Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(2): 629-635

Received: 10-01-2018
Accepted: 12-02-2018

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A review on effects of yeast (*Saccharomyces cerevisiae*) as feed additives in ruminants performance

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Abstract
Feed additives are groups of feed ingredients that are required in quantity and can cause desired animal response. In the past two decades, the potential roles of using products containing living microorganisms as specific microbial supplements have been better feed supplements for ruminants. Feed additives are useful for dairy producers to improve nutritive value of the diets for dairy animals and increased profits when used correctly. Additives should be viewed as enhancements of good feeding programs and it should not be considered as replacements of balanced rations and good feeding practices. The work on feeding yeast as probiotic was initiated as early as 1950's, although yeast biomass as a byproduct of alcohol industry was earlier used as a protein source. Yeast, which was later named as probiotic, was used only at a lower level as a feed supplement. The use of Saccharomyces cerevisiae (Sc) asa Probiotic when added to feed in small amounts began during the 1940’s and 1950’s. Data indicate that supplementation of yeast to the ruminant diet may improve feed intake weight gain and productivity, digestion and numbers of anaerobic cellulytic bacteria, and ruminal PH value. Also, italter the patterns of volatile fatty acids and influence absorption of some minerals.

Keywords: Yeast (*Saccharomyces cerevisiae*), ruminants, performance

1. Introduction
Various feed additives are in widespread use in diets of ruminants modulate rumen metabolism which ultimately enhance nutrient utilization and animal performance. Denev *et al.* [1] explained some microbial additives such as Direct-Feed microbial (DFM), Yeast cultures (YC), Live Yeast Cultures (LYC). In addition, a list of accepted microorganism for use in animal feeds was developed. Some of the major hypotheses on how DFM may benefit animals can be found in an excellent discussion by [2]. Both microbials increase milk yield in dairy cows and the body weight gain and feed conversion ratio in beef cattle [3]. Krehbiel *et al.* [4] reported that the yeast supplementation increased total volatile fatty acids (VFA), stabilization of rumen PH and decreased lactate concentration. The increase in feed utilization and improvement of rumen fermentation along with increased dry matter may also enhance milk production and animal performance [5]. However, Petersonet *et al.* Greenquist *et al.* [6] reported that supplementation of DFM resulted in no measurable impact on growth rate in finishing cattle. The objective of this study was to review the research currently under way on theYeast, *Saccharomyces cerevisiae* (Sc) as a Probiotic when added to feed in small amounts on performance of Awassi lambs.

1.1. Herbal Feed Additives
Natural feed additives such as medicinal plants are very important material that can improve feed efficiency utilization, growth rate [7]. Hassan and Hassan [8] reported clear improvement in live weight gain when lambs fed restricted concentrate diets supplemented with medicinal plants such as Nigella sativa (Ns) and rosemary. Karadzic lambs fed three levels of rumen degradable nitrogen (1, 1.3 and 1.6 g RDN / MJ of ME) supplemented with two levels Nigella sativa (Ns) (0 and 7.5 g / kg DM) improve the live weight gain in lambs fed diets supplemented with Ns as compared with those lambs fed diet without Ns [9]. Hassan and Hassan[10]found that serum urea nitrogen (SUN) in lambs received rosemary was significantly ($P<0.05$) higher than those fed diets without it. Hua-wei and Jian-ming [11] reported that herbal feed additives may favorably affect gut functions (e.g., enzyme activity, microbial) in vitro [12].

Concluded that with the herbal growth promoter, performance of the lambs can be improved. Medicinal plants as feed additives that manipulate the microorganisms living in the rumen have been increased the microbial protein [13].

1.2 Microbial Feed Additives

Microbial feed additives are used in ruminant feeds for different purposes. First is for the same reason that probiotics are used in non-ruminants, namely stabilization of the intestinal flora; this is applicable only in youngpre-ruminant animals, however, lactobacilli, enterococci and yeast have been reported to be helpful in improving live weight gain in calves and lambs [14] Several excellent reviews have described the role of *Saccharomyces cerevisiae* (Sc) and fungal fermentation extracts from *Aspergillus oryzae* (Ao) in animal feeds [15]. Salim [16] indicated that lambs fed Iraqi probiotic significantly increased daily intake of DM, OM, ME and TN. While, Seo *et al*.[17] revealed that lactic acid bacteria (LAB), lactic utilizing bacteria (LUB),or other microorganisms including species of Lactobacillus, bifido bacterium, enterococcus, streptococcus, bacterium, strains of Megasphaera elsdenii and Prevotella bryantii and yeast products containing *Saccharomyces* and *Aspergillus*. LAB may have beneficial effects in the intestinal tract and rumen both LAB and LUB potentially moderate rumen conditions and improve dry matter intake, feed efficiency and weight gain in calves. Luebbe *et al.* [18] reported that, numeric advantages were observed for averge daily gain (ADG) and feed efficiency when cattle were fed a DFM. The use of additives from cultures of live microorganisms as activators of ruminal fermentation has gained great scientific and productive interest [19]. The microbial additive as a product of biological activity, rich inlactobacilli, yeasts, carbonated short-chain organic acids and low pH [20], stabilizes the microbial flora of the ruminal ecosystem, at the time that increases the digestibility and that of the cell wall [21] Supplemented Yeast stimulated the growth of beneficial microorganisms in the rumen, the numbers of total ruminal anaerobic and cellulolytic bacteria increased with YC [22]. Yeast have been shown to provide vitamins (especially thiamin) to support the growth of rumen fungi[23].The ability of different strains of Sc to stimulate the viable count of bacteria in the rumen appears to be related to their ability to remove oxygen from rumen fluid, since respiration-deficient mutants of Sc failed to stimulate bacterial numbers[24].Total volatile fatty acids were significantly higher in the Wheat Straw +yeast [25].Xiao *et al*.[26]demonstrated that Ruminal pH, ammonia-N, and total volatile fatty acids were not altered by *Saccharomyces cerevisiae* fermentation products (SCFP).

1.3 Scientific Classification of Saccharomyces cerevisiae

Kingdom	: Fungi
Phylum	: Ascomycota
SubPhylum	: Saccharomycotina
Class	: Saccharomycetes
Order	: Saccharomycetales
Family	: Saccharomycetaceae
Genus	: *Saccharomyces*
Species	: Cerevisiae

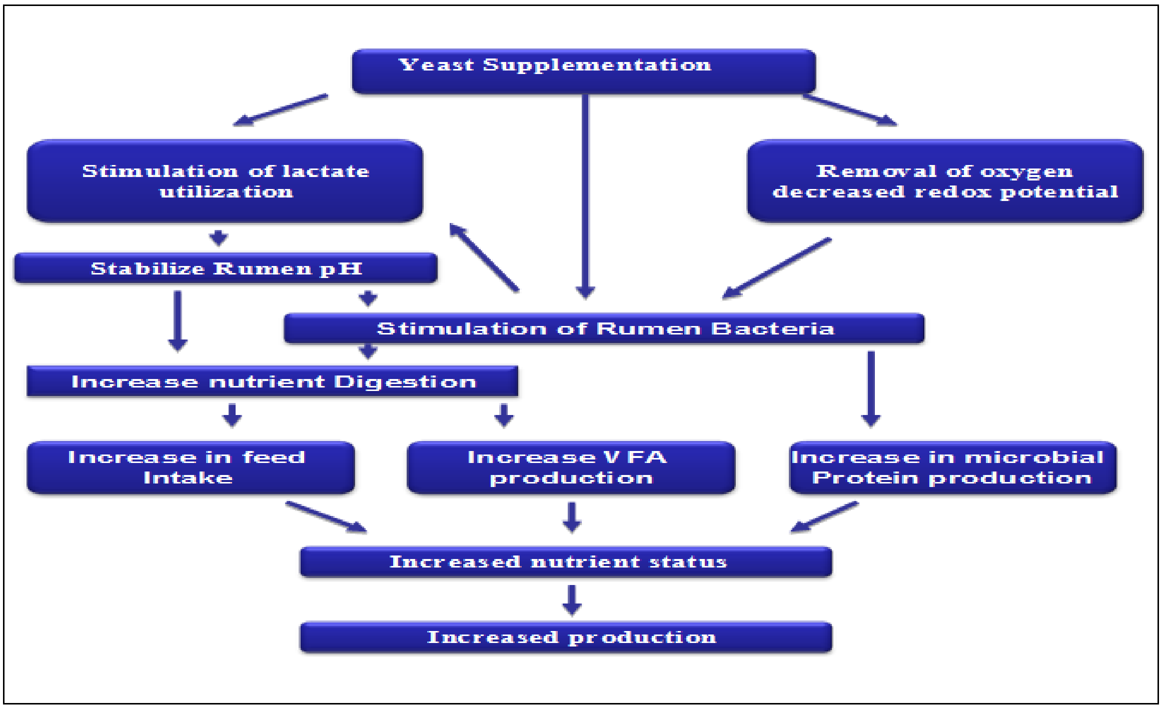

Fig 1: Schematic representation of the mode of action whereby yeast stimulates production in ruminant [27, 28]

1.4. Effect of yeast *Saccharomyces cerevisiae* of ruminants performance

1.4.1 Daily Feed Intake

Daily Feed Intakedry matter affected lamb growth performance and cellulolytic activity in the rumen but did not affect feed intake [29] Probiotics supplementation has been found to increase feed intake [30].Titi*et al*.[31] observed that supplementation of yeast culture in the diets of lambs and kids had no effect on dry matter intake (DM). Kumar, et.al. [52] concluded that supplementation of yeast culture (Sc) at 0.25 g/ head / day in the diet of buffalo bull calves had no any effect on feed intake.[32] demonstrated that Awassi lambs fed diets supplemented with SC, showed a mathematical increase in daily DM and OM intake of barley straw due to addition of Sc. Pienaar *et al*.[33] reported that lambs fed diets containing a rumen active live yeast product or an ionophore had no effect ($P<0.05$) on feed intake. Ding *et al.* [34] reported that male lambs were fed three treatment diets,basal dietsteam-flaked corn (CON), basal diet with monensin (MO) and basal diet with live yeast(LY) average daily intake (ADI) was unaffected by monensin and live yeastsupplementations. On the other hand [30] revealed that the positive effect of yeast supplementation with the percentage of concentrate in the diet and with the DMI.[16] found the use of four levels of feeding to achieve the target gain of 50,100,150and 200 g/day, respectively significantly (P<0.01) increased daily intake of DM, OM, ME and TN and greater responses to Iraqi probiotic where shown with high level of feeding. Also, [35] concluded that supplementation of dried yeast to rations of growing goat kid has improved, DMI, TDNI, DCPI.[36] found that dairy cows fed medium or high levels of dietary concentrate with (10 g Sc /cow /d) supplementation had only numerically higher on DMI. Similar to our findings, [37] found no DMI differences for dairy cows supplemented with live yeast (LY) as compared with control diet.

1.4.2. Liveweight gain and feed conversion ratio

More studies, however, are still needed especially with small ruminants (sheep and goats to throw more lights on the effect of yeast culture (Yc) and its mode of action [38][39] showed that goat's kids unsupplemented with yeast had lowered average daily gain than those with 2.5 and 5 g/day yeast. Khadem*et al*. [40] reported there was not effect on the feed conversion ratio (FCR), average of daily gain (ADG),live weight gain and FCR of finishing lambs of sheep fed diets supplemented with 10 g/kg Sc. Chaucheyras *et al*.[41] found that body weight gain in lambs improved using a diet with a yeast culture in combination with monensin. Inclusion the probiotic in animal diets seemed to improve lambs growth [42] and increased live weight gain and enhanced feed conversion ratio. Titi*et al*.[31] calves were fed a total mixed ration supplemented with yeast culture at a level of 20 kg/ yeast/ton of feed, the addition of the yeast culture did not affect in final weight, average daily gain and feed conversion ratio. Salim [16] reported that the live weight gain was (P<0.01) responded for increasing levels of feeding, but the interaction between level of feeding and probiotics recorded no significantly. Hassan and Hassan [10, 7]reported that significant improvement in live weight gain and feed conversion ratio was associated with lamb fed on diet supplemented with local Iraqi probiotic or medicinal plants as compared with control diet. Iraqi probiotic contain Sc seemed to be more efficient to increase body weight **,**feed conversion and decreased mortality. Pienaar *et al*.[33] reported that lambs fed diets inclusion of a rumen active live yeast product or an ionophore had no effect (P<0.05) on daily live weight gain and feed conversion ratio[43] revealed thatgoats fed diets supplemented with (0, 1.5, 3.0and 4.5) YC percentage that dietary yeast culture at the level of 4.5% increased total weight gain. It is concluded that S. cerevisiae NCDC-49 supplementation improved growth and feed conversion efficiency and had some positive influence on the rumen fermentation parameters [44].

1.4.3 Digestibility

The effects of specific yeast culture preparation on the performance of ruminants have been well documented over the last two decades. The effects of supplemental yeast culture on rumen development have not been determined. *Saccharomyces cerevisiae* (Sc),a facultative anaerobic yeast, exhibits some degree of rumen viability and can influence fermentation and populations of rumen microbes. Hong and Gallagher[45] revealed that sheep fed ration with or without Sc (5 g/h/day) showed no significant differences between control and treatment in *in-vivo* digestibility of DM, acid detergent fiber (ADF), nitrogen (N) or in vitro DM digestibility. Kholif and Khorshed [46] found no differences in the digestion of (DM) after 24 and 48 hrs when added yeast to ratios lactating buffaloes. Yeast supplementation to ruminants may increase the ratio of fiber digestion [47].Abdel-Ghani [48] revealed that goats fed the same diet supplemented with 3 or 6 g of YC, had higher nutrient digestion coefficients than the control group. A similar trend was observed in feed intake. The obtained results indicated that the addition of Scin recommended doses showed a positive effect on ruminal digestion [49].Titi*et al*.[31] reported that addition of probiotics (yeast culture) had no effect on dry matter (DM), crude protein (CP) and neutral detergent fiber (NDF) digestibility. However, in the same study, digestibility of organic matter (OM) and acid detergent fiber (ADF) increased in lambs supplemented with yeast culture in the diet. Lascano *et al*.[51] reported improved apparent dry matter (DM) crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) digestibility in meat goats fed diet supplemented with commercial probiotics than control group. Studies have demonstrated that yeast supplementation can influence digestive processes in the rumen [50].*Lascano et al*.[51] reported that heifers fed high concentrate diet had increased dry matter digestibility (75.67 vs. 72.96%), andyeast addition increased dry matter digestibility (74.97 vs. 73.65%). Kholif and Khorshed [[46] reported a positive effect of yeast supplementation on crude fiber (CF), acid detergent fiber (ADF), neutral detergent fiber (NDF), cellulose, and hemi cellulose digestibilities. Gaafar *et al*.[50] observed that feeding ration consisting of concentrate roughages (40:60) the digestibility of all nutrients and nutritive values increased with 15g baker's yeast/head/day supplementation. Otherwise Kumar *et al*.[52] concluded that supplementation of yeast culture at 0.25 g / head / day in the diet of buffalo bull calves had improved digestion of nutrients.Whereas, Mousa *et al*.[53] explain that ewes fed diets of concentrate to roughage (60:40) supplemented with 5 or 7.5 g/h/d live dried yeast, the digestibility of DM, CP,CF, TDN and DCP were higher with yeast supplemented groups than control group.Moreover, Soren *et al*.[54] reported that lambs fed diets supplemented with either Sc or a combination of Sc and *Lactobacillus sporogenes* (Sc+Ls) at 1.5 % of concentrate mixture. The digestibility of all the nutrients were similar among the groups, except for acid detergent fiber (ADF) digestibility, which was higher in Sc and (Sc+Ls) than the lambs of the control group. While, Ismaiel*et al*.[55] revealed that male lambs fed diets include (0.5 and 1kg/ ton concentrate) Sc increased CF digestibility than control group; TDN and DCP were not changed between treatments.On the other hand Sarwar *et al*.[56] indicated that lambs fed three levels of protein (18, 22 and 26% CP) supplemented with 20 ppm and 0.1% probiotics, higher digestibility of DM, TDN and DP with probiotics supplementation. Further Herawaty *et al*.[57] found that low quality roughage supplement with 0.5% Sc feed to beef cattle diet increased the nutrient digestibility when compared with no Sc supplementation but still lower when compared with control diet.

1.5 Rumen Characteristics

1.5.1 Volatile Fatty Acids (VFA)

The development of the rumen is primarily chemical being influenced by volatile fatty acid (VFA) metabolism and absorption in the rumen. These (VFA) are produced by naturally occurring microbes [58]. Adams*et al*.[59] observed little effect of yeast supplementation on ruminal (VFA) concentrations. On the other hands Doležali *et al.* [49] reported that the YC showed a positive effect on production of TVFA (127.6 vs. 84.0 mmol/l), and the utilization of ammonia was higher in experimental groups (8.40) than the control (9.06 m mol/l).Galip [60] stated that when Sc was added to the forage-enriched ration ruminal VFA concentrations tended to increase.Also Kholif and Khorshed [46] found no differences in the concentrations of acetate, propionate, and butyrate after 24 and 48 hrs when baker's yeast was include. The ratio forage: concentrate of the diet at 3hrs post feeding, the TVFA of rumen fluid were increased from 91.26 to 103.34 mmol/l in control vs. 2.5g with Sc [39]. Concentration TVF increased with Sc [50]. Longuski *et al.* [61] found that yeast supplementation (56 g/cow/d) had no effect on total ruminal VFA or acetate concentration. Further Bal and Gokus [36] reported that total VFA concentration was not affected by either the yeast supplementation or dietary concentrate level, averaging 102.3 mml. Neither acetate nor propionate concentrations were affected with the yeast supplementation in both 50 and 70% concentrates. However, ruminal acetate and propionate concentrations were decreased and increased respectively. TVFA concentration was significantly higher ($P<0.01$) in live YC fed kids at 2 and 4 months [44].

1.5.2 Rumen PH
Rumen pH is one of the most critical determinants of rumen function, particularly for the cellulolytic bacteria, which fail to grow at pH 6.0 and below [62]. Ruminal pH was not affected by Sc supplementation [39]. Gaafar *et al.* [50] revealed that pH value decreased significantly ($P<0.05$) with Sc. However, the highest and the lowest ruminal pH values were recorded for sheep in 2.5 g Sc and control groups [40]. Furthermore, Abdel-Ghani [48] reported that ruminal pH of dairy cows and goat were respectively increased byYc Probiotics and yeast culture have many benefits when added to a diet. Kholif and Khorshed [46]found no alteration in ruminal NH_3-N concentration due to the addition of yeast. Doležali *et al.* [49] found the addition of yeast culture into the feeding ration in sheep decreasing in PH and fluctuated near the lower limit as compared with control group. Guedes *et al.* [63] reported that the inclusion of Sc increased ruminal PH and decreased lactate concentration. Rumen PH was not affected by yeast culture [64]. Otherwise Bal and Gokus [36] reported that ruminal PH reductions associated with feeding high dietary concentrate (70%) diets in dairy.

1.5.3 Ruminal Ammonia Concentration
Rumen ammonia concentration has been used as an indicator of microbe protein degradation and of non-protein nitrogen utilization [65]. Dawson *et al.* [66] reported that the addition of Scto hay based diet fed to steers had no effect on NH_3-N concentrations.Newbold *et al.* [24] also found that NH_3 concentrations increased when sheep were fed on Sc. A Ruminal NH_3-N concentration was increased at 4hrs post feeding Sc supplementation [67] *Saccharomyces cerevisiae* supplementation was associated with an increased flow of microbial protein leaving the rumen and enhanced supply of amino acids entering the small intestine [68]. However, Putnam *et al.* [70] observed no effect with yeast on the passage of nitrogen fraction and amino acids to the small intestine. 46. Hong and Gallaghe [46] found no alteration in ruminal NH_3-N concentration due to the addition of yeast. Stewart and Smith [63] reported that the inclusion of Sc at 1 g/day had no effect on NH_3-N concentration. A commercial live yeast culture addition to the diets of lambs at 4 g/day did not affect NH_3-N concentration [70]. Doležali *et al.* [50] revealed that NH_3-N concentration value decreased with Sc. NH_3-N was not affected by live yeast culture supplementation at 4 g/day [71, 73, 74]. Fatma *et al.* [72] reported that the inclusion of Sc at 0.5 % increased NH_3-N concentration.

2. Conclusions
The addition, of *Saccharomyces cerevisiae* improvemed total daily intake with high levels of concentrate supplementation, improved rumen enviroment across treatments with TVFA, pH, NH3-N, propionic and butyric acids.

3. Acknowledgement
The authors express their deep gratitude to Dr. Hassan S.A. Jawad\ Department of Animal Production\ Faculty of Agriculture\ University of Baghdad, for his valuable assistance in publishing this paper.

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