Effects of *Saccharomyces cerevisiae* as dead yeast culture on feed supplement in fattening cattle on growth, intake parameters and nutrient digestibility

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SUMMARY

This study was carried out to study the interest of the incorporation of a dead yeast culture *Saccharomyces cerevisiae* in the concentrate and to see its effect on the growth, the ingestion and the digestibility in vitro of the cattle of fattening. The trial involved a fattening farm containing 20 fattening cattle divided into two homogeneous groups based on initial body weight of 396.4 ± 69.7 kg and 404.6 ± 97.8 kg (Pr. > F) respectively for the control group (C) and the experimental group (Y). The ration used is wheat straw and concentrate. This same ration was distributed for the group Y plus a quantity of 10 g / head / day powder in the concentrate yeast culture. Amount of feed distributed was 3 kg DM wheat straw and 8 kg DM concentrate. This trial lasted 112 days (including adaptation period). The weights are calculated every two weeks with a cattle scale. The refused amounts of wheat straw are also weighed at each control. A significant (P <0.01) increase in the mean total daily gain (ADGT) during the trial was noted 450 g / head. And a significant (P <0.01) increase in the final weight gain (FWG) of 51.6 kg / head for the "yeast" group compared to the "control" group. Feed Intake does not differ with yeast intake. Voluntary feed intake increased for group (Y) at third control. For food conversion, it was similar for group Y and group C with 2.6 ± 0.003, P <0.05, respectively.

KEY WORDS

Bulls, acidogenic diet, yeast, productivity, rumen.

INTRODUCTION

In Tunisia, cattle's breeding is an important component of agricultural production and the national economy. As a result of population growth, the state has always invested in improving the beef sector to meet the ongoing need for red meat. The increase in the number of cattle was at the expense of the available food. This intensification of livestock production has led to excessive use of concentrated feeds and cereals in animal feeds, specifically in the fattening of young bulls. Nevertheless, to succeed fattening, certain conditions must be respected and a minimum of knowledge in breeding is necessary. In order to value their products and improve their incomes, these feeders increase the proportions of concentrated feeds in animal feed without taking into account the risks of metabolic diseases such as acidosis led by this misuse, leading to decreased performance. To prevent this risk, several studies have shown that the use of food additives seems to be an effective solution to limit the risk of latent acidosis in ruminants.

In particular, yeast *Saccharomyces cerevisiae* has been widely studied (Chaucheyras-Durand et al., 2008[1]; Desnoyers et al., 2006[2]; Chaucheyras-Durand & Durand., 2010[3]). They make it possible to maintain good animal health following digestive comfort and thus improve their zootechnic performance.

The objective of this study is to explore the effect of the addition of *Saccharomyces cerevisiae* yeast culture in the feeding of cattle's on in vitro digestibility and zootechnic performance in intensify system.

MATERIALS AND METHODS

Experiment design and measurements

The trial was conducted in north eastern Tunisia for 112 days out of 20 Holstein cattle that were split into two equal groups (10 cattle per group) according to age (15 months), body weight (400 ± 5.8 kg) fed the same ration (composed of wheat straw and concentrate). Each bull of the yeast group (Y) also received 10 g / head / day of yeast *Saccharomyces cerevisiae* powder on the concentrate. The ration consists of wheat straw (5 kg DM / head / day) and 8 kg DM concentrate for the control group (C). For group Y he also received 10 g / head / day of *S. cerevisiae*. The weights were measured every two weeks with a cattle scale. We also calculated the average daily gain (ADG), the total daily gain (ADGT), the final weight gain (FWG) and the feed conversion (FC). The refused quantities of wheat straw are also weighed each control with a balance. It should be noted that the entire amount of concentrate is ingested.

Yeast Culture is *Saccharomyces cerevisiae* yeast grown on a media of sucrose and cane molasses.

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Sampling and chemical analysis

Chemical composition of various feed resources was determined in the animal nutrition laboratory at National Institute of Agronomic Research Tunisia (Table 1). Nutritive values of experimental aliments were determined following the method described by Sauvant (1981)[4]. Samples of diets were dried in a forced-air oven at 105 °C for 24 h to determine DM. Dried samples were then ground through a 1-mm screen. Ground samples were used to determine ash content (450 °C for 8 h), crude fiber (CF) by the method of Weende (AOAC, 1984)[5]. Fat matter was determined by Randhall (AOAC, 1984)[5]. Crude protein was determined by Kjeldahl method (AOAC, 1984)[5].

In vitro fermentation parameters

Determination of the total gas was performed on the contents of the rumen filtered from cattle just after slaughter. In syringes, were put 0.3 g of substrate (concentrate ground to 1 mm), 10 ml of rumen juice and 20 ml of artificial saliva. The syringes are then placed vertically in a water bath at 39 °C; the reading is done each two hours after mixing syringes until a bearing (Orskov and Mc. Donald., 1979)[6].

Statistical analysis

The results of the effects of diets on the measured parameters (weights, adg, feed intake, fc) were subjected to analysis of variance with the GLM procedure of the statistical package SAS (2000)[7] and compared by t-test diff. The statistical model was: $Y_{ij} = \mu + R_i + e_{ij}$

With:

Yij: measured parameter.

μ: overall mean.

R_i: fixed effect of diet (i = 1, 2).

e_{ij}: residual error term.

Significance was declared at P <0.05 unless otherwise declared.

Table 1 - Chemical composition and nutritive value of concentrate and Wheat straw.

Diets	Concentrate	Wheat straw
DM (%)	89.61	89.51
TN (%DM)	1.90	0.64
CP (%DM)	11.9	4
CF (%DM)	6.3	29.3
Asch (%DM)	9	7
OM (%DM)	91	88.3
FM (%DM)	4.3	–
NEA (%DM)	68.5	–
PDIE (g/kg DM)	96	48
PDIN (g/kg DM)	80	22
UF (g/kg DM)	1.06	0.4

DM: dry matter; OM: organic matter; CP: crude protein; FM: fat matter; CF: crude fiber; UF: meat fodder unit: NEA: non extractif azote; PDIE: digestible protein in the liver of energy origin; PDIN: digestible proteins in the liver of microbial when the ration is deficient in degradable nitrogen.

RESULTS AND DISCUSSION

Chemical composition of food

The chemical composition of foods is shown in Table 1. For wheat straw, it has a low crude protein (CP) content (4%) and fodder unit (UF) (0.4 UF / kg DM). The CP content could be considered deficient (Norton, 1994)[8]. For feed concentrate, CP and UF contents are 11.9% and 1.06 UF/kg DM respectively.

Growth (weight) and average daily gain (ADG)

The results showed that supplementation of 10 g yeast *Saccharomyces cerevisiae* per head per day only increase significantly average daily gain: ADG1 P <0.01, ADG4 P <0.04 and ADG6 P <0.06 by 1180 g/d, 570 g/d and 980 g/d respectively for ADG1, ADG4 and ADG6. There was a significant (P <0.01) increase of ADGT during all trial by 450 g/head. And a significant (P <0.01) increase of final weight gain (FWG) by 51.6 kg/head for "yeast" group in comparison with "control" one (Table 2).

Prebiotics can increase the weight gain of ruminants. Prebiotics isolated from healthy goat, when fed to goats for eight weeks, commencing at 75 days of age, resulted in improvement in average body weight by 9% (Apas et al., 2010)[9]. Similar improved growth rate was obtained with a yeast-based commercial probiotic containing *S. cerevisiae* given to growing dairy heifers (Ghazanfar et al., 2015)[10] when fed to pregnant white Dorper ewes on a palm kernel-based diet, increased DM intake and live weight gain during pregnancy, followed by better performance of the lambs during early lactation (Le et al., 2014)[11]. Likewise, a novel bacterial strain isolated in Australia, *P. jensenii* 702, significantly enhanced weight gain in Holstein calves by (25%) during the pre-weaning period and by (50%) during the weaning period (Adams et al., 2008)[12].

Frizzo et al. (2011)[13], based on meta-analysis of 21 publications between 1985 and 2010, concluded that lactic acid prebiotics bacteria in comparisons with and without *L. acidophilus, L. plantarum, L. salivarius, E. faecium, L. caseilparacasei* or *Bifidobacterium* spp., increased body weight gain (standardized mean difference = 0.22822, 95% confidence interval = 0.1006 to 0.4638) and improved feed use efficiency (standardized mean difference = -8.141, 95% confidence interval = -1.2222 to -0.4059) in young calves compared with control groups when probiotics were added to milk replacer, but were ineffective when added to whole milk. In contrast, some studies have reported no effect on calf growth when the diet was supplemented with *L. acidophilus* (Abu-Tarbouch, Al-Saiady & El-Din, 1996)[14]; Cruywagen, Jordaan &Venter, 1996)[15], a mixture of *L. acidophilus* and *L. plantarum* (Abu-Tarbouch, Al-Saiady & El-Din, 1996[14], B. subtilis (Galina et al., 2009)[16], or a mixture of *L. acidophilus, L. lactis* and *B. subtilis* (Galina et al., 2009)[16].

The results found are in agreement with those of Cano Lopez et al. (2010)[17] who found no significant differences between the two treatments at the level of the QGMs (p >0.05), even if numerically it is higher in the animals that received the yeasts. On the other hand, the tests carried out by El'Hassan et al. (1993)[18] and Hancock et al. (1994)[19] on young bulls reported a significant increase in GMQ when animals were fed an acidogenic diet and this could be the cause of the yeast effect which probably helps to limit fermentative disturbances in the rumen generally caused concentrated diets (Desnoyers, 2008)[20].

Table 2 - Effect of yeast culture on growth [Weight (W)] and ADG.

	Group		MSE	Pr. > F
	Control	Yeast culture		
W0 (kg)	396.4±69.7	404.6±97.8	84.9	0.8
W1 (kg)	416.9±68.7	441.5±98.4	84.8	0.5
W2 (kg)	469±68.3	491.2±90.2	80	0.5
W3 (kg)	493.2±69	523.8±93.7	82.3	0.4
W4 (kg)	501.9±69.5	540.6±92.3	81.6	0.3
W5 (kg)	511.2±72.3	542.6±85	78.5	0.3
W6 (kg)	524.9±79.9	570±86.9	83.2	0.2
W7 (kg)	538.5±84.9	587.7±87.1	85.9	0.2
ADG1 (kg/d)	1.46^{b}±1.1	2.64^{a}±0.8	0.9	0.01
ADG 2 (kg/d)	3.72±2.6	3.56±1.4	2.07	0.8
ADG 3 (kg/d)	1.74±0.7	2.33±0.9	0.79	0.1
ADG 4 (kg/d)	0.62^{b}±0.3	1.19^{a}±0.8	0.6	0.04
ADG 5 (kg/d)	0.67±0.5	0.97±0.6	0.58	0.2
ADG 6 (kg/d)	0.99^{b}±0.7	1.97^{a}±1.3	1.07	0.06
ADG 7 (kg/d)	0.97±0.7	1.25±0.7	0.7	0.3
ADGT (total) (kg/d)	1.28^{b}±0.4	1.73^{a}±0.3	0.36	0.01
FWG (kg)	142.1^{b}±46.4	193.7^{a}±30.7	39.7	0.01

a, b: Mean values with different letters in the same row are significantly different; MSE: mean standard error; (±): standard deviation; ADGT: adg during all trial; FWG: final weight gain.

Feed intake and feed conversion (fc)

Voluntary intake increased for the Y group from the third control, but this increase wasn't mentioned a significant difference (P >0.05). For the feed conversion (FC), it was similar for the Y group and the C group which around 2.6±0.003; (P <0.05) (Table 3).

Our results are consistent with those of Desnoyers et al. (2006)[2], who found that the amount ingested does not differ

Table 3 - Effect of yeast culture on feed intake and feed conversion (FC).

	Group		MSE	Pr. > F
	Control	Yeast culture		
Inake1 (g DM/d)	416.9±26.5	444.8±37.2	85.1	0.4
Inake2 (g DM/d)	469±26.1	492.2 ±37.4	79.9	0.5
Inake3 (g DM/d)	493.2 ±26	526.4±34.3	81.7	0.3
Inake4 (g DM/d)	501.9±26.2	543.2±35.6	81.3	0.2
Inake5 (g DM/d)	511.2±26.4	548.6±35.1	79.1	0.3
Inake6 (g DM/d)	524.9±27.5	573.4±32.3	83.9	0.2
Inake7 (g DM/d)	538.5±30.4	585.2±33	85.6	0.2
Inake8 (g DM/d)	152.2±32.3	155.4±33.1	32.2	0.8
FC1	2.602 ±0.005	2.602±0.007	32.2	0.5
FC2	2.604±0.004	2.605±0.006	30.3	0.5
FC3	2.607±0.004	2.608±0.004	31.2	0.4
FC4	2.608±0.003	2.609±0.004	31.01	0.3
FC5	2.609±0.003	2.610±0.003	29.8	0.3
FC6	2.609±0.003	2.610±0.003	31.6	0.2
FC7	2.610±0.003	2.611±0.003	32.6	0.2
FC8	2.610±0.003	2.612±0.003	0.005	0.9

MSE: mean standard error. (±): standard deviation.

Table 4 - The parameters a, b, c and a+b of non linear model of gas production and estimated parameters from gas produced at 24 hours: comparaison of the two trials diets (C) and (Y).

Group	Control	Yeast	MSE	Pr < F
a (ml)	-0.6b ±1.6	1.8a ±1.02	0.4.10-4	<0.0001
b (ml)	140.4^{a} ± 22.4	118.1^{b} ±6.2	0.36.10-5	<0.0001
c (h-1)	0.02^{a} ±0.006	0.032^{b} ±0.003	0	<0.0001
a + b (ml)	139.8^{a} ±24	116.3^{b} ±7.2	–	<0.0001
Prod gas 24 h (ml)	64^{b} ±1.4	68.5^{a}±0.7	1.11	0.05
DMO (%)	77.7^{b}±1.2	81.7^{a}±0.6	0.99	0.05
EM (MJ)	11.38^{b}±0.22	12.08^{a}±0.1	0.17	0.05
VFA (mmol/syringue)	1.47±0.02	8.95±10.4	7.36	0.4
EM (Kcal)	2719.4^{b}±53	2888^{a}±26.5	41.9	0.05

a, b: Mean values with different letters in the same row are significantly different; MSE: mean standard error.
a: amount of gas product (ml) immediately from the substrate; b: potential of gas production; c: speed of gas production.

with the addition of yeast in the diet. This lack of difference can also be explained by the fact that the straw was not really distributed at libitum. The addition of yeast increases the voluntary intake of forage (Majdoub-Mathlouthi et al., 2011)[21]. Mutsvangwa et al. (1992)[22] reported that the addition of yeast to an acidogenic diet contributes to the increase in dry matter intake in beef cattle. On the other hand, other work conducted by Moncoulon & Auclair (2001)[23] even showed a significant decrease of 2.6% in the quantity of dry matter ingested. This trend can be explained by the fact that the yeast effect on ingestion is negligible with a diet rich in concentrated food (high energy intake) because of the metabolic satiety already established following the large production of VFA from carbohydrates quickly fermentable. Thus, the ingestion can probably increase in the case of a ration rich in fiber following the direct action of the yeast on the communities which degrade the fiber within the rumen by its action on the level of oxygen consumption (Marden et al., 2008)[24] and promote fibrolytic activity by accelerating digestive transit and subsequently increasing the amount of dry matter ingested (Chaucheyras-Durand & Durand, 2010)[3].

As the ingested did not differ significantly between animals in two groups throughout the trial, the statistical analysis also showed that there was not a significant difference (P >0.05) in the feed conversion between the two groups respectively (Table 3).

Parameters of rumen fermentative

This study showed (Table 4) that supplementation with yeast *Saccharomyces cerevisiae* didn't affect the facies' parameters fermentation (OMD, VFA's concentration and ME) and also the ammoniacal nitrogen (P >0.05). *In vitro* gas production in 100 glass syringes' ml undergoes a rapid evolution after incubation. After 24 hours of incubation the (C) diet registers the lower significant (P >0.05) amount of gas (64 ml / 0.3 g DM) and is followed by the diet complemented by yeast which gives the largest amount (68.5 ml / 0.3 g).

The kinetic parameters of the *in vitro* fermentation of different substrates, deduced from the exponential model of Orskov & Mc Donald (1979)[6] are mentioned in the table 4. The mixture (concentrated feed + Yeast) is the most rapidly (P <0.0001) fermented by the microbiota ruminal [0.03 (h-1)] followed by concentrated feed) [0.02 (h-1)]. *In vitro* fermentation of two substrates is dependent on a latency phase, indicated by the negative value of the soluble fraction (a) (-0.6 ml / 0.3 g DM and 1.8 ml / 0.3 g DM respectively for "C" and "Y" group respectively), which partly explains its low degradation. This latency phase seems to be due to the time required for microorganisms to adhere and colonize dietary fiber.

Regarding the other parameters, the values predicted mention that the digestibility of the organic matter (OMD) of the concentrated feed alone is 77.7% and 81.7% for the mixture (concentrate + *Saccharomyces cerevisiae)* respectively with a significant effect on this parameter (P <0.05). It's the same for ME released by the different substrates (P <0.05) (11.4 MJ *vs.* 12.1 MJ respectively for "C" and "Y" group respectively). As well as VFA recorded, the respective values were 1.5 mmol / syringe for the concentrated feed alone *vs.* 8.9 mmol / syringe for concentrated feed + *Saccharomyces cerevisiae* with a significant difference (P <0.05).

In general, the positive effect of yeast supplementation on rumen pH increased with the percentage of concentrate in the diet and with the Dry Matter Intake (DMI) level. Similarly, yeast increased the concentration of VFA with increased CP concentration and DM.

CONCLUSIONS

This study allowed us to specify the interest of yeast culture as a food additive to modulate microbial fermentations of rumen and improve performance cattle in production. The results show that supplementation can improve moderately the performance animal (growth, feed conversion). And it appears crucial to explore the mechanisms of action of the *Saccharomyces cerevisiae* metabolic activities and intra-ruminal lipid and nitrogen metabolism of ruminants.

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CONFLICT OF INTEREST STATMENT

No potential conflict of interest was reported by the authors.

References

1. Chaucheyras-Durand F., Walker N., Bach A. (2008) Effects of active dry yeasts on the rumen microbial ecosystem: Past, present and future. Anim Feed Sci Techno. 145, (1), 5-26. https://doi.org/10.1016/j.anifeedsci.2007.04.019.
2. Desnoyers M., Duvaux-ponter C., Bertin G., Roussel S., Tessier J., Piquerel P., Giger-Reverdin S. (2006) Effets de l'apport de levures (*Saccharomyces cerevisiae* CBS493.94) sur le comportement et la réactivité émotionnelle de chèvres laitières en acidose subclinique. Renc. Rech. Rumin. 13. Page 137.
3. Chaucheyras-Durand F., Durand H. (2010) Probiotics in animal nutrition and health. Lallemand Animal Nutrition, Blagnac, France. Benef Microbes. 1(1):3-9.
4. Sauvant D. (1981) Alimentation des ruminants, Ed. INRA, France. Prévision de la valeur énergétique des aliments concentrés et composés pour les ruminants. Prévision de la valeur nutritive des aliments des ruminants (Eel. C. nimarquilly.), ZlS7-258, INRA Publications. Roule de Saiut-Cvr, 78000 Versailles, (France). 580 p.
5. AOAC, Association of Official Analytical Chemists. (1984) Official Methods of Analysis. 14th Ed. AOAC, Washington, DC.
6. Orskov E.R., Macdonald I. (1979) The estimations of protein degradability in the rumen from incubation measurements weighted according to rate passage. J. Agr Sci Cambridge. 92, 499-502. https://doi.org/10.1017/S0021859600063048.
7. SAS User's Guide. (2000) Statistics, 8 Ed, SAS Inst., Inc., Cary, NC.
8. Norton B.W. (1994) Tree Legumes as dietary supplements for ruminants. In Gutteridge R.C. and Shelton H.M.: Forage tree legumes in tropical agriculture. CAB International, 192-201.
9. Apás A.L., Dupraz J., Ross R., González S.N., Arena M.E. (2010) Probiotics administration effect on fecal mutagenicity and microflora in the goat's gut. J. Biosci and Bioengineering, 110, (5), 537-540. https://doi.org/10.1016/j.jbiosc.2010.06.005.
10. Ghazanfar S., Anjum M., Azim A., Ahmed I. (2015) Effects of dietary supplementation of yeast (*Saccharomyces cerevisiae*) culture on growth performance, blood parameters, nutrient digestibility and fecal flora of dairy heifers. J. Anim and Plant Sci. 25, (1), 53-59, http://www.thejaps.org.pk/docs/v-25-01/08.pdf.
11. Le O., Mcneill D., Klieve A., Dart P., Ouwerkerk D., Schofield B., Callaghan M. (2014) Probiotic Bacillus amyloliquefaciens Strain H57 Improves the Performance of Pregnant and Lactating Ewes Fed a Diet Based on Palm Kernel Meal. In: ISNH/ISRP. International Conference, Canberra, Australia. https://espace.library.uq.edu.au/view/UQ:354091.
12. Adams M., Luo J., Rayward D., King S., Gibson R., Moghaddam G. (2008) Selection of a novel direct-fed microbial to enhance weight gain in intensively reared calves. Anim Feed Sci Technol. 145, (1), 41-52. https://doi.org/10.1016/ j.ani feed sci.2007.05.035.
13. Frizzo L., Zbrun M., Soto L., Signorini M. (2011) Effects of probiotics on growth performance in young calves: A meta-analysis of randomized controlled trials. Anim Feed Sci Techno. 169, (3), 147-156. https://doi.org/10.1016/j.anifeedsci.2011.06.009.
14. Abu-Tarboush H.M., Al-Saiady M.Y., El-Din A.H.K. (1996) Evaluation of diet containing lactobacilli on performance, fecal coliform, and lactobacilli of young dairy calves. Anim Feed Sci Technol. 57, (1), 39-49. https://doi.org/10.1016/0377-8401(95)00850-0.
15. Cruywagen C., Jordaan I., Venter L. (1996) Effect of Lactobacillus acidophilus supplementation of milk replacer on preweaning performance of calves. J. Dairy Sci. 79, (3), 483-486. https://doi.org/10.3168/jds.S0022-0302 (96)76389-0.
16. Galina M., Ortiz-Rubio M., Delgado-Pertiñez M., Pineda L. (2009) Goat kid's growth improvement with a lactic probiotic fed on a standard base diet. Options Méditerranéennes. Série A, Séminaires Méditerranéens. (85), 315-322. http://om.ciheam.org/article.php?IDPDF=801024.
17. Cano Lopez G., Villalba Mata D., Philippe F. (2010) Comparaison de l'effet de l'apport en levures Saccharomyces cerevisiae vivantes ou inactivées sur les performances de croissance de bovins en engraissement. Renc. Rech. Ruminants, 2010, 17.
18. El Hassan S.M., Newbold C.J., Wallace R.J. (1993) The effect of yeast in the rumen and the requirement for viable yeast cells. Anim. Prod. 54: 504 (Abstract).
19. Hancock D.L., Brake A.C., Montgomery A.L., Dominey J.R., Mattingly C.A, Cecava M.J. (1994) Influence of yeast addition and Compudose implantation on feedlot performance and carcass characteristics of growing and finishing steers. J. Anim. Sci. 72 (Suppl 1):300.
20. Desnoyers M. (2008) Intérêt de l'apport de levures sur la susceptibilité à l'acidose et lecomportement alimentaire du ruminant. Thèse doctorat. Institut des sciences et Industries duvivant et de l'environnement (AgroParisTech). 387 pages.
21. Majdoub-Mathlouthi L., Chammaoui A., Kraiem K. (2011) Effet de la levure *Saccharomyces cerevisiae* sur les performances des taurillons à l'engraissemnt alimentés à base de fourrages pauvres. Lives Res for Rural Development. 23(11).
22. Mutsvangwa T., Edwards I.E., Topps J.H., PATERSON G.F.M. (1992) The effect of dietary inclusion of yeast culture (*Yea-Sacc*) on patterns of rumen fermentation, food intake and growth of intensively fed bulls. Anim. Prod. 55:35-40.
23. Moncoulon R., Auclair E. (2001) Utilisation du BIOSAF® Sc 47 pour la production de viande de taurillon. Rapport de Recherche. pp 17.
24. Marden J P., Julien C., Monteils V., Auclair E., Moncoulon R., Bayourthe C. (2008) How does live yeast differ from sodium bicarbonate to stabilize ruminal pH in high-yielding dairy cows? J. Dairy Sci. 91:3528-3535.