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Silage of by-products of orange. Evolution and modification of quality of fermentation

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SUMMARY - Silage of orange by-products (mainly the peel) is tested in micro-silos, carrying out and checking 4 treatments: addition of 4% formic acid, of dehydrated sugarbeet pulp, of 25g/kg salt. The results show that due to their high water content, orange by-products ferment very easily; it is the salt that better limits fermentation but it is the formic acid which gives the better silage.

RESUME - "Evolution fermentaire de l'ensilage de pulpe d'orange". L'ensilage des sous-produits de l'orange (principalement peau) est experimenté en micro-silo - 4 traitements sont realisés: avec addition d'acide formique 4%, de pulpes de betteraves déshydratées, de sel 25 g/kg - et controlé. Les résultats montrent que, du fait de leur grande richesse en eau, les sous-produits de l'orange sont très fermentescibles; c'est le sel qui limite le plus les fermentations mais c'est l'acide formique qui donne le meilleur ensilage.

Introduction

The use as animal feed of by-products of orange obtained in the canning industry has been described by several authors (Martinea and Medina, 1982. Ocio et al. 1989).

One of the most important aspects raised by this study is the evolution of its fermentative quality, in which the concentration of volatile fatty acids (Villalón and Suárez, 1961; Bryant, 1973) and the pH are of prime imprtance (Kapelle and Postman, 1952).

It is the inexistence of data referring to the silage of by-products of orange which has led to this work, in which an attempt is made to study the fermentation and the best way of achieving a good fermentation through the use of additives (Pinheiro Machado, 1985).

Material and methods

The experiment was carried out on what remained, mainly peel, after washing and extraction of the segments of the fruit. This material was put in microsilos and samples taken at days 0, 2, 4, 7, 12, 24, 36, 48 and 100.

At the end of this process we analysed the lots to which formic acid had been added at 4% (F) (62.5 g/kg), dehydratedpulp of beetroot (P) (62,5 g/kg) and sodium chloride (S) (25 g/kg) and a fourth lot as a control.

The following were determined: dry matter, pH, lactic, acetic, propionic, isobutyric and butyric acids according to the methods proposed by Canale et al. (1984).

The results were evaluated by means of simple regression analysis, using variance analysis (Least Square Difference) to differentiate between the lots.

Results and analysis

Lactic acid concentration underwent a progressive increase throughout the silaging process (Table 1), greater in the first days and always within the limits described by Catchpoole and Henzell (1971) as being optimum in a lactic fermentation, that is between 3 and 13%. These results are in accordance with those of Penderson et al. (1973); Gouet et al. (1979) and Luis and Ramirez (1985),

Table 1. Mean concentration of fermentation parameters in silage of orange by-product (% dry matter).

Day of sample	Lactic acid	Acetic acid	Propionic acid	Isobutyric acid	Butyric acid	p^H	Dry matter
0	2,30	2,00	0,03	0	0,06	2,09	21,60
2	8,96	5,33	0	0,06	0	5,39	22,78
4	9,03	6,70	0	0,06	0	6,76	18,29
7	6,83	6,06	0,03	0	0,20	4,29	20,10
12	7,30	6,26	0	0,03	0,33	6,62	18,42
24	7,33	4,90	0,03	0,03	0,06	5,02	23,55
36	8,96	5,46	0,20	0,06	0,03	5,75	18,46
48	8,36	6,43	0,33	0,13	0,36	7,25	19,32
100	8,90	5,73	0,43	0,10	0,46	6,75	22,13

Table 2. Mean composition (% dry matter) and variance analysis (LSD) in various treatments of orange by-product silage.

Treatment	Lactic acid	Acetic acid	Propionic acid	Isobutyric acid	Butyric acid	p^H	Dry matter
(level of signif.)	(0,474)	(0,611)	(0,971)	(0,801)	(0,801)	(0,615)	(0,402)
Sodium chloride	8,26*	11,83*	0,46*	0,13*	0,10*	2,48*	22,17*
Formic acid	10,23*	6,96*	0,46*	0,13*	0,13*	2,71*	20,28*
Beetroot pulp	12,30*	11,53*	0,50*	0,16*	0,13*	2,73*	17,95*
Control	13,80*	12,06*	0,56*	0,16*	0,13*	2,98*	22,55*

who mention that there is an initial accelerated development of lactic acid bacteria with a maximum concentration after six days, stabilizing thereafter. Acetic acid (Table 1) increased parallel to lactic acid but never showed a higher concentration.

Similarly, isobutyric and butyric acids increased slightly from very reduced initial concentrations to reach values of between 0.10 and 0.46%, satisfactory levels to obtain good silage (Table 1).

The concentration of total volatile acids was always below that of lactic acid during the silage process as recommended by Catchpoole and Henzell (1971). These results coincide with those of Cervera et al. (1985), who note that orange pulp ferments rapidly and maintains high levels of lactic acid production because of the high concentration of soluble carbohydrates in its composition (15% according to Fernandez et al. (1984).

An analysis of the influence which the different additives have on the silage (Table 2) showed that the great production of lactic acid corresponded to the control (13.80%), a level which even surpassed the optimum limit for traditional fodder crops (13%) described by Catchpoole and Henzell (1971), this confirming the high fermentative potential of the product studied. The quality of lactic acid produced by the addition of formic acid (10.23%) was not high, although the differences between the concentration of lactic acid and total volatile acids were smaller with this treatment than with the others realized, 7.68% as opposed to 12.32, 12.52 and 12.91%, basically because the production of acetic acid in the lots treated with formic acid was noticeably less.

The smallest quantity of butyric acid appeared in the lot treated with sodium chloride (0.10%) and did not reach the level advisable for conventional fodders (0.20%), although the volatile acid concentrations as a whole were no higher than the levels of lactic acid, as is recommended by Catchpoole and Henzell (1971). No significant difference was noted between the different treatments for this parameter.

Acetic acid concentration (Table 2) was lowest with formic acid (6.9%), much below the concentration of lactic acid. Thisis because formic acid inhibits the proteolytic flora, a fact which improves fermentation (Castle and Watson 1970a and 1973b; Chamberlain et al. 1982; Hederson et al. 1982; Alomar and Marambio, 1984 and Rooke et al. 1988).

As regards propionic acid (Table 2), the values for the four lots showed no significant differences, the concentrations fluctuating between 0.56% in the control and 0.46% in the treatments with formic acid and sodium chloride, respectively. The lowest values for isobutyric acid were obtained with the treatments with formic acid and sodium chloride (0.13%).

It can be concluded that, in general terms, treatment with sodium chloride gives a better fermentation. Although it does not produce the maximum concentration of lactic acid, it is responsible for the lowest values for acetic acid and total volatile acidity (7.68%), even if the differences between lots were not significant. These results are in agreement with those obtained by Castle and Watson (1985).

As can be seen from Table 1, pH during silage tends to decrease. As occurs with the organic acids, the greatest changes in pH manifest themselves during the first 5 days of silage, as reported by Ashbell et al. (1987). As the pH of the original material citrus pulp is very low due to the high content of citric and other acids (Cervera et al. 1985) it is not surprising that the final pH is low, similar to that obtained by Volcani and Roderig (1953) and Volcani and Schindeier (1953), which indicates the good conservation properties of the material.

As regards the differences in pH between the different treatments (Table 2), it is of note that the lowest value was obtained with sodium chloride (2.48%) and the highest belonged to the control (2.98%), with significant differences between them. This is not in accordance with Rooke et al (1988) whose results showed no significant differences between treatments.

Dry matter of the silage fluctuated strongly during the whole experiment, finishing with a value only slightly higher than the initial value, 22.13% from 21.60%.

This slight increase in dry matter might be due to the original by-product's high water content, a consequence of the industrial process to which it had been submitted. Only after this water has completely drained away will the silage be totally stable.

Several authors (Whittembury et al. 1967, McDonald, 1968) coincide in affirming that in silos with a high level of humidity the pH should be inferior to the traditional limit. This would explain why in silage of an orange by-product, the process stabilizes more easily as it reaches a low pH.

Conclusions

The considerable level of water in the original material is due to industrial processes, and this limits the silage quality to a great extent, making a previous treatment of drying or ventilation advisable. The evolution of the organic acids during silage reflects a lactic fermentation, in which the concentration of lactic acid surpasses that of volatile acids.

Treatment with formic acid results in a better fermentation and higher nutritive value of the by-product of orange, where it acts by limiting undesired fermentations.

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