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Review Article

Importance of Yeast in Ruminants Feeding on Production and Reproduction

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Abstract: Benefits of yeast supplements for ruminants are shifts in microbial population numbers and species, favorable changes in volatile fatty acids contents of rumen, positive effects on rumen ammonia disappearance, positive effects on rumen pH, promotes metabolism digestion, increase in fiber digestibility and changes in microbial protein and amino acids in large intestine. In addition, benefits of Yeast supplements for ruminants are improving the overall intestinal bacteria balance, reducing digestive problems, lower risk of acidosis and reduction in the humidity of bedding resulting in lower stress levels. Feeding on feed mixture contained Active dry yeast (ADY) improved the appetite of animals which lead to increase the feed intake and consequently increased the daily weight gain of the treated animals. From the physiological point of view, adding ADY caused significant increase the levels of both T_4 and T_3 hormones which lead to increase the protein and fat biosyntheses. Moreover, benefits of yeast supplements for ruminants are increased milk production and improvements in milk quality, improves milk selenium content, reduced mastitis and somatic cell count, less stillbirths, weak neonates, improves fertility, reduced incidence of retained placenta, improved immune response, increases immune resistance, high content in B-vitamins and trace elements, enhances weight gain and feed utilization.

Keywords: Yeast, Digestibility, Growth, Milk Production, Reproductive Efficiency, Blood Components

1. Introduction

Yeast products are widely utilized as feed additives for ruminant animals in many parts of the world There is a widespread belief among dairy and beef producers and ruminant nutritionists that yeast products are beneficial by enhancing feed intake and overall animal performance and is safe tool for enhancing ruminant production and safeguarding health [1]. However, the mechanisms have been proposed to explain why yeast products could stimulate DM intake and productivity in growing and lactating cattle are presented by Robinson [2]. The oldest hypothesis is that the yeasts are able to grow, at least for a short period of time, in the rumen thereby directly enhancing fiber digestion and/or producing nutrients that stimulate growth of rumen bacteria, which do the bulk of the fiber digestion. It has also been suggested that yeasts utilize nutrients, such as lactic acid which, if allowed to accumulate in the rumen, could suppress bacterial growth and/or suppress DM intake by driving rumen pH down [3].

A more recently suggested possibility is that growth of yeast in the rumen utilizes the trace amounts of dissolved oxygen, particularly at the interface of the cellulolytic bacteria and fiber, thereby stimulating growth of rumen bacteria, to which oxygen is toxic [4]. It seems clear that for these mechanisms to be operative, yeasts in the product have to be viable, in the sense of being able to grow for at least a short period of time in the rumen. Hence the origins of the debate between live and dead yeast products. The alternate mechanism is that it is the yeast culture itself, which is created in the yeast fermentation process, which provides a mixture of micro-nutrients to stimulate bacterial growth in the rumen thereby facilitating increased fermentation of fiber and/or utilization of end products of fiber fermentation to prevent their accumulation in the rumen. Supporters of this theory point to a limited research base showing that when cultures of live brewers or fermentation yeasts are fed to ruminants, there are few, if any, changes to rumen fermentation and/or animal performance [5].

Feeding a yeast following weaning has been found to increase feed intake, daily gain and feed efficiency in beef cattle while in lactating dairy cows, feeding yeast and yeast cultures products significantly increased milk production, milk composition and dry matter intake [6, 7]. In USA, nutrient yeast is used where producing animal feed, as well as an additive to the feed ration of farmed animals, farmed poultry and fur-bearing animals. According to the Association of American Feed Control Officials and American Pet Diner Products recommendations, active dried yeast *(Sc)* must be supply daily to pellet ration of anials which contains crude fiber, not less than 20.0% and not more than 30.0% for best results. Therefore, adding Yeast to the diet of animals may be increase in celluolytic fiber digestion and consequently enhance utilization of feed and improve feed efficiency. Live yeast supplemented to pellet ration for help controlling digestive problems in animals and to stabilize the micro flora in the gut, consequently improving the fiber digestion, which means better overall feed utilization and a healthier gut because animals required higher fiber diets i.e. higher calorie diets for young, growing or lactating animals for enhanced health vitality [8]. Therefore, providing yeast as proper nutrition is one of the best ways to ensure the health of the rabbit and adult rabbit's diet. S. C. has demonstrated positive effects in different species such as broilers, calves, beef cattle, dairy cow and rabbit [9].

The objective of this article is to summarize studies that have been published in the scientific literature that have examined the impact of yeast on rumen fermentation, fiber digestion and productive and reproductive performance of farm animals.

2. Ruminant Responses to Yeast Supplementation

2.1. Effect of Yeast on Digestibility and Nutritive Values

The concentrations of total, total viable and cellulolytic bacteria increased significantly by 41.0, 33.5 and 57.4%, respectively, with yeast culture supplements to the diet of buffalo calves [10]. Plata et al. [11] found also NDF digestibility increased with *Sc* addition (48.6 vs. 60.45). Some of the benefits associated with *Sc* include increased DM and NDF digestion; in addition, the *Sc* increases NDF digestibility and the number of protozoa present in the rumen and increased the microbial protein flow from the rumen in lactating dairy cattle [12] and in buffalo bulls [13]. El-Ashry et al. [14] found that adding live dried yeast to the buffaloes calve diet improved the digestibility coefficient of OM, CP, CF, EE and NFE. The same trend was recorded for digestible crude protein (DCP). Addition of Sc to the ration of large animals improved in-vitro DM and OM disappearance and increased in-vivo digestibility of DM, CP and CF [15].

Panda et al. [16] found also that digestibility of CP increased from 63.9 to 68.7% with supplements of yeast culture to the diet of crossbred male calves. The CP digestibility improved significantly from 70.6 to 79.5, TDN increased significantly from 70.4 to 73.7 and DCP increased significantly from 12.7 to 14.3 CF as well as CF digestibility increased by 26.9% with yeast supplementation to the diet of the rabbits compared with the group fed basal diet without ADY [17]. The same authors found that adding ADY significantly increased apparent digestibility of DM, OM, CP, CF and Ash. The improvement in CF digestibility may be due to that yeast stimulates the cellulolytic bacteria and attributed the increase in CP digestibility to the stimulation of proteolytic bacteria. Saleh et al. [18] found also that CF digestibility in Barki male lambs was increased by 12.3% with yeast supplementation compared with the basal diet and showed slight improvement in nutritive value of ration with ADY supplements, so, the total TDN was increased from 75.43 for control treatment to 76.31 for ADY treatment and concluded that yeast supplement to the diet of male lambs improved the apparent digestibility of nutrients and the nutritive values of diet and this may be due to an increase in the rumen bacteria number or stimulate some of the rumen bacteria sp. like proteolytic or cellulolytic bacteria or both. More improvement in nutritive values were reported by Allam et al. [19] who found that TDN and DCP values increased from 73.73 to 81.88 and from 13.19 to 15.32, respectively, when yeast 2.5 g/h/day was added. EI-Ayek et al. [20] found that CP content of CFM markedly increased by about 7.8% as a result of YC supplementation compared to the control one. Digestibility of CP was significantly higher for diet than the control diet

Table 1. *Mean values of apparent digestibility and nutritive values in the ration supplemented with ADY fed to rabbits.*

*Apparent digestibility%	Control	ADY
Dry matter (%)	76.5	79.5*
Organic matter (%)	78.0	81.0*
Crude protein (%)	70.6	79.5**
Crude fiber (%)	63.3	80.3**
Ether extract (%)	77.7	76.3NS
Nitrogen-free extract (%)	84.3	83.6NS
Ash%	52.7	58.7
Nutritive values:		
Total digestible nutrients (%)	70.4	73.7*
Digestible crude protein (%)	12.7	14.3**

*Habeeb et al. [17], NS = Not significant, *= P<0.05 and ** = P<0.01.

Most researchers agree that yeast supplementation strategies have measurable effects on rumen fermentation and rumen metabolism. Initial rate of digestion is markedly improved by live yeast culture addition and feed intake can be considered to be a function of initial rates of fiber digestion and therefore, it may be assumed that increased initial fiber digestion rates may increase dry matter intake [5].

Table 2. *Mean values of apparent digestibility and nutritive values for ration fed to lambs with or without ADY supplements.*

*Apparent digestibility%	Control	ADY
Dry matter	76.51	77.53
Organic matter	78.99	79.86
Crude protein	70.68	73.48
Crude fiber	59.00	66.26
Ether extract	77.84	80.26
Nitrogen-free extract	84.33	83.58
Ash	53.67	56.10
Nutritive values		
Total digestible nutrients (%)	75.43	76.31
Digestible crude protein (%)	10.42	10.81

*Saleh et al. [18]

Table 3. *Effect of live dried yeast and yeast culture in the diets of growing buffalo calves on nutrients digestibility and feeding values.*

*Apparent digestibility%	Control	Live DY	YC
OM	$67.89^{b}\pm0.58$	$70.88^{a}\pm0.58$	$71.90^{a}\pm0.49$
CP	$70.43^{c}\pm0.39$	$75.08^{b}\pm0.77$	$77.93^{a}\pm0.70$
CF	$49.30^{b}\pm0.39$	$54.92^{a}\pm0.70$	$56.70^{a}\pm0.63$
EE	73.70 ± 0.59	72.90 ± 0.55	73.98 ± 0.68
NFE	$70.18^{b}\pm0.72$	$73.69^{a}\pm0.70$	$73.10^{a}\pm0.49$
Feeding values%			
TDN	$52.83^{b}\pm0.54$	$55.90^{a}\pm0.55$	$56.23^{a}\pm0.45$
DCP	$8.00^{b}\pm0.11$	$8.13^{a}\pm0.09$	$8.73^{a}\pm0.09$

Means in the same row with differ superscripts differ ($P<0.05$).
*Al-Ashry et al. [21]

2.2. Effect of yeast on Milk Yield, Composition and Dry Matter Intake

Studies in several laboratories have demonstrated that YC supplementation can influence digestive process in the rumen and feed intake. Dry matter intake (DMI) is often considered to be a function of the initial rate of fibber digestion; early stimulation of ruminal activity can be expected to have a major impact on the feed consumption and can provide a driving force for improved animal performance [5]. Yeast cultures have also been fed to pre-partum cows improving DMI [22]. Feeding YC has increased dry matter intake [23]. Many other investigations demonstrated a significantly positive effect of Yea-Sacc®1026 on DMI [24, 25, and 26]. Allam et al. [19] reported that DMI tended to increase significantly by the addition of yeast with level of 2.5 and 5 g/h/day. El Ashry et al. [27] found that DMI from concentrates was increased from 18.26 to 19.86 g/kg LBW when *Sc* was added to the diet of male barky lambs. However, Saleh et al. [18] found that adding ADY to male lambs tended to increase insignificantly DMI from CFM and rice straw.

The positive effect on animal production, when observed, is better explained by an increase of feed intake rather than a better feed digestibility. The YC stimulated the rate of degradation of solid feeds in the rumen within the first 6 to 8 hrs after the meal; the animals can ingest more dry matter to fill their digestive compartment at the same level and this physical regulation could be involved to explain the higher feed intake in treatment animals [28]. Another factor that can influence the physical regulation of intake is the outflow rate of digesta from the rumen [29].

Yeast Culture increases the population of total rumen bacteria and this increase in turn helps increase feed intake as well as feed stuff digestibility, therefore, as more nutrients go into the animal via greater intake, and more nutrients are provided to the animal via greater digestibility, the animal is put on a generally higher plane of nutrition [5]. Changes in rumen fermentations or rumen parameters attributed to yeast feeding are: increase in cellulolytic digesting bacteria; increased fiber digestion; enhanced utilization of lactic acid by rumen bacteria; increased propionic acid production in the rumen and more stable rumen pH. These products actually do alter rumen fermentations, have a metabolic effect on the animal or improve feed intake [30].

Wang et al. [31] found that feeding a ration with 21% forage neutral detergent fiber and yeast culture positively affected dry matter intake, actual milk yield and 3.5% fat corrected milk. Wu Zilin [32] demonstrated that inclusion of yeast culture in the daily ration of Chinese Holstein lactating cows increased DMI 3.94%, milk yield 4.04, 3.5%FCM 7.07%, milk fat percent 5.77% and significantly increased the amount of milk produced, but had minor effect on percent of milk protein and lactose content. Analyzed the results gained from 22 studies with Yea-Sacc®1026 involving more than 9039 lactating dairy animals Dawson and Tricarico [23] found an average increase in milk production of 7.3% in yeast-supplemented animals. Responses to supplementation were variable and ranged from 2 to 30% increase in milk production. The improvement of milk production was 1.8 L in the controlled experiments which are probably significant. It became 1.4 L in the field studies and the effects of yeast were highest within the first 100 days of lactation and YC can also action the persistence of lactation after the production peak of dairy cows. The authors suggest that YC supplements can have a significant role in strategies for economically enhancing the performance of ruminant animals. The same authors showed that YC preparations are least effective when animals are fed well balanced diets that promote the stability of the gastrointestinal microbial population and are more likely to have dramatic effects under conditions of dietary and environmental stress.

Strohlein [33] also reported that the addition of LYC (*S. cerevisiae*) into the feeding ration of dairy cows improved their milk performance significantly. Jouany [29] decided that a positive effect of yeasts on the performance of dairy cows and on the content of milk components resulted from increased daily feed intake and improved digestibility of nutrients. Formigoni et al. [34] reported that Yea-Sacc®1026 improved significantly the DMI and milk yield of dairy cows, on the overall period, but also, during heat stress period and the Yea-Sacc®1026 improved significantly the composition of cow's milk, including fat ($P<0.01$) and protein ($P<0.05$) content. Bertin and Andrieu [35] demonstrated the beneficial effect of Yea-Sacc®1026 on the performance of high producing dairy cows. Yea-Sacc®1026 significantly improved milk production among high-producing dairy cows. Dairy cows fed Yea-Sacc®1026 were better able to rebuild body stores better than control cows. Kravale et al. [36] also reported that Yea-Sacc®1026 significantly improved milk yield of dairy cows, fat and protein content in cow's milk especially during the hot season. Economic results of the dairy herd were improved in the Yea-Sacc®1026 group in comparison with untreated control.

Many other investigations demonstrated a significantly positive effect of Yea-Sacc®1026 on Milk production of dairy cows [26, 37], lactating buffalo [38], dairy sheep and goats and meat production of lambs [39], calves and finishing bulls [24]. Nikkhah et al. [40] found that milk compositions including fat and percent total solids were improved by the addition of LYC. In lactating dairy cows, feeding a yeast and yeast cultures products significantly increased milk production, milk composition and dry matter intake.

Yea-Sacc®1026 helps of ruminant animals achieve their full potential-cost effectively–through better utilization of feed. Yea-Sacc®1026 reduces digestive disorders, drives dry matter intake, improves feed efficiency, increases milk yield, improves milk composition, and improves meat production. Yea-Sacc®1026 is the first LYC to gain EU approval as performance enhancing product for dairy cows, fattening cattle and calves [41].

The effect of different doses of LYC (*S. cerevisiae,* strain SC-47) (0, 3, 6 and 12 g of yeast/day respectively) on the lactating performance of Holstein dairy cows was described by Nikkhah et al. [40] and concluded that the LYC had a beneficial effect on the rumen health. Other available data of Ando et al (2004) indicated that in the rumen fluid of animals receiving supplements of LYC, the total content of volatile fatty acids, and the percentage of propionic acid, and acetic acid increased, the content of ammonia decreased and the total numbers of ruminal bacteria significantly increased. Ando et al. [42] stated also that dietary supplementation of Yea-sacc®1026 a significant increase in degradability of roughage in 6 h (P<0.05) after live yeast addition.

To evaluate the effects of pre- and post-partum yeast feeding on early lactation milk in Jersey and Holstein cows, Britt et al. [6] found that the research group received 2 oz. of Yeast daily during in the pre-partum or post-partum periods had an 8.25 lb per day milk yield, a 0.395 lb per day fat yield, and a 9.92 Lb per day fat corrected milk biological advantage over the control group and concluded that there was a $1.00 economical advantage per day to the research group. Housewright et al. [9] found that cows supplemented with Yeast live cell culture had numerically higher milk production than the cows receiving the dead cell yeast culture. On average an increase of 14 lbs per cow per day was observed when cows were supplemented with 56.75 g/head/day of yeast live cell culture. Schingothe et al. [43] found that feed efficiency defined as kilogram of energy corrected milk/kilogram of DM intake was improved by 7% for cows fed the yeast and concluded that the yeast can improved feed efficiency of heat stressed dairy cows in mid-lactation.

Britt et al. [6] found that Milk yield, butterfat%, butterfat yield, protein yield, fat corrected and energy corrected milk were not statistically but were biologically higher in the yeast group than the control group and there was a $0.54 economical advantage daily to the yeast group. The yeast group did have an advantage over the control group in faster recovery from a drop in milk production following an increase in ambient temperature since both groups were subject to the same heat stress conditions. Lehloenya et al. [44] found that daily uncorrected milk, solids-corrected milk, and 4% fat-corrected milk production for multiparous Holstein cows fed propionibacteria plus yeast during mid lactation was 9–16% greater than control cows. The authors concluded that combined feed supplement may hold potential as a natural feed alternative to enhance lactational performance. The same authors found that milk lactose% in multiparous Holstein cows fed propionibacteria plus yeast during mid lactation was 3–5% greater than in control while milk fat % was 8–18% greater in control than treated cows. Sretenović et al. [45] reported that preparation Yeast culture influenced quantity and composition of the milk by 2.57 kg 4% FCM or 8.70% (P<0.01) and 7.16% milk fat (P<0.05). Ashour et al. [46] found that daily milk, 4% FCM, fat and total solids yields and milk energy output in Egyptian native cows were improved significantly with yeast supplementation *(Sc^{1026})* while the DMI and gross efficiency of milk energy production were insignificantly increased due to this supplementation.

Blezinger [46] found that milk production for heifers consuming the yeast-mineral mix appeared to be greater as well as weaning weights and weight per day of age appeared to be improved by availability of a yeast-mineral mix. Blezinger [46] showed that yeast inclusion increased total mineral supplemental intake. Both mineral consumption and absorption have been positively affected by the addition of yeast culture to free-choice mineral mixes Total supplemental mineral intake was 0.23 and 0.40 lb per day for the control and yeast-mineral, respectively. The yeast-mineral intake was 4.8 ounces per day, and the total yeast consumption per day was 1.2 ounces per day. The difference in total supplement intake between treatments was 0.19 ± 0.072 lb per day. From a different perspective, use of yeast has been shown to have a positive influence on intake in newly received stocker and feedlot cattle. Yeast appears to be useful in reducing stress effects in these cattle and has been shown to be of benefit in getting fresh cattle started on feed somewhat faster. Blezinger [46] reported that Yeast cultures have a positively affect animal performance and improved feed intake, production and reduced rectal temperatures during summer heat stress in dairy.

Schingoethe et al. [43] used the yeast culture to evaluate its effect on production efficiency during the summer weather. Weekly daytime high temperatures during the 12 wk period averaged 33°C (28 to 39°C). Yeast culture has improved mean daily 4% fat-corrected milk (31.2 and 32.0 kg/d), but percentages of milk fat (3.34 and 3.41) and true protein (2.85 and 2.87) were similar for both diets.

Poppy et al. [47] reported that treatment with yeast culture increased MY 1.18 kg/d, and stated that yeast culture treatment effect of 1.34 kg/d. Yeast culture supplementation increased 3.5% FCM by 1.61 kg/d and ECM by 1.65 kg/d. Milk fat yield and PY results showed significant treatment effects with 0.06 kg/d and 0.03 kg/d, respectively. Poppy et al. [47] reported that during early lactation DMI increased by 0.62 kg/d and during the late lactation studies, average DMI declined significantly. The change in DMI in early lactation may be an opportunity for nutritionists and farm consultants to modify DMI of cows during the critical period of transition to increase intakes and possibly aid in transition health while decreased DMI in later lactation, along with increasing milk production, will increase efficiency of milk production.

Similar finding was reported by Desnoyers et al. [48] who found that yeast products are commonly used around the world for inclusion in diets of production animals. It is thought that yeast products affect the rumen microbial population, causing changes in ruminal VFA production that result in increased milk production as well as an increase in milk fat and milk protein yields from lactating dairy cows [49].

Generally, ADYs have been shown to improve performance, the most consistent effects being an increase in DM intake and milk production 50, 51 and 52]. Schingothe et al. [43] found that feed efficiency defined as kilogram of energy corrected milk / kilogram of DM intake was improved by 7% for cows fed the yeast and concluded that the yeast can improved feed efficiency of heat stressed dairy cows in mid-lactation.

Kholif and Khorshed [53] found that selenized yeast supplementation in the diets of Egyptian lactating buffaloes improved significantly the nutrients digestibility coefficient and increased milk yield, 4% FCM yield, milk protein and solids not fat contents as well as fed efficiency (milk yield/DMI and FCM/DMI) compared with control.

Many nutritionists and researchers agree that dry matter intake is the primary factor in determining milk production in dairy cattle and increases milk production ranged from 3 to 30% when live yeast culture was fed.

Table 4. *Effect of yeast culture on milk production in early lactation dairy cows[a].*

Items	Control	Yeast Culture
Milk Yield, lb/d	68.4	69.5
4% Fat Corrected Milk, lb/d	61.7	64.8 *
Butterfat,%	3.36	3.57 *
Protein,%	3.05	2.97 *

[a] Harris and Lobo [54].* Means within a row are different ($P<0.05$).

Table 5. *Effect of yeast culture on milk production in early lactation dairy cows[a].*

Items	Control	Yeast Culture
Milk Yield, lb/d	68.1	69.8
3.5% Fat Corrected Milk, lb/d	65.7	69.1 *
Butterfat,%	3.27	3.41 *
Protein,%	3.10	3.15 *

[a] Harris and Webb [55]. * Means within a row are different ($P<0.05$).

Table 6. *Effect of yeast culture on milk production in mid-lactation dairy cows from eleven high producing dairy herds[a].*

Items	Control	YC
Milk Yield, lb/d	80.7	82.6 **
150d Adjusted Milk Yield, lb/d [b]	77.1	79.0 **
4% FCM, lb/d	75.8	76.5
Butterfat,%	3.65	3.55 **
Butterfat, lb/d	2.91	2.90
Protein,%	3.15	3.13 **
Protein, lb/d	2.52	2.56 *

[a]Shaver and Garrett [56]. management level milk
* Means within a row are different ($P<0.01$), ** Means within a row are different ($P<0.001$).

Table 7. *Effect of yeast culture on milk production and component yields in early-lactation dairy cows[a].*

Items	Control	Yeast Culture
Milk, lb/day	92.2	93.5 *
Butterfat, lb/day	2.95	3.22 *
Protein, lb/day	2.98	3.15 *
3.5%FCM, lb/day	87.1	92.2 *

[a] Sanchez et al. [57].
* Mean significantly different from control ($P<0.05$).

Table 8. *Effect of yeast culture on milk production in early lactation primiparous and multiparous dairy cows[a].*

Items	Primiparous		Multiparous	
	Control	YC	Control	YC
Milk, lb/day	55.9	61.3 †	85.1	89.0
Butterfat,%	3.88	3.59	3.88	3.82
Protein,%	3.16	3.00 †	3.05	3.05
Lactose,%	4.63	4.66	4.49	4.50
Butterfat, lb/day	2.12	2.18	3.26	3.37
Protein, lb/day	1.74	1.83	2.56	2.69
Lactose, lb/day	2.60	2.87 ††	3.81	4.01

[a] Robinson and Garrett [58]. † Means within a row are different ($P<0.10$). †† Means within a row are different ($P=0.12$).

Table 9. *Effect of yeast culture on milk production and composition of lactation in early-lactation Jersey dairy cows[a].*

Items	Control	YC	*P*-value
Dry Matter Intake, lb/day	26.2	30.2	0.05
Milk, lb/day	47.0	50.5	0.31
Butterfat,%	4.27	4.44	0.28
Protein,%	3.64	3.78	0.15
Lactose,%	4.93	4.99	0.18
Total Solids,%	13.60	13.90	0.10

[a] Dann et al. [22].

Table 10. *Effect of Active Dry Yeast (YEA-SACC® 1026) at the rate 10 g/ head/ day in the diet of lactating baladi cows on daily milk yield, daily FCM 4% and milk energy#.*

Items	Control	Yeast YEA-SACC® 1026#
Daily milk yield (kg)	5.74 ± 0.92	6.19 ± 0.92*
Daily FCM 4% (kg)	4.91 ± 0.76	5.30 ± 0.77*
Milk dry matter (%)	10.90 ±0.17	10.86 ± 0.18
GE (M cal / Kg DM)	5.60 ± 0.02	5.61 ± 0.02
DE (M cal / Kg DM)	5.43 ± 0.02	5.44 ± 0.02
ME (M cal / kg f DM)	5.22 ± 0.02	5.22 ± 0.02
NEM (M cal / Kg DM)	4.49 ± 0.01	4.49 ± 0.01
NEG (M cal / Kg DM)	3.60 ± 0.01	3.61 ± 0.01

* Significant at $P< 0.05$ #Abo-Amer [59].

Table 11. *Milk production of spring-calving and weaning weight of calving heifers supplemented yeast while grazing fescue heifers.*

Parameters	Control	yeast
*Milk, Ib/day	9.6	12.9
**Weaning weight, Ib	382.1	408.9

Blezinger [46]
*Based on weight- suckle-weight measurements,
**Adjusted for birth weight

Table 12. *Quantity and composition of milk Holstein-Friesian cows influenced by preparation Yeast culture*[*].

Parameters	Control	Treated cows
Average 4%FCM	29.55[A]	32.12[B]
4%FCM (1st control)	24.33[A]	29.16[B]
4%FCM (2nd control)	30.81[a]	33.71[b]
4%FCM (3rd control)	30.00[a]	32.81[b]
Milk fat,%	3.91[a]	4.19[b]
Milk protein,%	3.05	3.11
Lactose,%	4.91	5.16
Fat free dry matter,%	11.65	11.72

A, B significant at the level P<0.01
a, b significant at the level P<0.05
[*]Sretenoviić et al. [45].

Studies in dairy cows indicated that supplementation with YC may increase DMI and milk production and improve milk composition. However, several factors affect the response of dairy cows to YC supplementation, such as stage of lactation, type of forage given, feeding strategy (total mixed ration (TMR) or forage and concentrate given separately), and forage: concentrate ratio.

Table 13. *Influence of Yeast strains on DMI, milk production, milk components and net energy for lactation*[*].

DMI and Milk Production	Source		Diet		Benefit	
	Papers	Exp.	Control	Diet +Yeast	Overall%	%Exp.
Dry matter intake (kg/d)						
Alltech[1026]	3	5	19.1	19.5	+2.1	60
Diamond V XP	11	12	20.8	21.1	+1.7	63
CH-Biomate Plus	4	5	22.0	22.1	+0.5	60
Milk Production (kg/d)						
Alltech[1026]	3	5	22.7	23.5	+3.5	80
Diamond V XP	11	12	35.6	36.6	+2.6	83
CH-Biomate Plus	4	5	36.0	37.2	+3.4	100
Milk protein (%)						
Alltech[1026]	3	5	3.17	3.13	-1.3	60
Diamond V XP	11	12	3.12	3.10	-0.6	63
CHBiomate Plus	4	5	3.10	3.04	-2.1	100
Milk fat (%)						
Alltech[1026]	3	5	3.34	3.33	-0.3	40
Diamond V XP	11	12	3.64	3.72	+2.2	75
CH-Biomate Plus	4	5	3.61	3.63	+0.6	40
Diet Energy Density (Mcal/kg DM)						
Alltech[1026]	3	5	1.30	1.32	+1.5	-
Diamond V XP	10	10	1.65	1.68	+1.8	-
CH-Biomate Plus	4	5	1.60	1.63	+1.9	-

[*]Schingoethe et al. [43].

2.3. Effect of Yeast on Productive Performance

Growth responses to YC in meat producing ruminants was variable and ranged from no significant increase in average daily gain to an increase of more than 20% [5]. Panda et al. [16] found that mean daily gain for male calves which were given a daily dose of yeast cell suspension (*Sc)* was greater than that of control (478±40 g vs. 339±28 g). Saleh et al. [18] found that adding ADY increased significantly total gain and ADG by 12.1% and that ADG was significantly increased until 85 days of experiment or until LBW of lambs reached 42.2 kg, thereafter the differences between control and treatment groups in ADG were not significant (p>0.05). These results mean that ADY was efficient with lambs from weaning to approximately 42.2 kg LBW i.e. during first growing stage. In male Barki lambs, EL Ashry et al. [27] found that adding yeast culture to the diet increased ADG from 139.3 to 148.3 g, but the difference was not significant. In growing Buffalo calves, EL-Ashry et al. [21] found that adding live dried yeast to the ration increased ADG from 678.4 to 744.6 g for experiment which extended for 9 months and the differences between both was not significant. In beef cattle the addition of *SC* leads to an increase of live weight depending on the type of diet tested. Growth parameters (average daily gain, final weight, DM intake, feed to gain ratio) have been reported to be improved by daily ADY supplementation in several studies [60, 61].

In rabbits, Habeeb et al. [17] found that average daily gain and feed intake improved by 12,6 and 21.2%, respectively, when ADY was added. Total gain increased also by 12.6% due to ADY supplement to the diet of rabbits. The same authors found that the accumulative ADG for male rabbits fed ration supplemented with either 0.0 or 10.0 g ADY/ kg CFM showed that ADG was significantly increased until LBW of rabbits reached 2.5 kg at the end of the experiment. These results mean that ADY was efficient with rabbits from weaning to approximately 2.5 kg LEW i.e. during growing stage until market age.

An increase in body weight gain and feed efficiency in calves has been seen when YC is added to the diet [62]. Lesmeister et al. [60] fed *S. cerevisiae* in calf starter to Holstein calves from 2 to 42 days of age and found that average daily gain and DMI was higher for the treatment group. Laborde [63] found that calves receiving starter containing yeast culture showed significant increased body weight when compared to other calves at week 6 and 8 and concluded that yeast cultures have been shown to improve growth performance and health of calves when supplemented in the diet. Belknap [64] reported that average daily gain was improved from 2.92 to 3.10 lb/head/day due to feeding yeast culture and feed efficiency was also improved from 6.45 to 5.95 lb feed/lb gain.

Blezinger [46] showed improved weight gains in yeast culture fed cattle grazing fescue pasture and found that Yeast products such as S C may assist in digestion of forages. The same author found also that pregnant heifers appeared to gain slightly more weight if they had access to a free-choice mineral supplement containing yeast when compared to a control mineral. In this particular study, however, the control heifers lost less weight during the interval of calving and peak lactation although this may have some relation to milk production differences. Cow-calf pairs consuming yeast-mineral mixes resulted in increased weaning weights. The gestating heifers appeared to gain slightly more weight if they had access to a free-choice mineral supplement containing yeast than a control mineral. There also appeared to be slightly more body-weight gain for the yeast- supplemented heifers compared to controls during early-spring grass growth.

Midwest Feed Manufacturer [65] revealed that calves on the yeast culture treatment consumed numerically greater dry matter and had a higher average daily gain than the control cattle. Although the control group gained an exceptional 3.69 lb/hd/day, the yeast culture group still out performed by gaining 3.98 lb/head/day (P < 0.01). Moreover, feed efficiency was numerically better for the yeast culture group as well. Once again, when economics are applied to this trial, the net benefit of feeding yeast culture was over 20 cents/head/day.

On other side, Macedo et al. [66] found that differences were not observed (p>0.05) between YC and C sheep on body weight (36.00 vs 36.75 kg), dry matter intake (68.10 vs 69.50 kg), average daily gain (290 vs 300 g/d) and feed conversion (4.22 vs 4.15 g DM/g gain) and concluded that adding yeast culture did not improve production performance of intensively fattened Pelibuey sheep.

Table 14. *Growth and feed performance of male rabbits fed ration with or without ADY supplement[*].*

Items	Control	ADY	Change%
Initial live body weight, g	670 ±10	660±11	-1.5[NS]
Final live body weight, g	2450[b]±20	2660[a]±25	+8.6*
Total weight gain, kg/70 days	1.78[b]±0.02	2.00[a]± 0.01	+12.6**
Daily body weight gain, g	25.4[b]±0.4	28.6[a]±0.3	+12.6**
Daily feed intake(g feed /head)	76.2[b]±7	92.3[a]±9	+21.2**
Daily feed intake (g DM /head)	68.3[b]±5	82. 8[a] ± 8	+32.2**
Feed conversion (g feed /g gain)	3.00[b]	3.20[a]	+6.7*
Feed conversion (g DMI/g gain)	2.69[b]	2.90[a]	-7.8*

[*]Habeeb et al. [17].
[*] Significant at P< 0.05, [**] Significant at P< 0.01 and NS=not significant
Change% = (Treatment meant– control overall mean) x 100 / control overall mean

Table 15. *Effect of Active Dry Yeast (YEA-SACC® 1026) at the rate 10 g/ head/ day in the diet of lactating baladi cows on growth performance of their calves during suckling period[#].*

Growth performance	Without treatment	Treatment with YEA-SACC® 1026[#]
Daily body gain (g) Change%	422.62 ±14.34	523.81±17.39+23.94**
Relative growth rate Change%	4.72±0.23	5.86±0.39+24.19**

Change% = (Treatment meant– control overall mean) x 100 / control overall mean. [**] Significant at P< 0.01 #Abo-Amer [59]

Table 16. *Effect of live dried yeast and yeast culture on performance of growing buffalo calves and economic efficiency.*

Items*	Control	Live DY	YC
Initial weight, kg	112.0±7.1	113.5±11.4	112.0±6.1
Final weight, kg	295.2^{b}±11.2	317.8^{ab}±7.2	322.6^{a}±2.2
Total gain, kg	182.2^{b}±9.3	204.3^{ab}±7.5	210.6^{a}±6.4
DG, g/d	678.4^{b}±34	744.6^{ab}±26	780.3^{a}±23
DMI, kg/d	7.29±0.46	7.30±0.40	7.16±0.26
F. C. kg DM/kg gain	10.73^{a}±0.34	9.64^{b}±0.31	9.18^{b}±0.31
F. C. kg TDN/kg gain	6.49^{a}±0.21	6.17^{ab}±0.20	5.90^{b}±0.20
F. C. kg DCP/kg gain	0.93±0.03	0.94±0.03	0.92±0.03
Return, LE	2.69	3.18	3.29
Economic efficiency	100	118.20	118.96

Means in the same row with differ superscripts differ (P<0.05).
*Al-Ashry et al. [21].

Table 17. *Analysis of animal body weight gain during different periods of the year and stages of production**.

Body weight gain, Ib/mo		
Periods	Control	yeast
July-February Gestation period,	35.8	40.7
February-April Calving-Peak lactation	-63.3	-76.1
April-June Spring Grass Growth	21.8	30.9

*Blezinger [46].

Table 18. *Influence of Yea-Sacc*^{1026} *on DMI, body gain and FE.*

DMI, body gain and FC	Source		Diet		Benefit.	
	Papers	Exp.	Control	Diet + Yea-sacc^{1026}	Overall%	% exp.
DMI (kg/d)	4	8	7.39	7.54	+2.0	75
BWG (kg/d)	4	8	1.25	1.30	+3.7	100
FE(kg gain/kg DM intake)	4	5	0.175	0.179	+1.8	60

*Robinson [2].

Table 19. *Effect of Diamond V Yeast Culture on 28-day performance of low-stress receiving cattle**.

Items	Control	Yeast culture	P-value
Initial LBW	596	596	
Final LBW	703	712	0.01
ADG, lbs	3.69	3.98	0.01
DMI, lbs/head/day	14.78	15.58	0.19
Feed: Gain	4.00	3.91	NS

*Midwest Feed Manufacturer [65].

2.4. Effect of Yeast on Reproductive Performance

Concerning effect of ADY on reproductive performance, Abdel-Khalek et al. [67] revealed that mean period elapsed from parturition until drop of the fetal membranes was lower significantly in buffaloes treated with yeast culture than that of the control animals (5.07 vs 8.14 hours). The interval required for pregnant uterus to return intrapelvic, time of postpartum cervical closure and postpartum uterine horns symmetry was earlier significantly in buffaloes treated with yeast culture (16.7, 24.0 and 25.7 days, respectively) than control group (29.5, 37.7 and 38.0 days, respectively). Dietary treatments resulted in changes in intensity of oestrous behavior of buffalo cows as compared to the control. Average service period length was 0 in treated animals and 12.3 days in control animals; number of cervices/conception was 1.0 in treated buffalos and 1.33 in control and number of days open was 42.7 in treated and 54.2 in control. Buffaloes in treated showed the shortest calving interval 358 days vs 373.2 days in control. Within the first 50 days postpartum buffalo cows in treated with yeasts showed the highest conception rate (83.3%) while control buffalo cows showed the lowest (50%) values. On other side, Bruno et al. [68] studied treatment Multiparous Holstein cows with diet containing 30 g/d of a culture of *Saccharomyces cerevisiae* (YC; *n* = 358) from 20 to 140 d postpartum and found that feeding a yeast culture of *S. cerevisiae* had no impact on reproduction of cows under heat stress.

2.5. Effect of Yeast on Blood Analysis

In lactating buffalo, El-Ashry et al [14] found that total proteins, albumin and globulin concentrations increased insignificantly from 6.64 to 7.09, 3.30 to 3.50 and 3.34 to 3.37g/dl, respectively, when added 10 g/h/day Baker's yeast (containing 10^{9} CFU *Sc* per gram) while GOT and GPT activities were not significantly affected due to treatment. In male lambs, Saleh et al. [18] found that total proteins, albumin, globulin and urea concentrations increased insignificantly while GOT and GPT activities were not significantly affected by the yeast supplementation. In Barky male lambs, El-Ashry et al. [27] reported that serum total proteins, albumin and globulin increased significantly from 7.93 to 8.26, 4.31 to 4.45 and 3.61 to 3.98 g/dl, respectively while urea concentration was not significantly affected with yeast supplements. Stella et al. [52] reported that supplementation of live *Sc* for lactating dairy goats during early lactation period was not affected significantly on plasma NEFA, GOT, GGT and glucose concentrations while treated animals had somewhat higher plasma BHBA.

In rabbits, Habeeb et al. [17] reported that the levels of T_3 and T_4 hormones as well as liver immunity function (i.e. total proteins, albumin and globulin), serum total lipids and triglycerides concentrations increased significantly while urea-N and creatinine (liver function) and cholesterol (heart function) concentrations as well as serum SCOT and SGPT activities (liver function) were not significantly affected with adding ADY to the diet of growing rabbits. Adding ADY caused a significant increase the levels of both T_4 and T_3 hormones which lead to increase the protein and fat biosyntheses. At the same time, ADY improved the appetite of rabbits and increase the digestion of food and consequently improved the utilization of the diet which leads to increase the feed intake which leads to increase the blood metabolites. Consequently, ADY have a positive effect on protein and fat metabolism as well as thyroid hormonal secretions and in the same time had no adverse effect on liver, kidney and heart functions.

Lehloenya et al. [44] found that plasma insulin levels in multiparous Holstein cows fed propionibacteria plus yeast during mid lactation (9–30 weeks) were 30–34% greater than control. The authors concluded that combined feed supplement may hold potential as a natural feed alternative to hormones and antibiotics to enhance lactational performance. In Egyptian native cattle, Ashour et al. [69] found that treatment with yeast supplementation *(Sc^{1026})* produced highly significant decrease in the activity of ALT enzyme and significant increase in the activity of AST enzyme while yeast treatment did not affect concentrations of blood plasma thyroid hormones (T_3, T_4).

The increase in cellulose digestion due to adding yeast may be responsible in the increase of the volatile fatty acids production which is the building blocks for the protein, fat and vitamins synthesis necessary to allow the increase in weight gain and feed efficiency [70]. In addition, yeast is considering the source of B-complex vitamins which represent the digestion and appetite stimulating vitamins. These vitamins make as important co-enzymes like Nicotine-amide Adenine Dinucleotides (NAD) and Flavin Adenine Dinucleotides (FAD) which responsible on biological oxidation to produce the necessary ATP for protein, fat and carbohydrate biosynthesis. Moreover, yeast offers several important nutritional benefits such as naturally high levels of protein (45% minimum), a wide array of amino acids (16 total amino acids), a high concentration of the B vitamins and several minerals necessary for maintaining healthy animals (10 essential and trace minerals) [5].

Yeast produces enzymes which assist animal digestion *as* well as nutrients which feed and stimulate digestive bacteria found in the gut and yeast also improved digestion by providing the digestive enzymes amylase for starch digestion, protease for protein digestion, lipase for fat digestion and cellulase for butterfat synthesis [71]. Apply nutrition yeast for feeding animals as a protein-rich additive, which contains biological pure active substances of microbiological origin, protein, all indispensable amino acids, vitamins, fertnents facilitating digestion and assimilation of fodder, as well as micro and macro elements which enhance immune function and performance [72, 73].

Table 20. *Blood components in male rabbits fed ration with or without ADY supplement.*

#Blood components	Control	ADY	Difference%
	Liver function		
Total proteins (g/dl)	7.01^b±0.3	7.91^a±0.2	$+12.8^{**}$
Albumin (g/dl)	3.45^b±0.1	3.94^a±0.1	$+14.2^{**}$
Globulin (g/dl)	3.56^b±0.1	3.97^a± 0.1	$+11.5^{*}$
GOT (U/l)	23.50±3	24.40±5	$+3.8^{NS}$
GPT (U/l)	22.10±3	23.40±2	$+1.4^{NS}$
	Kidney function		
Urea-N(mg/dl)	32.64±5	33.78±4	$+5.9^{NS}$
Creatinine(mg/dl)	1.00±0.01	1.02±0.01	$+2.0^{NS}$
	Thyroid function:		
T_3(ng/dl)	83^b±4	100^a±5	$+20.5^{**}$
T_4 (ng/ml)	45^b±4	55^a±6	$+22.2^{**}$
	Lipid fractions		
Total Lipids(mg/dl)	360^b±12	396^a±16	$+10.00^{**}$
Total cholesterol (mg/dl)	126±6	120 ±7	4.80^{NS}
Triglycerides (mg/dl)	140^b±6	160^a±5	14.29^{**}

#Habeeb et al. [17].
** Significant at P< 0.01 and NS=not significant.
Difference% = (Treatment meant– control overall mean) x 100 / control overall mean.

Table 21. *Effect of feeding ration with or without ADY supplement (5g/h/d) on some serum parameters in male lambs.*

Item	#Control	ADY
Total protein (g/dl)	9.31	10.61
Albumin (g/dl)	3.85	4.14
Globulin (g/dl)	4.46	6.47
Urea (mg/dl)	32.64	34.78
GOT (U/l)	33.5	34.4
GPT (U/l)	21.3	22.4

#Saleh et al. [18]

Table 22. *Effect of live dried yeast and yeast culture in the diets of growing buffalo calves on blood components.*

Items*	Control	Live DY	YC
Total protein (g/dl)	5.26^b±0.27	5.36^a±0.19	5.89^a±0.16
Albumin (g/dl)	3.27^a±0.07	2.98^b±0.11	3.08^{ab}±0.06
Globulin (g/dl)	1.99^b±0.24	2.23^b±0.17	2.78^a±0.16
Urea (mg/dl)	46.25±2.64	51.25±4.01	51.92±4.19
Creatinine (mg/dl)	1.33±0.07	1.42±0.09	1.38±0.09
Cholesterol (mg/dl)	64.25^a±2.27	58.08^{ab}±4.10	54.50^b±3.98
GPT (U/l)	144.44±15.7	127.97±11.97	141.22±9.59
GOT (U/l)	56.15^a±2.42	50.56^{ab}±2.31	49.33^b±3.36

a, b Means in the same row with differ superscripts differ (P<0.05).
*Al-Ashry et al. [21].

Table 23. *Blood biochemical parameters of Holstein-Friesian cows.*

Parameter	Time of sampling			
	Trial beginning		Trial end	
	control	Treat.	Control	Treat.
Glucose (mg/dl)	3.43	3.42	3.27	3.53
Total billirubin (mg/dl)	2.62	2.23	3.80	2.73
AST, U/L	67.40	58.35	107.32	105.58
ALT, U/L	23.57	21.50	32.20	33.50
Calcium	2.60	2.62	2.35	2.32
Phosphorus	2.07	2.25	2.07	2.08

Sretenoviić et al. [45].

3. Conclusion

In ruminants the beneficial effects of yeast as microbial feed additive on the performance of animals were summarized as:

1. Increases the palatability of feed.
2. Stimulation of rumen microbes and enhanced microbial protein synthesis in the rumen.
3. pH stabilization in the rumen, viable yeast acts as a modulator of rumen pH.
4. Oxygen scavenging from the rumen.
5. Supply of vitamins and minerals to fiber degrading microbes.
6. Reduced ammonia nitrogen in rumen liquor. This can be either due to a reduced degradation of dietary protein, or due to an enhanced use of ammonia by bacteria resulting in an enhanced production of microbial protein or both.
7. Increase rate of fiber digestion and the rate of digesta flow.
8. Improves bacterial count and VFA in rumen liquor, decreases the ratio of acetic to propionic acid, mainly due to higher production of propionic acid.
9. Higher production of carboxy-methyl cellulose activity in rumen liquor.
10. Better ruminal digestion, metabolism and improved nutrient utilization.
11. An increase in feed conversion efficiency and body weight gain in growing animals.
12. Improved milk production in dairy animals.
13. Protection of young animals against enteropathic disorders such as diarrhea by inhibiting the colonization of coliform bacteria in the gut.

These beneficial effects of yeast on the performance of animals are also cleared in Figure (1).

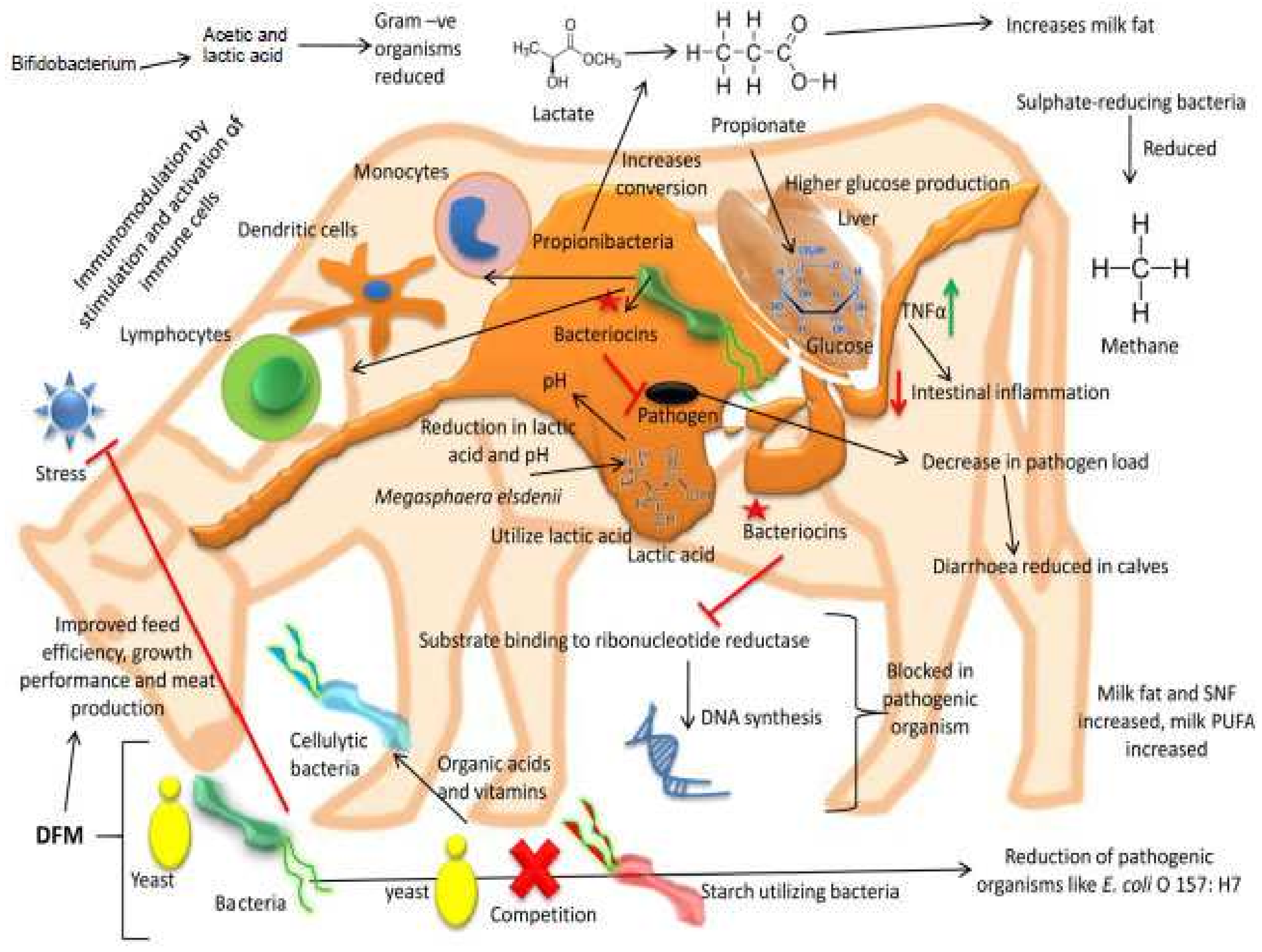

Figure 1. *importance of yeast in ruminants feeding on production and reproduction (According to Rifat et al., 2016 [1].*

Disclosure Statement

No potential conflict of interest was reported by the author.

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