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Quadratic effect of the protein content of a solid state fermented baby banana (*Musa acuminata* AA) treated with whey

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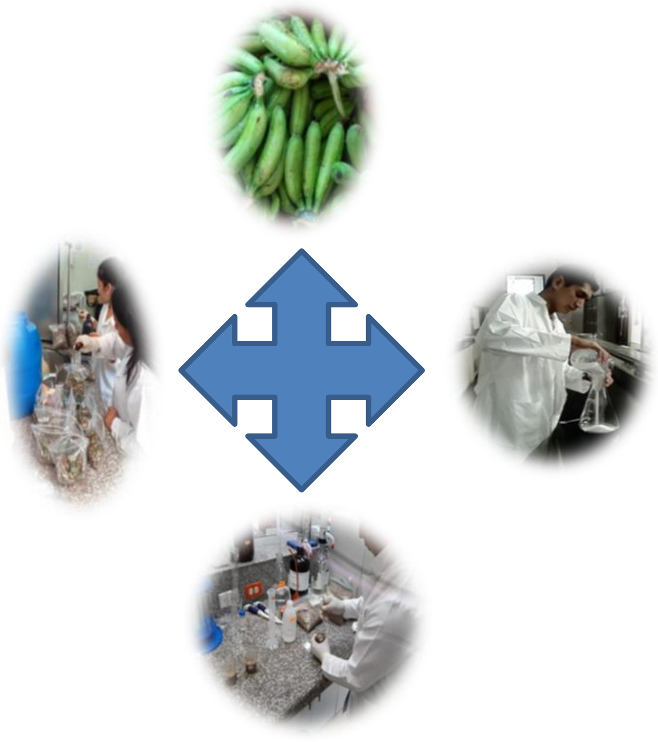
Graphical Abstract



Abstract

To predict the protein content in a solid state fermented (SSF) baby banana (*Musa acuminata* AA) of waste inoculated with whey, using linear, quadratic, cubic, compound, exponential and logistic regression models. In SSF samples of 8 days post-processing, inoculated with 0, 1, 5 and 10 ml of whey/kg of mixture, the protein content of the SSF was determined. For data processing the SPSS version 22 software was used. A quadratic effect of the protein content was observed in the SSF of baby banana (R^2 = 0.99; Y = 6.372 + 2.003*X - 0.138*X^2). In conclusion, the use of increasing doses of whey as an inoculant of the SSF of baby banana showed a quadratic effect on the protein content.

Key words: *waste baby banana, protein enrichment, SSF, nonlinear regression*

Introduction

The high cost of raw materials for the elaboration of balanced diets for animals increases production costs. In the formulation of balanced diets, one of the largest items constitutes the protein sources. In this environment, it is necessary to use technologies that improve the protein content of animal feed (Caicedo et al 2019a).

In the Amazon Region of Ecuador there are many food sources that have a good energy content, high fiber and low protein (Sánchez et al 2018). However, it is known from the literature that the processing of energy raw materials through biotechnology processes such as SSF increase the protein content through the action of microorganisms (Borras-Sandoval et al 2015; Fonseca-López et al 2018). The objective of this research was to predict the protein content in a solid state fermented (SSF) baby banana (*Musa acuminata* AA) of waste inoculated with whey, using linear, quadratic, cubic, compound, exponential and logistic regression models.

Materials and Methods

Location

The present study was carried out in the Bromatology Laboratory of the Amazon State University, located in the Pastaza canton, Pastaza province, Ecuador, this area has a humid subtropical climate, with rainfall varying between 4000 and 4500 mm annually, altitude of 900 m.a.s.l., average relative humidity of 87% and temperatures ranging between 20 and 28 ºC (INAMHI 2014).

Preparation of the SSF of baby banana

For the preparation of the SSF of baby banana, rejection fruit was collected, in a green state, washed, and ground in a knife mill with 1 cm sieve. Next, a clean plastic was placed on a concrete floor and all the components of the SSF (raw banana, molasses, calcium carbonate, vitaminized pecutrin, wheat powder and whey) were mixed homogeneously at room temperature of 24 ºC for 5 minutes, after this time they were introduced in Ziploc plastic bags with a capacity for 1 kg sealed for 8 days under shade at room temperature. Silage formulation is shown in (Table 1).

Table 1. Preparation of baby banana silages

Raw materials, % inclusion	**Formulation 1**	**Formulation 2**	**Formulation 3**	**Formulation 4**
Chopped green baby banana	77	76	72	67
Wheat dust	20	20	20	20
Molasses	2	2	2	2
Vitaminized Pecutrin	0.5	0.5	0.5	0.5
Calcium carbonate	0.5	0.5	0.5	0.5
Whey	0	1	5	10
TOTAL	**100**	**100**	**100**	**100**

Protein determination in baby banana SSF

To carry out the protein analysis, 1 kg of random sample was collected from the microsyls of 8 days of fermentation. The protein was extracted according to the techniques of the AOAC (2005).

Statistical analysis

For the analysis of the protein data in the silages, linear, quadratic, cubic, compound, exponential and logistic regression models were used, using the statistical software SPSS version 22.

Results and Discussion

The quadratic model ($Y = a + bx + cx^2$) presented the best fit for the evaluation of the protein content of baby banana SSF inoculated with different levels of whey (Table 2, Figure 1).

Table 2. Coefficients of the quadratic regression model for baby banana SSF protein

	Non-standardized coefficients		Standardized Coefficients		
	B	Standard error	Beta	t	Sig.
Whey ml/kg	2,003	,047	2,794	42,456	,015
Whey ml/kg **2	-,138	,005	-1,990	-30,242	,021
(Constant)	6,372	,077		82,699	,008

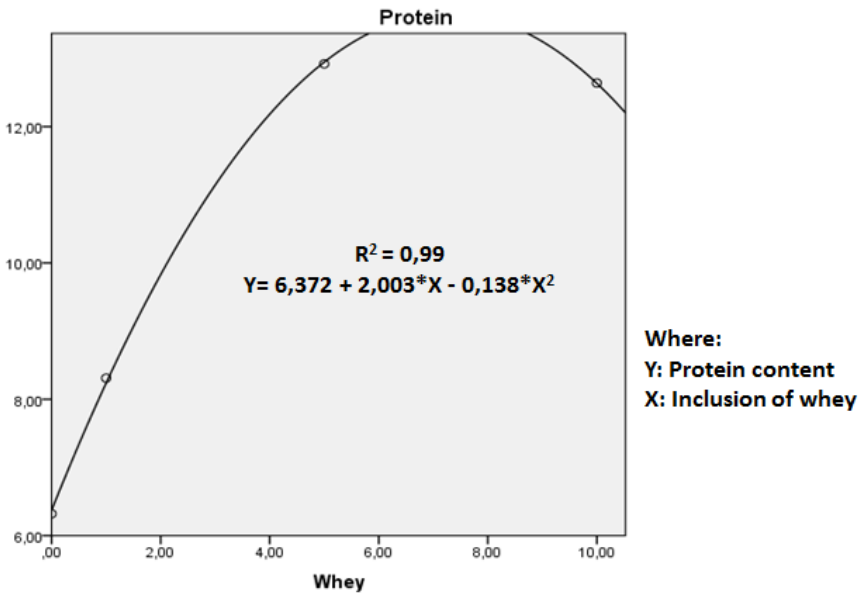


Figure 1. Quadratic regression curve for protein

The response for the protein content in baby banana silage was quadratic at a concentration between (0 and 10% of whey inclusion), this is because the successfully preserved silage achieves a good colonization (Suman et al 2015; Ritala et al 2017) and early stabilization with which microbial activity slows down, avoiding losses of DM (Dolezal and Zeman 2005; Tyrolová et al 2017). This is due to the favorable temperature and pH conditions of the silage material (Romero et al 2017; Zhou et al (2019). In this regard, Caicedo et al (2019bc) using as taro tubers and baby banana substrates, inoculated with natural yogurt, on day 8 of fermentation, they obtained a significant protein increase, compared to the raw material in its natural state.

Conclusions

The use of increasing doses of whey as an inoculant of the SSF of baby banana showed a quadratic effect on the protein content

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