390
Mumtaz *et al.* (2000)	27	18.6	13.1	0.0	1.0	43.3	37	--

had increased ($p<0.05$) feed intake and weight gain.

However, FCR was lower in birds fed diet containing *Saccharomyces cerevisiae* than control group. Manal and El-Naga (2012) concluded that dietary dry yeast at 0.5% could improve the performance, carcass characteristics and economic efficiency of broiler birds.

Some impotent characteristics of yeasts are given below:

1. Yeasts that are completely dispersed during each stage of fermentation. These yeasts are non-flocculent or are described as being powdery.
2. Yeasts that don't flocculate initially, but form light aggregates towards the end of fermentation
3. Yeasts that initially disperse but flocculate towards the end of fermentation.
4. Yeasts that flocculate right from the beginning of fermentation.

Yeast *Saccharomyces cervices* is used in alcohol industry in Pakistan (Onifade *et al.,* 1996). It is the most useful yeast ever known, as it causes bread leavening, wine and beer production (Vancraeynest *et al.,* 2007). This is due to its ability to convert sugar like maltose and glucose into ethanol and carbon dioxide (Auclair, 2001). Yeast *Saccharomyces cervices* is the most economical SCP requiring less labor and input per Kg DM than any other conventional sources. Compared to fungi yeast contains higher protein contents. Yeast *Saccharomyces cervices* contain 93, 44.4, 2.7 and 1.0 of DM, CP, CF and EE, respectively. It also contain 1990 kcal/kg metabolizable energy, however fungal biomass contains 30 to 60% CP, 1.9% Calcium (Ca) and 2.4% phosphorus (P) (Aghdamshahriar *et al.,* 2006). Yeast has advantages such as their large size, lower nucleic-acid content and high lysine. However, its main advantage is its traditional use in fermentation, which makes acceptable to the general public.

Chemical composition of distillery yeast sludge

Distillery yeast sludge is produced as byproduct of ethanol production during the fermentation of sugarcane. It has about 30% protein and high biological value (Sharif *et al.,* 2012). It has an excellent amino acids profile containing lysine, Methionine, Leucine, Isoleucine, threonine, valine and tryptophan (Abbott *et al.,* 1991). Nutritive composition of DYS varies widely depending upon the chemical spent, strain of yeast used, nature of molasses and time spent in fermentation (Esmail, 1999). The variation has been reported mainly in crude protein and metabolizable energy (Haider, 2010). Energy variations are mainly due to the amount of lipid and NFE content (NRC, 1994). Protein variations are largely due to the number of yeast cell present in the biomass (Brinton and Warren, 1986). Mumtaz *et al.* (2000) studied the effect of fermented distillery sludge in the diet of broiler. Sludge was washed three times in order to reduce the soluble carbohydrates and minerals by centrifugation.

They observed increased protein contents (18.25–25%) and decreased ash contents (37.14 – 29%). After fermentation, sludge contained crude protein 37.4%, true protein 24.06%, ether extract 0.66%, ash 25%, lysine 189 mg/100ml and RNA content 2.87%. Similarly, Rameshwari and Karthikeyan (2005) conducted a study to determine the nutritive composition of DYS. They showed that dried yeast sludge contained 21, 4, 2.4, 10, 3, 0.35, 0.23, 0.23, 5.5, 56, 3.6, 2.8, 1.2, 0.06 and 3.0% protein, methionine, tryptophan, lysine, calcium, iron, phosphorus, phenol, crude fiber, ash content, glucan, mannan, glycogen, thiamine and ascorbic acid, respectively. The amino acids in DYS vary as sludge is obtained from different sources. For example, the amino acid in yeast sludge consists of 7.7% lysine, 4.8% threonine, 1.7% methionine, 1% tryptophan, 7% leucine, 4.6% isoleucine, 4.1% phenylalanine, 5.3% valine, 2.4% arginine and 2.7% histadine (Han *et al.,* 2007) while DYS used in a different research contained 6.3 g aspartate, 17.6 g glutamic acid, 3.1 g threonine and 1.9 g methionine (Ali, 2004). Distillery yeast sludge contains low amount of fiber range from 0 to 1%. Due to low fibers DYS is an excellent ingredient from the diet of poultry (NRC, 1994). Feed ingredient of low fiber content means high energy availability resulted in increased digestibility and absorption (Onwumela *et al.,* 2012). Kavanagh *et al.* (1982) compared the composition of activated sludge produced by treatment of meat works effluents with the treatment of domestic sewage. They showed that amino acid profile and proximate composition of both sludge were same. However, the amount of toxic metals such as zinc, lead and cadmium were much lower in activated sludge produced by treatment of meat works effluents.

Nutritional significance of distillery yeast sludge

Distillery yeast sludge can be used as protein supplement instead of *Saccharomyces cervices* in the diet of poultry. It contains high concentration of protein with crude protein from 21 to 27% and true protein from 18 to 20% (Ali, 2004; Rameshwari *et al.,* 2005). Distillery yeast sludge contains about 2200 kcal metabolizable energy. Nitrogen free extracts is abundantly available in DYS from 39 to 40% of the DM (Mumtaz *et al.,* 2000). Distillery yeast sludge also contain small amount of fats and has been reported to contain approximately 2% ether extract (Ali, 2004; Haider, 2010).

Distillery yeast sludge obtained from various sources differ in CP and DM, the moisture contents of fresh DYS remains between 70 to 75% (Ali, 2004; Hashmi *et al.,* 2006). Moisture contents were decreased to 7% when dried to room temperature. The lowering the moisture contents has improved the handling and storage of DYS (Aghdamshahriar *et al.,* 2006).

Use of yeast and yeast products in the diet of poultry

Manal and El-Naga (2012) conducted a study to determine the influence of supplemented dry yeast on broiler growth performance. Four diets were formulated supplemented with dry yeast at the level of 0, 0.3, 0.5% and 0.7%. They observed lower feed intake (4.14 kg/ bird), higher body weight (1.84 kg) and better FCR (2.25) in birds fed diet containing 0.5% dry yeast. Similarly, Paryad and Mahmoudi (2008) studied the efficacy of various levels of yeast (*Saccharomyces cerevisiae)* on broiler growth performance. Four diets were formulated containing yeast at the level of 0, 0.5, 1.5 and 2%. They observed higher weight gain, lower feed intake and better FCR in birds fed diet containing 1.5% yeast. This is because yeast *(Saccharomyces cerevisiae)* enhanced health of intestinal lumen which improved breakdown and absorption of diet particles as the resulting in improved bird's performance.

Ghally *et al.* (2007) carried out a research to study the effect of yeast culture (YC) on growth performance and economic efficiency in Japanese quails (*Coturnix coturnix japonica*). Three groups A, B and C were designed and diets were formulated with the use of YC 0, 1 and 2% level, respectively. They showed that birds fed diets containing 2% YC had higher ($p< 0.05$) body weight gain and better ($p< 0.05$) FCR. The reason of higher weight gain may be due to that yeast culture contains peptides, amino acids, organic acids and MOS etc. which improved bird performance.

Effect of yeast and yeast products on growth performance

Replacing fish meal with preprocessed waste activated sludge (pWAS) had 19% more weight gain with minimum mortality than those raised on fishmeal (Chirwa and Lebitso, 2014). Sacakli *et al.* (2013) investigated the effects of brewer's yeast (*Saccharomyces cereviciae*) on egg production, serum antibody titer and cholesterol levels in laying hens. Three levels of (*Saccharomyces cereviciae*) l, 3 and 5% in feed were used. Results showed that yeast supplementation had non-significant effect on feed intake and production performance in laying hens. Mutassim (2013) studied the influence of YC on broiler growth performance. Four diets were formulated containing four levels (0, 1, 2 and 3 g / kg) of YC. They showed that birds fed diet containing 3 g/kg YC had higher weight gain and better FCR compared to others. Reza *et al.* (2013) studied the influence of YC on production performance in broiler birds. They showed that birds fed diet supplemented with YC at 3% had higher weight gain and better FCR.

Upendra and Swamy (2013) studied the effect of different *Saccharomyces cerevisiae*, *Lactobacillus sporogenes* and their combination effect on broiler growth performance. They used 0.1% *Saccharomyces cerevisiae*, 0.1% *Lactobacillus sporogenes* and 0.05 + 0.05% in combination form. They showed that birds fed diet supplemented with *Saccharomyces cerevisiae* had higher weight gain. Onwumelu *et al.* (2012) replaced full fat soyabean (FFSB) in parts with raw soyabean (RSB) treated with yeast in broiler diet. Fifteen diets were formulated in which the ratio between RSB and FSSB were 0:100, 25:75, 50:50, 75:25 and 100:0 and each of these having 3 levels of supplemented yeast 6, 8 and 12 g/kg. Their results showed that diet containing 75% FFSB, 25% RSB and 8 g/kg yeast had improved ($p< 0.05$) weight gain, lower ($p< 0.05$) feed intake and better ($p< 0.05$) FCR compared to control group. Similarly, Abdelrahman, (2012) studied the effect of YC supplementation on broiler performance. Chicks were randomly divided into four groups G1, G2, G3 and G4 supplemented with maize oil, dry fat, dry fat + 0.2% of YC and dry fat + 0.3% of YC, respectively. They observed improved ($P< 0.05$) body weight and better FCR ($P< 0.05$) in group G4 compared to group G2 and G3.

Saccharomyces cerevisae supplementation in broiler diet at 1.5% had higher weight gain and better FCR compared to control (Aluwong *et al.,* 2012). Adebiyi *et al.* (2012) studied the influence of *Saccharomyces cerevisae* supplementation on broiler growth performance. Four diets were formulated containing yeast at level of 0, 1, 1.25 and 1.5%, respectively. They showed that weight gain was not affected by yeast supplementation. However, birds fed diet supplemented with yeast at the level of 1% had better feed conversion ratio (2.10 kg) as compared the control group (2.34 kg). Fathi *et al.* (2012) examined the effect of supplemental YC on growth performance in broiler. Four diets A, B, C and D were formulated supplemented with YC at the level of 0, 1,

1.25 and 1.5 g/ kg. They observed higher (p< 0.05) body weight and low mortality in diet D compared to others. Shahryar *et al.* (2012) replaced fish meal and poultry by product with yeast *(Saccharomyces cerevisiae)* in broiler diet. Five treatments A (control) B (yeast replaced 40% of fishmeal), C (yeast replaced 60% of fishmeal), D (yeast replaced 40% of poultry by product) and E (yeast replaced 60% of poultry by product) were designed. They showed that weight gain, FCR and mortality were non-significant different among all treatments due to same protein levels in all diets. Reisinger *et al*. (2012) examined the influence of yeast derivatives on broiler growth performance. Three diets were formulated containing 0, 1.0 and 2.0% of yeast derivatives. They concluded that yeast derivatives when used at 1% had significant effect on weight gain; however, feeding efficiency was improved by dietary addition of yeast derivatives at 2%.

Feeding broiler chicks on diets containing different levels of distiller's dried grains with soluble (DDGS) up to 60% improved body weight gain (Ghazalah *et al.,* 2012). Similarly, Al-Mansour *et al.* (2011) studied the influence of YC on broiler growth performance. Four diets were formulated containing YC at the level of 0, 1, 1.25 and 1.5 g/kg. They observed improved growth performance at the level of 1.25 g/kg YC. Vahdatpour *et al.* (2011) studied the efficacy of different form of *Saccharomyces cerevisiae* (SC) on quail growth performance. Four diets were formulated containing 0, 1g/kg active SC, 1 g/kg inactive SC and 0.5 g/kg active + 0.5 g/kg inactive SC. They observed significantly lower (p< 0.05) feed intake, higher (p< 0.05) body weight and better (p< 0.05) FCR in dietary treatments B and C. Hosseini (2011) conducted an experiment to check the effect of *Saccharomyces cerevisiae* on broiler production performance. He used five levels (0, 0.5, 0.1, 0.15 and 0.2%) of *Saccharomyces cerevisiae* in the diet of broiler. He concluded that *Saccharomyces cerevisiae* at 0.2% had higher body weight gain and better FCR.

Layers fed diets containing live yeast at of 0.4 and 0.8% had higher egg production and better FCR compared with control group (Saadia and Nagla, 2010). Riad *et al.* (2010) studied the influence of *Saccharomyces cerevisiae* on production performance of birds. They showed that birds fed diet containing *Saccharomyces cerevisiae* had better FCR and reduced mortality. Gao *et al.* (2009) checked the influence of yeast (*Saccharomyces cerevisiae*) on growth performance in broilers. They used *Saccharomyces cerevisiae* at 0, 0.25 and 0.5% in broiler diets. They showed that dietary *Saccharomyces cerevisiae* had higher weight gain. Saied *et al.* (2011) studied the influence of supplementing *Saccharomyces cerevisiae* on growth performance in broilers. They showed that supplementation of *Saccharomyces cerevisiae* had higher feed intake, weight gain and better FCR.

Suksombat *et al.* (2011) studied the effect of commercial yeasts (*Saccharomyces cerevisiae*) on broiler growth performance poisoned with aflatoxins (AFB1). The treatment groups were control ration lacking yeasts (T_1), 250 ppb AFB1 (T_2), commercial yeast + 250 ppb AFB1 (T_3) and bovine yeast (BY) + 250 ppb AFB1 (T_4). They showed that birds fed diet containing yeast had higher weight gain and better FCR.

Chimote *et al.* (2009) carried out an experiment to check the effect of yeast and acidifier supplementation on growth performance in Japanese quails. Three treatments; A (serve as control diet), B (control diet supplemented with yeast) and C (control diet supplemented with acidifier) were designed. They observed significantly higher (p <0.01) body weight and better (p <0.01) FCR in group B (fed yeast supplemented diet) and C (fed acidifier supplemented diet). Similarly, Kamalzadeh *et al.* (2009) conducted an experiment to check the influence of yeast glucomannan on performance of growing broiler. They showed that supplementation of glucomannan had improved weight gain, feed intake, FCR and reduced weight of liver and mortality. Mulyono *et al.* (2009) checked the influence of *Saccharomyces cerevisiae* and zinc on growth performance in broilers. They showed that birds fed diet containing *Saccharomyces cerevisiae* had higher body weight gain and better FCR. Shah *et al*. (2009) investigated the effect of locally available probiotic (Organic Green Culture; OGC) containing micro-organisms like *Saccharomyces cervisiae, Lactobacillous acidophillous, Bacillus subtilis* and *Aspergillous oryzae* on broiler growth performance at starter phase (1-21 days). Four experimental diets were formulated containing OGC probiotic at 0, 1, 2 and 4 g/kg diet, respectively. They showed that the addition of OGC probiotic had higher feed intake, weight gain and better FCR.

improved (p< 0.05) weight gain and better (p< 0.05) FCR were observed in birds fed diet supplemented with 2.5 g/kg YC (Gao *et al.,* 2008). Yalcin and Erdem (2008) conducted an experiment to check the effect of mannon oligosaccharides from *Saccharomyces cerevisiae* on growth performance in broiler chicks. They used mannon oligosaccharides at the level of 0.05, 0.10 and 0.15% in broiler diets. They reported that *Saccharomyces cerevisiae* supplementation had no effect on weight gain, feed intake and FCR. Quigley *et al.* (2008) evaluated the influence of supplemented YC on broiler growth performance. Four dietary treatments, comprising of 0, 2.5, 5 and 7.5 g / kg of YC were designed. They showed that supplementation of yeast culture at 2.5 g/kg had higher weight gain and better FCR. Safameher and Shivazad (2007) studied the effect of *Saccharomyces cerevisiae* on growth performance in broilers. They showed that birds fed diets containing *Saccharomyces cerevisiae* had higher weight gain and better FCR.

Hashmi *et al.* (2006) carried out a study to check the

influence of yeast sludge supplementation on broiler performance. Two levels (0 and 1%) of yeast sludge were used in commercial diet. They observed non-significant (P>0.05) difference in feed intake, weight gain and FCR. This is because amount of MOS is limited (0.26%) in 1% yeast sludge. Mahdavi *et al.* (2006) checked the effect of yeast on layer hen's performance. Five experimental diets (0, 0.25, 0.5, 0.75 and 1 g/kg yeast) were fed to layer hen. The results showed that using yeast had no significant effect on feed intake, body weight gain and FCR. Ghasemi *et al*. (2006) studied the impact of phytase and *Saccharomyces cerevisiae* on broiler growth performance. Three diets were formulated supplemented with *Saccharomyces cerevisiae* at 0, 0.1 and 0.2% of diet dry matter. They showed that birds fed diet containing *Saccharomyces cerevisiae* had higher weight gain, however; FCR was not affected by supplementation of *Saccharomyces cerevisiae.* Menocal *et al.* (2005) determined the effect of *Saccharomyces cerevisiae* cell wall on growth parameters in broilers. Four diets were formulated containing *Saccharomyces cerevisiae* cell wall at of 0, 0.5, 1 and 1.5 kg / ton. They concluded that 0.5 kg / ton of *Saccharomyces cerevisiae* cell wall in the diet of broilers had increased feed intake, body weight gain and better FCR. Zhang *et al.* (2005) studied the influence of *Saccharomyces cerevisiae* cell component on the production performance in broilers. Four dietary treatments include; whole yeast, *Saccharomyces cerevisiae,* yeast extract and *Saccharomyces cerevisiae* cell wall were added at 0.5, 0.3 and 0.3 percent, respectively. They concluded that whole yeast and *Saccharomyces cerevisiae* cell wall had higher body weight gain compared to control.

Birds fed diet containing 0.01% had higher (p< 0.05) feed intake, body weight and better FCR (Santin *et al.,* 2003). Santin *et al.* (2001) studied the effect of *Saccharomyces cerevisiae* on growth performance in broilers. They added 0.1 and 0.2% of cell wall of *Saccharomyces cerevisiae* in the broiler diets. They showed that addition of 0.2% cell wall of *Saccharomyces cerevisiae* had higher weight gain and improved FCR. Celik *et al.* (2001) conducted a research to check the influence of *Saccharomyces cerevisiae* on broiler growth performance. They used different levels of *Saccharomyces cerevisiae* in broiler diet. They showed that birds fed diet supplemented with 0.2% had higher weight gain. Ali *et al.* (2000) examined the influence of YC and dietary protein levels on performance of growing Japanese quails. A 2×3 factorial plan of six dietary groups was applied. The two factors contain protein level (22 and 24% CP) and YC supplementation (0, 1.5 and 3%). They observed increased body weight gain and better FCR in the chicks fed diet supplemented with YC (3%) compared to others. Similarly, Taksande *et al.* (2009) studied the influence of different species of yeast on growth performance of Japanese quails. They formul-ated three diet A (0.05% *Saccharomyces cerevisiae*), B (0.05% *Saccharomyces boulardii*) and C (0.05% *Lactobacillus sporogenes*). They showed that birds fed diet containing *Saccharomyces cerevisiae* had significantly higher (p< 0.01) weight gain and better (p <0.01) FCR.

Addition of yeast in broiler diet at 1% had no detrimental effects on growth performance in broiler birds (Ahmed *et al.,* 2015). Karaoglu and Durdag (2005) studied that effect of *Saccharomyces cerevisiae* on growth performance in broilers. They used three levels (0, 1 and 2 g /kg) of *Saccharomyces cerevisiae* in the broiler diet. They showed that *Saccharomyces cerevisiae* had no effect on feed intake, body weight gain and FCR. *Saccharomyces cerevisiae* had non-significant effect on feed intake (Nawaz *et al*., 2008). Gheisari *et al*. (2006) evaluated the influence of various levels and forms of live yeast on broiler growth performance. They used two forms (granular and powdery) and four levels (0, 0.1, 0.2 and 0.3%) of live yeast in broiler diet. They showed that live yeast supplementation had non-significant effect on feed intake, body weight and FCR. Aydin and Aydin (2012) evaluated the effects of dietary yeast extract (YE) containing β-glucans and mannan-oligosaccharide on growth performance in Japanese quails. Four diets were formulated with the supplementation of 0, 1, 2 and 3% YE. They showed that there was no change in productive performance of the quails by the supplementation of yeast extract. Rameshwari and Karthikeyan (2005) conducted a study to determining the nutritive content of DYS. They fed DYS to layer chicks at levels of 0, 10, 30, 50 and 70%. They showed that by increasing the levels of DYS in diet, weight gain marginal declined. They suggested that DYS can safely be included for growing chicks up to 30% level.

Effect of yeast and yeast products on slaughter parameters

There were no dietary effects of supplemented yeast autolysate on excreta pH, carcass yield, excreta moisture and the weight of gizzard, liver, spleen, heart, intestine and bursa of Fabricius (Yalcin *et al.,* 2013). There were also decreased in abdominal fat and *E. coli.* count because MOS helps in the binding of *E. coli.* Fathi *et al.* (2012) examined the effect of supplemental YC on carcass characteristics in broiler. Four diets A, B, C and D were formulated supplemented with YC at the level of 0, 1, 1.25 and 1.5 g/kg. They observed that breast meat had significantly higher percentage in birds fed diet containing 1.5 g/kg YC compared with the other diets. Abdelrahman, (2012) studied the effect of YC supplementation on broiler performance. Chicks were randomly divided into four groups G1, G2, G3 and G4 supplemented with maize oil, dry fat, dry fat + 0.2% of YC and dry fat + 0.3% of YC, respectively. They showed that

the abdominal fat was lower in chicks from groups G1, G3 and G4 compared with group G2. This is because abdominal fat and excessive fat deposition are highly correlated. The use of YC reduces fat contents and improves meat quality in broiler.

Onwumelu *et al.* (2012) replaced full fat soya bean (FFSB) in parts with raw soyabean (RSB) treated with yeast in broiler diet and studied carcass characteristics. A total of fifteen diets were formulated in which the ratio between RSB and FSSB were 0:100, 25:75, 50:50, 75:25 and 100:0 and each of these having 3 levels of supplemented yeast 6, 8 and 12 g/kg. They revealed that diet containing 6 g/kg yeast had higher liver, gizzard, pancreas, spleen and abdominal fat weight. Shahryar *et al.* (2012) replaced fish meal and poultry by product with yeast *(Saccharomyces cerevisiae)* in broiler diet. Five treatments A (control) B (yeast replaced 40% of fishmeal), C (yeast replaced 60% of fishmeal), D (yeast replaced 40% of poultry by product) and E (yeast replaced 60% of poultry by product) were designed. Their results indicated that 60% yeast replacement with both fish meal and poultry by product improved quality of meat because yeast contain higher amount of vitamin B6, Zn and Se. Manal and El-Naga (2012) examined the effect of dietary yeast supplementation on broiler performance. Three inclusion levels were used containing 0.3, 0.5 and 0.7% dry yeast and results showed that diet 0.5% of dry yeast improved all parameters of carcass characteristics. It is concluded that dietary dry yeast at 0.5% could improve the performance and carcass characteristics. Miazzo *et al.* (2011) investigated the influence of brewer's yeast on carcass characteristics in broiler. They concluded that brewer's yeast at 0.3 and 0.6% had improved meat quality in broilers.

Saccharomyces cerevisiae at 0.2% had higher dressing percentage (Hosseini, 2011). Vahdatpour *et al.* (2011) studied the efficacy of different form of *Saccharomyces cerevisiae* on carcass characteristics in Japanese quails. Four diets were formulated containing 0, 1g/kg active SC, 1 g/kg inactive SC and 0.5 g/kg active + 0.5 g/kg inactive SC. They reported increased dressing percentage and gizzard weight in all diet containing SC. Chicks fed diet containing active SC had depressed ($p< 0.05$) proventriculus weight and heart weight. Chicks fed diet containing 1g/kg active SC had lower ($p< 0.05$) intestinal weight than control birds. Zhou *et al.* (2010) reported the effects of yeast supplementation on carcass characteristic in broilers. They showed that yeast supplementation had no effect on organs weight. However, relative liver weight was higher in group containing higher level of yeast. Furthermore, abdominal fat decreased in group containing higher level of yeast. Karaoglu and Durdag (2005) studied that effect of yeast on carcass characteristics in broiler. They used three levels (0, 1 and 2 g /kg) of *Saccharomyces cerevisiae* in the broiler diet. They showed that dressing percentage was not affected by inclusion of yeast.

Chimote *et al.* (2009) performed an experiment to study the influence of yeast and acidifier supplementation on carcass characteristics in Japanese quails. Three diets A (Basal diet), B (Basal diet with supplementation of yeast) and C (Basal diet with supplementation of acidifier) were formulated. They showed that dressing percentage was higher in B and C group. In contrast, Ghally *et al.* (2007) carried out an experiment to check the effectiveness of dietary YC on carcass characteristics in Japanese quails. Three diets A, B and C were formulated with the use of YC at 0, 1 and 2% level, respectively. They showed that supplementation of YC in the diet of quail birds had no significant effect on dressing percentage and edible giblets proportions. El-Sheikh *et al.*, (2009) examined the influence of yeast on carcass characteristics in layers. The yeast supplemented at 0.1 and 0.2% in laying hen diets. They reported that 0.2% yeast had increased spleen weight compared to control group. Yeast supplementation had no effect on thymus weight. Adejumo *et al.* (2004) determined the effect of dried yeast supplementation on carcass characteristics and organ weights in broiler chicks. Birds were divided into 5 dietary treatments. Diet A was control and contained 23.1 percent CP without yeast, diet B served as basal diet containing 18 percent CP without yeast, diet C, D and E had the same composition as diet B but contained 0.08, 0.16 and 0.32 percent yeast, respectively. They reported that dietary yeast significantly improved breast and thigh meat yield and also weights of the organs (liver, gizzard, heart).

Birds fed diet supplemented with *Saccharomyces cerevisiae* had higher dressing percentage and organs weight (liver, kidney and spleen) (Raju *et al.,* 2004). Nawaz *et al*. (2008) conducted an experiment to determine the influence of dry yeast (*Saccharomyces cerevisiae*) supplementation on carcass parameters in broiler chicks. They showed that dry yeast supplementation had no effect on any of the carcass parameter.

Effect of yeast and yeast products on intestinal properties

Supplementation of dried yeast had non-significant effect on intestinal development (Zhang *et al.,* 2012). They also reported that yeast supplementation significantly decreased ($P<0.05$) colibacillus content while lactobacillus content sharply increased ($P<0.05$). Hassan *et al.* (2012) explained the effectiveness of *Saccharomyces cerevisiae* on intestinal flora in Japanese quails. Four diet were formulated; Diet A and B served as infected and non-infected control basal diet while diet C and D served as infected and non-infected basal supplemented with 3 g SC /kg. They observed significantly reduced ($p < 0.05$) cecal colonization in birds

fed a diet C and D (supplemented with *Saccharomyces cerevisiae*). This is because yeast *(Saccharomyces cerevisiae)* enhanced the health of intestinal lumen which improved breakdown and absorption of diet particles resulted in better bird's performance.

Effect of yeast and yeast products on nutrients digestibility

There were non-significant differences in CP, EE and ash in breast muscle among all groups (Upendra and Swamy, 2013). Afsharmanesh *et al.* (2010) investigated the influence of *Saccharomyces cerevisiae* on nutrients utilization in broilers. Two diets were formulated containing *Saccharomyces cerevisiae* at 0 and 20 g/kg. They observed low pH in ileal digesta birds fed diet containing yeast. Low pH could improve utilization of the nutrients. Salamat *et al.* (2011) explored the influence of dietary supplementation of yeast on nutrient digestibility in broilers. They showed that birds fed diet containing *Saccharomyces cerevisiae* had increased digestibility of calcium and phosphorous in the ilium. Spring *et al.* (2000) stated that *Saccharomyces cerevisiae* enhanced intestinal lumen health and improved digestion and absorption of nutrients, due to which growth performance improved. The results indicated that feeding 1.5% yeast to chicks improved feed intake, weight gain and FCR but chicken offered greater level of yeast (2%) had lower body weight gain and feed intake than control and 1.5% yeast groups. Abaza *et al.* (2008) checked the influence of some natural feed additive in broilers. Broilers fed diets containing yeast showed significant effects on digestibility, dry matter and crude protein.

Ali *et al.* (2000) conducted an experiment to appraise the influences of various dietary protein levels and YC supplementation on nutrient digestibility of growing Japanese quails. A 2×3 factorial plan of six dietary groups was assigned. The two factors were protein level (22 and 24% CP) and yeast culture supplementation (0, 1.5 and 3%). They observed higher digestion coefficient of CP, CF, EE and NFE in the birds supplemented with yeast culture. Similarly, Taksande *et al.* (2009) studied the effect of *Saccharomyces cerevisiae, Lactobacillus sporogenes* and *Saccharomyces boulardii* on nutrient digestibility in Japanese quails. They observed significantly higher nitrogen retention in the birds fed diet containing *Saccharomyces cerevisiae* at 0.05% in diet.

The DYS reported a source of protein of high biological value. The SCP were usually more digestible than others. The DYS had better amino acid profile compared with other protein sources. Yeast sludge being a source of SCP was also highly digestible and it had been reported that, DYS increased feed intake and digestibility of the total feed (Mathew *et al.*, 1998). The increased digestibility was probably due to high MOS and B-glucan present in cell wall of *Saccharomyces cervices*. The MOS and B-glucans provide a protective function to the mucosa by preventing pathogens from binding to the villus (Santin *et al.*, 2003). Diets that contain yeast cell wall or whole yeast have increased height of villus (Zhang *et al.,* 2005). Greater villus height increased activities of enzymes (Mehdi *et al.,* 2012) resulting in improved digestion. Longer villus indicated more mature epithelia and enhanced absorptive function. Enberg *et al.* (2000) and Apajalahti *et al.* (2004) reported that *Saccharomyces cerevisiae* was responsible for the production of digestive enzymes and vitamin B complex which improved the nutrient digestibility in broiler chicks. Gao *et al.* (2008) showed that the digestibility of Ca and P on day 35 increased as dietary yeast culture increased. However, these effects were not reported by others (Mathew *et al.,* l998; White *et al.,* 2002; Van *et al.,* 2003).

Saccharomyces cerevisiae has been used in poultry feed for improved nutrients digestibility and better production performance. The proximate composition of *Saccharomyces cerevisiae* containing dried yeast (SDY) reported is a protein supplement due to its content of 59.09% CP (Ayanwale *et al.*, 2006). The fiber content of SDY (11.65) appears to be on the high side for poultry birds but Chowdhury *et al.* (2009) stated that yeast fiber, though high does not compose of cellulose, hemicellulose and lignin as in the foods of plant origin rather the fiber consist chiefly of mannans and chitin. This contributes remarkably to the high digestibility coefficient of yeast poultry. The high ash level of SDY has been attributed to its level of phosphorus (Dibner and Buttin, 2002). This situation can lead to better bone mineralization in the animal. The performance characteristics results of the SDY fed pullets compare well with the control and other results shown on pullet performance (Furuse and Okumura, 1989). Hudha *et al.* (2010) found that yeast culture increased organic phosphorus utilization in turkey. The increased mineralization of eggs by the SDY might be responsible for the high shell weight observed in SDY fed pullets. The improvement observed in internal egg quality (Yolk weight) could be due to the supply of yeast phytase coupled with the supply of some essential micro nutrients as reported by Jensen *et al.* (1976) that yeast phytase was capable of increasing bio-availability of certain minerals such as Ca, Cu, Zn, Fe, Mn and even gross energy of the feed.

The effect of *Saccharomyces cerevisiae* on performance and nutrients digestibility was examined in an experiment in broilers fed with diet containing different levels of phosphorous. The lower levels of yeast with non phytate phosphorus (NPP) significantly decreased ileal digestibility of crude protein and calcium. The addition of yeast culture significantly increased ileal digestibility of both P and Ca. The enhancement of NPP dietary significantly increased the concentration of P, Ca and ash in the tibia. Only birds fed with the diets containing 0.45%

yeast culture significantly had higher ash percentage than the other groups. Serum Ca and P were significantly affected by different levels of NPP in the diet. The effect of yeast culture on concentration of serum P and total protein was significant. In conclusion, the increased retention of P, CP and mineral utilization in deficient NPP diets by yeast culture resulted in increased availability of P and Ca to the broilers, which could have led to improved growth performance (Salamat *et al.,* 2011).

Effect of yeast and yeast products on Economics

Addition of DYS in the diet decreased cost of feed (Rameshwari and Karthikeyan, 2005). Similarly, Chirwa and Lebitso (2014) replaced fish meal with pWAS in broiler diet. Five diets were formulated by replacing fish meal with pWAS at 0, 25, 50, 75 and 100%. They revealed that growing chicken on pWAS saved the cost (46%) due to the fast growth rate. Ghally and El-Latif (2007) concluded that supplementation of yeast culture (*Saccharomyces cerevisiae*) at the level of 2% in diet of Japanese quails have 7% more economic efficiency than the other dietary groups. Taksande *et al.* (2009) also reported that quail birds who fed basal diet supplemented with *Saccharomyces cerevisiae* at the inclusion level of 0.05% have significantly lowest cost of production per 100 grams of meat than the other dietary treatments. Kumari *et al.* (2001) also reported cost effective feeding with yeast.

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