

## Chemical composition and nutritive value of torula yeast (*Candida utilis*), grown on distiller's vinasse, for poultry feeding

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The object of this work was to determine dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), ash, metabolizable energy and retention of nutrients of the torula yeast from distiller's vinasse, for its use in poultry feeding. The torula yeast from vinasse had average value of 43.24 % CPB, 1.60 % CF, 1.20 % EE, and 7.15% ash. There were average values of apparent metabolizable energy (AME) of 2811 kcal/kg, corrected by the nitrogen balance (AMEn) of 2362 kcal/kg and coefficient of metabolization of the energy (CMGE) of 58 %. The apparent retention of the dry matter was 65.20 %, and of 53.81 % for nitrogen and of 63.46 % for total phosphorus. It was concluded that it is feasible to use distiller's vinasse as basic substrate for the production of torula yeast, by not having differences in the chemical composition and the nutritional value of this protein source; thus, it can be used in poultry feeding.

Key words: yeast, metabolizable energy, retention of nutrients, broiler chickens.

Feeds production for animal use is supported by the utilization of grains, mainly soybean and corn, which are also part of human feeding. Currently, these grains are evaluated for their utilization in the production of biofuels (ethanol and biodiesel). This fact has brought about current assessments on the energy-feed dilemma (Pérez 2007). Thus, it is needed an endless search for alternative feeds permitting higher availability to balance animal diets (Dale 2007).

Among the alternative or non-conventional feeds, there are the microorganisms, belonging to the different groups of yeasts, bacteria, fungi, and algae, which are important sources of protein, vitamins, minerals, and factors that enhance the growth (Miyada 1990). Out of them, yeasts are considered the most favorable for their use in animal feeding.

Most of the yeast species are spread in different media. However, the species *Candida utilis* is characterized for its great power of adaptation to the changes in the growth and multiplication conditions. Besides, it has high content of proteins and excellent profile of essential amino acids (Saura *et al.* 2003). Out of these advantages, Cuba developed a productive technology of torula yeast that is used as basic substrate of the distiller's vinasse. The reduction of the organic load from this residual and, at the same time, the obtainment of a valuable and scarce product (protein source) is the greatest benefit of this process (Otero *et al.* 2007).

The chemical composition of the yeasts may vary according to different factors: substrate, concentration of salts, degree of aeration, number of successive washes to remove impurities and drying technology (Miyada 1990). Thus, the substrate is considered the most determinant factor in the variation of the chemical composition of the yeasts (Álvarez and Valdivié 1980). Therefore, it is important

to know its nutritive value for a more efficiently in animal feeding.

In this respect, Rostagno *et al.* (2007) noted that for the elaboration of rations for monogastric animals is fundamental to figure out the nutritional value of the feeds, represented by the content of amino acids, the coefficients of digestibility of the nutrients and the energy values.

The metabolizable energy is the best expression of the energy available in the feeds devoted to poultry. Albino *et al.* (1992) and Nunes (2003) stated that in order to be successful in the formulation of poultry rations is very important to figure out the energy content of the feeds, which allows to supply the adequate amount of energy in each stage of the life cycle.

The objective of this work was to determine DM, CP, CF, SE, ash, metabolizable energy, and retention of nutrients from the torula yeast, grown on distiller's vinasse, for its utilization in poultry feeding.

### Materials and Methods

The torula yeast (*Candida utilis*) was obtained through a process of aerobic fermentation, using distiller's vinasse as substrate. It was from the industrial complex "Antonio Sánchez" in the Cienfuegos province, Cuba.

The chemical analysis was performed in the Laboratory of Animal Nutrition of the Husbandry Department of the Federal University of Minas Gerais (UFMG, Brazil). Dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), and ash were determined according to AOAC (2006).

For the determination of the apparent metabolizable energy (AME) and the apparent metabolizable energy corrected by the nitrogen balance (EMAn), the traditional method of total collection of feces was used

(Albino *et al.* 1992) in broiler chickens. The animals were allocated in metallic battery cages and receiving a starter ration, formulated according to Rostagno *et al.* (2005) up to 21 d of age. Later, they were transferred to the metabolism room in the period from 21 to 29 d of age, using 100 male chickens Cobb-500, with average weight of 663 g, distributed randomly into two treatments and five repetitions, with ten birds per experimental unit. The treatments consisted of a control diet, and another diet substituting 20 % of the macronutrients of the control diet by torula yeast from vinasse, according to the methodology of Rostagno *et al.* (2007).

The experimental period lasted 9 days, five of adaptation and four for the total feces collection. The birds were given water and feed ad libitum and 24 h of light. The composition and supply of the control diet (table 1) were formulated according to Rostagno *et al.* (2005). The average temperature throughout the experimental period was of 26 °C and the average humidity of 60 %.

Table 1. Percentage composition and contributions of the control diet in humid basis (HB)

Ingredients	%
Corn meal	55.0
Soybean meal (46% CP)	38.5
Soybean oil	2.40
Dicalcium phosphate	2.00
Calcium carbonate	0.995
Common salt	0.42
DL-methionine	0.25
L-lysine	0.15
Premixture of vitamins*	0.100
Premixture of minerals**	0.050
Coline chlorite	0.080
Cocciostate	0.055
<b>Contributions calculated, %</b>	
Crude protein	22.4
Metabolizable energy, Mj/kg	2951.0
Calcium	1.02
Available phosphorus	0.48
Lysine	1.21
Methionine+cystine	0.85

\*Premixture of vitamins- (per kg of feedstuff)- Vit. A y D3- 15 000 000 IU; Vit. E-15 000 IU; Vit. B1- 2.0g; Vit. B2- 4.0g; Vit.B6- 3.0g; Vit. B12- 0.015g; Nicotinic acid -25g; Pantho-  
tenic acid -10g, Vit.K3- 3.0g; Folic acid<sup>1</sup>.0g; Coline- 250g; Selenium-100mg; Antioxidant-10g

\*\*Mineral premixture- (per kg of feedstuff)- Fe-80g; Cu-10g; Co-2g; Mn-80g; Zn-50g; I-1g

The feed intake was controlled daily and the feces collection was performed twice a day (every 12 h) to avoid the fermentation. The feces were collected in trays covered with nylon and they were stored at -10 °C in

previously identified bags up to the end of the collection period. At the end of the experiment, the total amount of feed consumed per repetition was determined. The feces were unfrozen, weighed, and homogenized to withdraw aliquots (100g) from each repetition. They were dried in forced ventilation oven at 60 °C, for 72 h. Later, the samples were ground through sieves of 1 mm, to analyze and determine DM and nitrogen from the rations and the feces, according to Silva (1990). The gross energy of the rations and of the feces was determined by means of a adiabatic calorimetric pump.

The variables calculated were: apparent metabolizable energy (AME), apparent metabolizable energy corrected by the balance of nitrogen (AMEn), apparent retention of the DM (ARDM), of the phosphorus (ARP) and of nitrogen (ARN), according to the formulas of Matterson *et al.* (1965):

$$\text{AME of the (EE) or (RR) (kcal/kg DM)} = \frac{\text{GE ingested} - \text{GE excreted}}{\text{MS ingested}}$$

$$\text{AME of the feed (kcal/kg DM)} = \frac{\text{AMERR} + (\text{AMEER} - \text{AMERR})}{\text{g /g of substitution}}$$

$$\text{AMEn of the ER or RR (kcal/kg DM)} = \frac{\text{GE ingested} - (\text{GE excreted} + 8.22 * \text{NB})}{\text{MS ingested}}$$

$$\text{AMEn of the feed (kcal/kg DM)} = \frac{\text{AMEnRR} + (\text{AMEnRE} - \text{AMEnRR})}{\text{g/g of substitution}}$$

where,

GE= Gross energy

NB = Nitrogen balance = N ingested – N excreted

ER = Experimental ration

RR = Reference ration or control

$$\text{ARDM (\%)} = \frac{\text{DM ingested} - \text{DM excreted} \times 100}{\text{DM ingested}}$$

$$\text{ARN} = \frac{\text{N ingested} - \text{N excreted}}{\text{N ingested}}$$

$$\text{ARP} = \frac{\text{P ingested} - \text{P excreted}}{\text{P ingested}}$$

Out of the data of AMEn and the GE, it was calculated the coefficient of metabolization of the gross energy (CMGE), according to the formula of Vieira *et al.* (2007):

$$\text{CMGE} = (\text{AMEn/GE}) \times 100$$

The data were analyzed with descriptive statistics. The mean, standard deviation and variation coefficient were determined through INFOSAT (Balzarini *et al.* 2001).

## Results and Discussion

The chemical composition of the torula yeast from vinasse is shown in table 2. Average value of crude protein content of 43.24 % was found. This range was according to the several types of yeasts, and may vary from 27 to 62 %, according to the genus and the type of strain (Miyada 1990). The value of crude protein is comparable with that reported for torula yeast from final molasses of sugarcane (Valdivié 1976, Piloto and Macías 2005 and Saura *et al.* 2008) and for soybean meal (40 to 44 %, according to NRC 1994). However, it should be considered that the value of a protein source is in

the balance of its amino acids, particularly the essential amino acids. According to González *et al.* (1974), 16 % of the protein from torula yeast is in the form of non-protein nitrogen (NNP), and 84 % is protein nitrogen. Therefore, not all the protein in the yeasts is used by the animals, especially by the monogastrics. Thus, the determination of the biological value of the proteins is more important in the yeasts.

Table 2. Chemical composition of the torula yeast from vinasse

Indicators, %	Mean	SD	CV, %
Dry matter	91.65	0.05	0.05
Crude protein	43.24	0.08	0.18
Ether extract	1.20	0.004	0.33
Crude fiber	1.60	0.01	0.63
Mineral matter	7.15	0.02	0.28

The DM in the torula yeast from vinasse was similar to that reported by Valdivié (1976), Tillán (1983) and Miyada (1990) when evaluating other yeasts. In this research, the contents of EE (1.20 %) and CF (1.60 %) had values similar to that of the yeasts. The EE varied between 2 and 6 %, the CF reached relatively low values, usually lower than 1 % (Carrillo 1971 and Miyada 1990).

The mineral material confirmed the report of Miyada (1990) and Moreira *et al.* (1998) about the high content of the inorganic fraction of the yeasts. This could vary from 4 to 14 %, according to the substrate and the salts added in the fermentation process.

The mean values of apparent metabolizable energy (AME) and that corrected by the balance of nitrogen (AMEn), as well as the coefficient of metabolization of the energy (CMGE), are provided in table 3.

Table 3. Values of metabolizable energy (AME and AMEn) and coefficient of metabolization of the energy (CMGE) of the torula yeast from vinasse

Indicators	Mean	SD	CV, %
GE, kcal/kg	3984.0	0.06	0.65
AME, kcal/kg DM	2811.0	48.0	1.10
AMEn, kcal/kg DM	2362.0	75.0	3.17
CMGE, %	58.29	1.85	3.17

The GE reached values similar to those of Longo *et al.* (2005), when assessing alternative protein ingredients for broiler chickens, including the yeasts.

The AME of the torula yeast from vinasse had average value of 2811 kcal/kg of DM, superior to the report in Feedstuffs (2010) for the torula yeast (2160 kcal/kg) and for the soybean meal (2240 kcal/kg, 44 % CP). Nevertheless, this value may vary due to factors such as

the substrate where the yeast grows, the method to determine the AME, the age of the birds, among others.

The AME was 16 % superior to the AMEn, which is normal when the values of AME are determined in growing birds, according to Nery *et al.* (2007). This is due to the higher retention of nitrogen occurring in this stage for the deposition of protein tissue, and it is accentuated when a correction is made due to the endogenous and metabolic losses.

Leeson and Summers (2001) and Nunes (2003) stated the need for correcting the values energy estimated by the balance of nitrogen, because it is impossible to assure during a metabolism assay that all the birds have the same growth rate. According to Leeson and Summers (2001), the values of AME, when corrected by the nitrogen balance, always tend to be lower when the birds have positive nitrogen balance. That is, there were not weight losses or muscular tissue degradation, which accounts for the lower values of AMEn reported in this work.

The CMGE (58 %) for the torula yeast from vinasse is low, compared with the 5 % for corn, according to Vieira *et al.* (2007). This indicated that the yeast does not have a composition favoring the energy use in birds. Longo *et al.* (2005), when evaluating different protein sources in the pre-initial stage (1-7 d of age), found in broiler chickens 49.97 % of CMGE for the yeast *Saccharomyces*. Similar values were found by Nunes (2003) when evaluating the meat and bone meal (51.1 %), the feather meal (55.49 %), and the meal of incubatory residues (60.09 %), associating these values to particle size, CP, EE and mineral content in these feeds.

The apparent retention of nutrients is shown in table 4. The ARDM was 7 % inferior to the report of Tillán (1983), when evaluating the torula yeast from molasses in the feeding of broiler chickens. Álvarez and Valdivié (1980) also observed notable decline in the apparent retentions of dry matter (ARDM) and nitrogen (ARN), starting from 20 % of inclusion of torula yeast from the

Table 4. Apparent retention of dry matter, nitrogen and phosphorus of the torula yeast from vinasse (% dry basis)

Indicators	Mean	SD	CV, %
ARDM	65.20	1.58	1.10
ARN	53.81	1.80	3.34
ARP	63.46	0.91	1.43

molasses.

These low retentions of dry matter and nitrogen can be associated with the content of nucleic acids, which diminishes the utilization of the total nitrogen in the yeasts (Tillán 1983). Also, they can be related to the high content of ashes, which reduces the concentration of energy and amino acids in the diet (Shurson and Al-

ghandi 2008), and to the type of industrial processing (Álvarez *et al.* 1981).

According to Brewer *et al.* (1978), it could also be associated with the fact that the relative proportion of the essential amino acids has higher significance in the optimum performance of the animals rather than the absolute amount of one amino acid. This is due to the complex and antagonist relation between the amino acids, which affect the absorption and provoke adverse effect on the nitrogen utilization.

By knowing the richness in phosphorus of the yeasts it is important to know the availability of this element for the animals. In this study, it was found an ARAPt of 63.46 %, superior to the phosphorus retention in corn (58.3 %), and to the 40.6 % in sorghum, according to Godoy *et al.* (2005). Consequently, the inclusion of torula yeast from vinasse in corn-soybean diets will permit better balance of available phosphorus, and thus decrease in the excretion of this nutrient to the environment.

Gao *et al.* (2008) attributed this higher phosphorus retention to the activity of the phytases present in the yeasts. Therefore, the inclusion of torula yeast from vinasse in corn-soybean diets will permit better balance of available phosphorus, and thus decline in the excretion of this nutrient to the environment.

It is concluded that the chemical composition of the torula yeast grown on distiller's vinasse was similar to others used in animal feeding. The apparent metabolizable energy reached values of 2811 kcal/kg of DM, and the corrected by the nitrogen balance of 2362 kcal/kg of DM, superior to the soybean meal. The digestibility of the nutrients of 65 % shows that their utilization as protein source in poultry diets should be combined with other sources of greater digestibility or nutritive value, in a way that better balance and assimilation of nutrients can be attained by the birds.

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### References

- AOAC 2006. Official Methods of Analysis (18th Ed.). Ass. Off. Anal. Chem. Arlington, VA
- Albino, L.F.T., Rostagno, H.S. & Tafuri, M.L. 1992. Utilização de diferentes sistemas de avaliação energética de alimentos na formulação de rações para frangos de corte. Rev. Soc. Bras. Zootecnia. 21: 1037
- Álvarez, R. J. & Valdiviá, M. 1980. Metabolizable energy and nitrogen retention in torula yeast diets for broilers. Cuban J. Agric. Sci. 14:57
- Álvarez, R.J., Cabello, A. & Otero, M. 1981. A note on the biological value and digestibility of Cuban torula yeast dried by different methods. Cuban J. Agric. Sci. 15:71
- Balzarini, G. M., Casanoves, F., Di Rienzo, I. A., González, L. A. & Robledo, C. W. 2001. INFOSTAT software estadístico. Manual de usuario. Versión 1. Córdoba, Argentina
- Brewer, M. F., Halvorson, H.D. & Clark, H.E. 1978. Nitrogen retention of young men who consumed selected patterns of essential amino acids at a constant nitrogen intake. Amer. J. Clin. Nutr. 31: 786
- Carrillo, O. 1971. Yeast digestion in pigs. Thesis submitted towards the degree of M. Sc. Biol. Instituto de Ciencia Animal. Universidad de La Habana.
- Dale, N. 2007. Evaluación de la calidad de los ingredientes de alimentos para Aves. Industria avícola. 44: 40. Available: <[http://www.engormix.com/s\\_articulos\\_view.asp?art=376](http://www.engormix.com/s_articulos_view.asp?art=376)> [Consulted: 12/05/07]
- Feedstuffs. 2010. Reference Issue & Buyers Guide. Volume 80, number 38. p.16
- Gao, J., Zhang, H.J., Yu, S. H., Wu, S. G., Yoon, I., Quigley, J. Y., Gao, P. & Qi, G. H. 2008. Effects of yeast culture in broiler diets on performance and immunomodulatory functions. Poult. Sci. 87:1377
- Godoy, S., Hernández, G. & Chicco, C. 2005. Contenido de fósforo fitico, actividad fitásica y absorción del fósforo de cereales en pollos. Rev. Cient. FCV-LUZ. 6:505
- González, N., Kopecky, J. & Votruba, I. 1974. Determinación de la proteína real en la levadura forrajera. Rev. ICIDCA. 8:36
- Leeson, S. & Summers, J. D. 2001. Nutrition of the chicken. 4 Ed. Guelph: University Books. 591pp.
- Longo, F.A., Menten, J. F. M., Pedroso, A. A., Figueiredo, A. N., Racanicci, A. M. C., Gaiotto, J. B. & Sorbara, J. O. B. 2005. Diferentes fontes de protein na dieta pré-inicial de frangos de corte. Rev. Bras. Zootec. 34: 121
- Matterson, L.D., Potter, L.M. & Singsen, E.P. 1965. The metabolizable energy of feed ingredients for chickens. Res. Report 7:3
- Miyada, V.S. 1990. A levedura seca na alimentação de suínos. Suinocultura. Ed. Sociedade Brasileira de Zootecnia. Piracicaba: FEALQ. p. 39
- Moreira, I., Andreatt, F.L., Furlan, A.C., Scapinello, C. & Martins, N.E. 1998. Viabilidade da utilização da levedura de recuperação (*Saccharomyces spp.*), seca pelo método spray-dry, na alimentação de leitões em fase de creche. Rev. Bras. Zootec. 27: 319
- Nery, L.R., Albino, L.F.T., Rostagno, H.S., Campos, A.M.A. & Silva, C.R. 2007. Valores de energia metabolizável de alimentos determinados com frangos de corte. Rev. Bras. Zootec. 36: 1354
- NRC. 1994. National Research Council. Nutrient requirements of poultry. 9th rev. ed. Natl. Acad. Press, Washington, DC.
- Nunes, R.V. 2003. Digestibilidade de nutrientes e valores energéticos de alguns alimentos para aves. Universidade Federal de Viçosa. Tese de Doutorado em Zootecnia. Universidade Federal de Viçosa. 113 pp.
- Otero, M.A., Saura, G., Martínez, J.A. & Almazán, O.A. 2007. Fodder yeast production: a new approach for distillery vinasses treatment. Proc. Int. Soc. Sugar Cane Tech. 26:1127
- Pérez, M. P. 2007. El huevo más que un alimento. Seminario internacional sobre nutrición del huevo. CD-ROM. Hotel Nacional de Cuba. La Habana, Cuba
- Piloto, J.L. & Macias, M. 2005. Studies on the chemical composition of Cuban torula yeast grown on sugar cane molasses or residues from vinasses. Rev. Computadorizada de Producción Porcina 12:111

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- Rostagno, H.S., Albino, L.F.T. & Donzele, J.L. 2005. Tabelas brasileiras para aves e suínos: composição de alimentos e exigências nutricionais. 2 Ed. Ed. Universidade Federal de Viçosa. 186 pp.
- Rostagno, H.S., Bünzen, S., Sakomura, N.K. & Albino, L.F.T. 2007. Avanços metodológicos na avaliação de alimentos e de exigências nutricionais para aves e suínos. Rev. Bras. Zootec. Suplemento Especial. 36: 295
- Saura, G.L., Otero, M. A., Martínez, J. A., Garrido, N. C. & Bermúdez, I. P. 2008. Producción de levadura forrajera a partir de vinazas de destilerías, una opción ambiental. X Congreso Internacional sobre Azúcar y Derivados. Memorias. La Habana, Cuba
- Saura, G.L., Otero, M.A., Martínez, J.A, Fundora, N., Reyes, E., Vasallo, M.C. & Almazán, O.A. 2003. Propagation of yeast biomass from distillery wastes. Process and product evaluation. Int. Sugar J. 105:36
- Shurson, G. & Alghamdi, A. 2008. Quality and new technologies to create corn co-products from ethanol productions- In Distillers Grain in the US and international Livestock and poultry industries. Published by Iowa State University. Iowa USA. 231 pp.
- Silva, D. J. 1990. Análise de alimentos: métodos químicos e biológicos. Ed. Universidade Federal de Viçosa. 165 pp.
- Tillán, J. 1983. Algunos indicadores bioquímicos-fisiológicos que afectan la utilización del nitrógeno en aves alimentadas con levadura torula. PhD Thesis. Instituto de Ciencia Animal. La Habana, Cuba
- Valdivié, M. 1976. Utilización de la levadura torula, harina de colza y harina de girasol en las dietas para pollos de engorde. PhD Thesis. Instituto de Ciencia Animal. La Habana, Cuba
- Vierira, R. O., Rodríguez, P. B., feitas, R. T. F., do Nascimento, G. A. J., da Silva, E. L. & Hespanol, R. 2007. Composição química e energia metabolizável de híbridos de milho para frangos de corte. Rev. Bras. Zootec. 36:832

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The structure of cell wall of yeasts (genus *Saccharomyces*) is one of the factors that determine their health-promoting properties connected to the presence of  $\beta$ -glucans and mannoprotein. The aim of the study was to determine the influence of glycerol as a carbon source on structural polymers of cell wall ( $\beta$ -glucan and mannoprotein) of probiotic yeasts *Saccharomyces cerevisiae* var. *boulardii* and brewer's yeasts *S. cerevisiae* R9. Significant increase of the percentage of polysaccharide content in the cell wall dry weight of *S. cerevisiae* R9 brewer's yeasts was noted (in the range of 10–20 %) after The chemical composition, and hence eventually the nutritive value, of the so produced SCP was affected by the propagation conditions, especially the substrate feeding rate and the inoculum size at the beginning of fermentation. Under optimized propagation conditions, the amino acid composition of both yeast strains exhibited a good quality exhibiting most of the essential amino acids (for fish and poultry), especially lysine and sulfur containing amino acids. The biomass, especially that of *S. cerevisiae*, contained many essential vitamins of the B group. Moreover, the biomass of both yeasts c Request PDF on ResearchGate | Chemical composition and nutritive value of *Brassica juncea* canola for poultry and the effect of enzyme supplementation. | Canola breeding program undertaken to improve meal quality has led to the development of canola quality (i.e., low glucosinolate, low erucic acid) form of *B. juncea*, a mustard species known for its pure yellow seed coat. Under Western Canadian conditions, *B. juncea* suffers... The nutritive value of canola meals was investigated with broiler chickens fed corn/soybean meal-based diets containing 30% of meals from 4 to 18 d of age. A significantly lower ( $P < 0.05$ ) BWG was observed in birds fed the *B. juncea* diet when compared with those fed the conventional black-seeded *B. napus* canola (479 vs. 515 g/bird).