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A proximal chemical analysis in craft beer solid waste, and its acceptance in sows

Análisis químico proximal en residuos sólidos de cerveza artesanal y su aceptación en cerdas

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ABSTRACT

A proximal chemical analysis on organic solid waste was performed from three types of craft beer and its acceptance in the feeding of sows was detected. To determine the humidity, a stove was used at 105 °C for 24 hours, the ethereal extract was determined using a Soxhlet equipment and ethyl ether as solvent, the determination of ash content was made by calcination in a muffle at 700 °C; for crude fiber analysis, acid digestion with 0.2 N sulfuric was used, the crude protein was determined using a Kjedahl equipment in order to analyze the total nitrogen, the nitrogen-free extract, was determined by the difference of 100 % minus the addition of moisture, ash, fat, protein, and fiber. The total of digestible nutrients was computed by adding the digestibility of all organic compounds, and acceptance of the food was made through offering it as a first option to the sows from two farms. The organic solid residues of craft beer contain an average 2.43% of ash, 1.99% of ethereal extract, 4.91% of crude fiber, 64.20% of nitrogen-free extract, 10.91% of crude protein, and 73.47% of total digestible nutrients. The food achieved an acceptance of 83.4% when it was offered alone and 100% combined with other ingredients.

Keywords: Malting barley, bromatological composition, food for pigs, beer waste.

RESUMEN

Se realizó un análisis químico proximal en residuos sólidos orgánicos de tres tipos de cerveza artesanal y detecto su aceptación en la alimentación de cerdas. Para determinar humedad de residuos de cerveza se utilizó estufa a 105°C durante 24 horas, el extracto etéreo se determinó con equipo Soxhlet y éter etílico como solvente, la determinación de cenizas se realizó por calcinación en mufla a 700°C, para fibra cruda se utilizó digestión ácida con ácido sulfúrico 0.2 N, para proteína cruda se empleó equipo Kjedahl, el extracto libre de nitrógeno se determinó por diferencia del 100% de la suma de humedad, cenizas, grasa, proteína y fibra. El total de nutrientes digeribles se realizó mediante la sumatoria de la digestibilidad de los compuestos orgánicos. Los residuos sólidos orgánicos de cerveza artesanal contienen en promedio 2.43% de cenizas, 1.99% de extracto etéreo, 4.91% de fibra cruda, 64.20% de extracto libre de nitrógeno, 10.91% de proteína cruda y 73.47% de nutrientes digestibles totales. La determinación de la aceptación del alimento se realizó ofreciéndolo como primera opción a las cerdas de dos granjas. El alimento tuvo una aceptación de 83.4% cuando se ofreció solo y del 100% combinado con otros ingredientes.

Palabras clave: Cebada maltera, bromatológico, alimentos para cerdos, residuos de cerveza.

INTRODUCTION

The production of craft beer generates solid waste in significant quantities, which are not given adequate use, due to the difficulty of managing a product with high moisture content (80 %). In addition to this, the polysaccharide content of these residues makes them very susceptible to microbial growth, which causes their deterioration in a short term; therefore, it is necessary to apply a drying process for its conservation and storage.

The craft brewing industry has been increasing, due to the taste for this type of beer, in 2016; this type of industry grew 56 %, adding more than 400 small businesses (Villamil, 2016). The Mexican craft brewery produces at least 15,000 liters per year and it is usually made with four ingredients: barley malt, water, hops and yeast. However, despite the fact that the demand for artisanal beer has grown, there are disadvantages, such as a higher amount of taxes than major brewers, higher production costs due to the volume of raw material purchases and import of inputs from Germany, France or USA; since the national producers work for the big brewers (Bernáldez, 2013).

It is known that the production of beer in our country begins after the first years of Spanish colonization. However, malting barley began its development in Mexico in 1906, looking for to encourage the cultivation of this cereal to meet domestic needs (Galarza *et al*., 2006). According to data from the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA, according its acronyms in Spanish) during 2016, malting barley production increased by 33.4%, compared to the previous year with an annual production of 965 thousand 332 tons; Guanajuato is the entity that produced the most with 372,167 tons (SAGARPA, 2017). Malt barley differed from forage barley because of its lower protein content, with an average of 11.5 and 14 % respectively (Schwentesius, Aguilar and Gómez, 2004).

Grains such as barley, as well as most of the ingredients used during the brewing process are regularly sold wet and these are used in the feeding of cattle, horses, pigs and sheep. As for the cost of production of pigs, food represents between 70 and 80% of total expenses (Gabosi, 2012: Rodríguez, Rodríguez and Villamil 2012), which is why alternatives are sought for the formulation of new foods, being organic solid waste from the brewing industry is a viable option.

The voluntary consumption of the food requires the gustatory stimulation, through direct effects of neurophysiological processes that achieve a sensory perception (taste, smell, texture, and gastrointestinal signals), helping the animals to relate the food with their nutritional quality; which also influences the appetite stimulus, as a result of the education of preferred tastes within a learned behavior that leads to an improvement in the productivity of the animals (López, 2014). The "umami" taste is highlighted in pigs as a pleasant and characteristic taste of protein sources, of animal or vegetable origin, which causes a sensory stimulation generated by some amino acids, peptides and nucleotides, among other compounds (Roura *et al*., 2008).

The present investigation seeks to perform a proximal chemical analysis in solid waste of craft beer with the purpose of detecting its acceptance in the diet of reproductive sows.

MATERIAL AND METHODS

During the development of this research, organic solid waste from three types of beer: clear, amber and dark were ground and sieved with a 4.2 mm mesh, stored in plastic containers at room temperature (between 24-26 °C) for further analysis. Each test was performed in triplicate.

Determination of dry matter (MS). Approximately 2g of sample was weighed on porcelain capsules and placed in an oven at 105 °C for 24 hours, until constant weight was achieved according to the provisions of *NMX-F-257-S-1978*.

Determination of ashes (C). 3g of sample was weighed in porcelain capsules at constant weight, to subsequently pre-calcine the sample on a grid and bring it to a total calcination in the muffle at 700 °C for 2 h. Once the samples were cold, they were weighed to determine the ash percentage according to *NMX-F-066-S-1978*.

Determination of ether extract (EE). The test was performed in accordance with *NMX-F-089-S-1978*. Approximately 2g of the previously dried sample was weighed at 60 °C and determined with the Soxhlet equipment with ethyl ether as solvent for a period of 6h; the fat was then recovered in flasks previously dry to constant weight and the rest of the ether was removed at 100 °C; the flask was then weighed with fat and the percentage of ether extract was obtained by weight difference.

Determination of crude fiber (FC). The degreased malt samples obtained in the ether extract determination were used. The standard *NMX-F-613-NORMEX-20*03 was used, which indicates the acid digestion with 0.2N sulfuric acid, washed with hot water and basic digestion with 0.2N sodium hydroxide. The determination of the crude fiber was made based on the weight of the ashes of the digested sample.

Determination of crude protein (PC). It was carried out in Kjedahl equipment for the analysis of total nitrogen according to the *NMX-F-608-NORMEX-2011 . 1* g of sample was used for the digestion with sulfuric acid; after digestion it was taken to an automatic distiller. Distilled the sample was valued with 0.1 N hydrochloric acid. The factor 6.25 was used, which was multiplied by the percentage of nitrogen obtained for the calculation of total protein.

Determination of nitrogen-free extract (ELN). The content of ELN was calculated with the following formula:

% ELN = 100- (%humidity +%ash +%fat +%protein +%raw fiber)

Table 1. Results obtained from the bromatological analysis applied in organic solid waste of three types of craft beer: light, amber and dark

Type of beer	*%MS*	*%C*	*%EE*	*%FC*	*%ELN*	*%PC*	*%TND*
Light	86.13	2.37	1.94	4.93	65.98	10.91	75.96
Amber	83.17	2.69	1.82	4.91	62.85	10.90	71.41
Dark	84.05	2.24	2.22	4.89	63.77	10.93	73.06
Average	84.45	2.43	1.99	4.91	64.20	10.91	73.47

Determination of Total Digestible Nutrients (TND). It was calculated by adding all the organic compounds from the proximal analysis in the feed (crude proteins, ether extract, crude fiber and nitrogen-free extract), multiplied by its digestibility coefficient using the following formula:

$$TND = PC * 80 + ELN * 90 + FC * 50 + (EE * 90 * 2.25)$$

The acceptance test of the food. The three solid residues of beer previously dried and ground were mixed and offered as the first choice of food in the morning to 30 sows in reproductive stage, chosen at random and divided into two groups of 15 each; from two different farms in the municipality of Salvatierra, Gto., identified as farm 1 (G1) and farm 2 (G2). The first test was to provide one kilogram of ground solid waste (RSM1) to the animals as the only option in the morning. During the second test the animals were given the ground solid waste mixed with a commercial concentrate with 40% crude protein (RSM2) in a formulation already established in each farm; sorghum was replaced by solid waste and the result was also offered a Kg as the only option in the morning. The results were recorded as acceptance when the food was consumed in the first 15 minutes, or rejection when after 15 minutes had not been consumed the food offered.

A multivariate analysis of variance (ANOVA) was performed to compare the results of the bromatological analysis of the solid waste of barley malt of the three types of beer (light, amber and dark), as well as to compare the data of their acceptance or rejection of the food offered alone and as a member of a balanced feed, offered to sows in two different farms.

RESULTS AND DISCUSSION

The bromatological analysis of the solid residues of barley malt is presented in table 1.

Although the malting process of the barley for the elaboration of the three types of beers (light, amber and dark) is different, the percentage of the components (MC, C, EE, FC, PC and TND) in the residues do not present a significant difference between them ($P > 0.05$); indicating that the different procurement processes do not alter the chemical composition of the final product.

The results found in this study for protein of 10.91 % are similar to those reported by Callejo (2002), for the barley grain with a range of crude protein of 10 to 11 %; however, this value is lower than that reported by Enrique *et al*., (2014) of 12.08 %, of the NRC (2001) of 12.4 %

Table 2. Acceptance and rejection of ground solid waste (RSM1) and ground solid waste in a balanced feed (RSM2), offered to reproductive sows

Farm	RSM1				RSM2			
	Accepted		Rejected		Accepted		Rejected	
	No. de cerdas	%	No. de cerdas	%	No. de cerdas	%	No. de cerdas	%
G1	12	80.0	3	20.0	15	100	0	0
G2	13	86.6	2	13.3	15	100	0	0
Total	25	83.4	5	16.6	30	100	0	0

and of Castillo *et al*., (2012) of 13.16 %; suggesting that residues in the beer production process are affected in the chemical composition of the barley grain protein.

In this study, an average of nitrogen-free extract of 64.2 % was found, while Castillo *et al*., (2012) reported 69.1 % for the barley grain, and as for the TND, differences were also found; in the analysis performed an average of 73.47 % was observed, while the NRC (2001) reports 82.7 % in the barley grain. This may be due to the fact that carbohydrate is the material that is required in brewing beer.

In relation to the acceptance test of these residues, applying two treatments in two farms (G1 and G2) of the municipality of Salvatierra Gto, after having carried out the acceptance test it was observed that RSM1 in the G1 was accepted by 12 animals and rejected by three, and in G2 it was accepted by 13 and rejected by two; being a total rejection of 16.6 %. The test with RSM2 in the two farms (G1 and G2) was accepted by 100 % of the animals (Table 2).

According to the statistical analysis, it was found that there is a significant difference ($P < 0.05$) between the acceptance and rejection variables of the RSM1 and RSM2, for a 95 % reliability in the two farms (G1 and G2).

Wet beer residues have regularly been used in cattle feed (Mussatto, Dragone and Roberto 2006). Recent research has shown that brewery derivatives can be an option for animal supplementation, achieving adequate daily weight gains (GDP), similar to other energy supplements commonly used by producers, such as corn and sorghum; in addition to reducing the costs of feeding livestock and increasing profits (Rivas *et al*., 2017).

The acceptance of solid waste ground by the sows is explained by the characteristics of the cereal and by the content of dextrins, maltose, glucose and maltotriose, produced during the fermentation process by hydrolytic enzymes, such as alpha-amylase, beta-amylase and beta-glucanase (Badui, 2006). The umami taste is a flavor similar to that of meat and it is found in foods rich in proteins and fermented products. In addition, hydrolysis generates sweet, salty, bitter, acid and umami flavors in foods, acting synergistically to increase the perception of flavor (Badui, 2006, López, 2014). According to Roura (2011) pigs have a high sensitivity for umami taste, which increases voluntary consumption. They also have a positive preference for some amino acids that are not perceived as umami by humans, such as: glutamine, alanine, asparagine, proline, aspartic acid, glutamic acid, tryptophan and threonine.

It is considered necessary more tests to evaluate the economic and nutritional impact of wet beer residues in all stages of the pig that increase weight and feed conversion, aspects that can be reviewed as continuity of this work.

CONCLUSION

The different production processes of craft beer (light, amber and dark) do not cause significant differences in the chemical composition between the three types of waste; maintaining an important amount of nutrients that can be used for animal feed, which is related to a very good acceptance by reproductive sows.

BIBLIOGRAPHY

BADUI D. 2006. Química de los alimentos. México: Pearson Educación. p 738, ISBN: 970-26-0670-5

BERNÁLDEZ CA. 2013. Cerveza artesanal en México: ¿Soberanía cervecera y alimentaria?. *Culinaria*. 6:56-63. Disponible: http://web.uaemex.mx/Culinaria/seis_ne/PDF%20finales%206/cerveza%20artesanal%20ok.pdf.

CALLEJO GM. 2002 Industrias de cereales y derivados. Ediciones Mundi-Prensa. Madrid. p 400, ISBN: 9788484760245.

CASTILLO OF, Rodríguez SR, Prieto GF, Román GA. 2012. Características física y química proximal de paja, grano y almidón de cebada de la variedad esmeralda. *BioTecnología*. 16: (3), 9-20. ISSN 0188-4786. Disponible en: https://smbb.mx/wp-content/uploads/2017/10/Revista_2012_V16_N3.pdf.

GABOSI H. 2012. Alimentación porcina y los costos. Universidad Austral, Argentina: Centro de Información y de Actividades Porcinas. p 1-8 Disponible: http://www.ciap.org.ar/ciap/Sitio/Archivos/Alimentacion%20porcina%20y%20los%20costos.pdf.

LÓPEZ ONC. 2014. El gusto por el sabor salado. Perspectivas en nutrición humana. *Escuela de Nutrición y Dietética*. 16 (1) 99-109. ISSN 0124-4108. Disponible en: http://www.scielo.org.co/pdf/penh/v16n1/v16n1a8.pdf.

MUSSATTO SI, Dragone G, Roberto IC, 2006. Brewers' spent grain: generation, characteristics and potential applications. *J. Cereal Sci*. 43:1-14. ISSN: 0733-5210. DOI:10.1016/j.jcs.2005.06.001.

NMX-F-257-S-1978. Preparación de la muestra y determinación del porcentaje de humedad y de materia seca en té y productos similares. Normas mexicanas. Dirección general de normas. 08 agosto 1978. http://www.colpos.mx/bancodenormas/nmexicanas/NMX-F-257-S-1978.PDF.

NMX-F-066-S-1978. Determinación de cenizas en alimentos. Normas mexicanas. Dirección general de normas. 03 noviembre 1978. http://www.colpos.mx/bancodenormas/nmexicanas/NMX-F-066-S-1978.PDF.

NMX-F-089-S-1978. Determinación de extracto etéreo (método Soxhlet) en alimentos. Normas mexicanas. Dirección general de normas. 03 noviembre 1978. http://www.colpos.mx/bancodenormas/nmexicanas/NMX-F-089-S-1978.PDF.

NMX-F-613-NORMEX-2003. Alimentos- Determinación de Fibra cruda en Alimentos- Método de Prueba. 20 agosto 2003. https://app.vlex.com/#WW/search/jurisdiction:MX/nmx+f+613+normex+2003/WW/vid/692486885.

NMX-F-608-NORMEX-2011. Alimentos-determinación de proteínas en alimentos-método de ensayo. 12 septiembre 2011. http://www.colpos.mx/bancodenormas/nmexicanas/NMX-F-068-S-1980.PDF.

NRC. 2001. Nutrient Requirements of Dairy Cattle. National Academy Press, Washington D.C. Washington D.C.: National Academy Press. ISBN 0-309-06997.

RIVAS JM, Herrera MR, Santos DR, Herrera C, Escalera V, Martínez G. 2017. Bagazo húmedo de cervecería como sustituto de cereales en la suplementación de ovinos. *Abanico Veterinario*. 7(3):21-29. Disponible en: http://dx.doi.org/10.21929/abavet2017.73.2.

RODRÍGUEZ MG, Rodríguez CB, Villasmil AK. 2012. Costos de producción en explotaciones porcinas de ciclo completo en el Municipio Mara, estado Zulia, Venezuela. *Revista Venezolana de Gerencia*. *17*(*60):*709-729 ISSN 1315-9984. http://www.redalyc.org/articulo.oa?id=29024892008.

ROURA E. 2011. Obtenido de El gusto en el cerdo (parte II): que sea umami: Consultado en 17 de enero de 2018 Obtenido de El gusto en el cerdo (parte II): que sea umami: Consultado en 17 de enero de 2018 https://www.3tres3.com/nutricion/el-gusto-en-el-cerdo-parte-ii-que-sea-umami_3204/ .

ROURA E, Humphrey B, Tedo G, Ipharraguerre IR. 2008. Unfolding the codes of short-term feed appetence in farm and companion animals. A comparative oronasal nutrient sensing biology review.*Can. J. Anim. Sci*. 88 (4): 535-558. http://www.*pubs.aic.ca/doi/abs/10.4141/CJAS08014*.

VILLAMIL V. 2016. Cervecerías artesanales crecen 56% en 2016 y llegan a 400: Acermex. El Financiero, págs. Consultado el 12 de abril de 2017 Consultado el 12 de abril de 2017 http://www.elfinanciero.com.mx/economia/cervecerias-artesanales-crecen-56-en-2016-y-llegan-a-400-acermex.html .