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Ensiling potential of orange fruit wastes (Citrus sinensis)
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ENSILING POTENTIAL OF ORANGE FRUIT WASTES

(Citrus sinensis)

ABSTRACT. Orange fruit wastes (OFW) can be an important by-product in the processing of fruit plants, which produce mainly manufactured juice and essential oils. Several chemical bromatological variables of both fresh and fermented OFW were investigated to characterize the nutritional and fermentative potential for silage making. Direct ensiling technology without using additives is an alternative method that can provide a well preserved forage for animal nutrition at low cost, but the alcohol content was comparatively high in relation with the water soluble carbohydrate content of the forage before ensiling. The aerobic deterioration of the laboratory silage samples occurred without the visible growth of mould over the surface of the end product during the aerobic stability test. The OFW – leucaena silage showed high alcohol content. On the other hand, silage treatments with OFW plus 0.5 % urea and OFW-fish (2:1) have adequate chemical properties and can be recommended to farmers.

Keywords: orange fruit wastes, ensilage, chemical composition.

INTRODUCTION

Citrus of all species are widely grown in tropical and subtropical regions. The fruits are used mainly as dessert or breakfast fruit and for making juices and other citrus products. Citrus production in the producing countries is increasing (Arribas, 2001).

Brazil and the United States account for 93 percent of world orange juice production. In particular, the state of Sao Paulo in Brasil and Florida in the United States are the dominant producing areas for orange juice. Mexico is the third largest world orange producing country followed by Spain, China, and Italy. Other significant orange producing countries include South Africa, Israel, Egypt, Iran, Cuba, Costa Rica, Belize, Japan, and Australia (Spreen, 2000).

Ensiling is an important technique not only for the winter season in cold and temperate zones, but also for dry season in tropical zone to make good use of different biological materials with the highest nutritive value. So, in vitro gas production provides effective method for assessing ruminant feeds (Pedraza et al., 2006; Piquer et al., 2005).
Livestock production in Cuba is limited by fodder shortage during the dry season. To face this problem, man can apply different strategies such as the utilization of by-products and storing forage from wet season surplus.

It has been proved that a rational use of by-products allows to eliminate the myth that supplementation may be carried out only through imported cereals and that their use as food for animal production may contribute to the conservation of the environment (Ojeda and Cáceres, 2002).

Due to the perishable property of surplus fruit during seasons of overproduction in tropical countries, it would be convenient to develop methods of preservation that would enable these plant material to be utilized as animal feeds for longer periods of time (Aguilera et al., 1997).

It is reported a yearly world production of 106 millions tons of citrus fruits (FAO, 2001). The orange fruits represented the 63 % of the world citrus production.

However it is processed annually 600,000 tons of fresh citrus fruits to produce juice, in six Cuban plants, and the use of fresh citrus fruit wastes for animal nutrition is generalised today in our country. Often, this by-product is under-utilized causing some local environment pollution problems.

On the other hand, the production potential of the main fishing by-products in Granma Province is over 6,000 tons per year (Miranda, Otero and Cisneros, 2001).

Fish by-products are usually obtained from inedible whole fish or from waste in fish processing industries. This is an excellent source of protein and minerals for livestock, mainly for cows that have recently calved and for high-yielding cows.

The ensiling of the by-products, using molasses and other easily available feeds rich in fermentable carbohydrates, such as molasses, sweet potatoes, cassava roots, is a simple appropriate method of conservation which has been successfully applied recently in some countries. In all cases, the maximum amount of fish wastes that can be included in the silage should be 50 % with a dry source of carbohydrates and much lower, about 10 %, with fresh sources (Chedlyl et al., 1999).

Waste is an inevitable consequence of the food industry. Appropriate handling of waste has become an essential part of modern processing management. As concerns over the environment have increased, progresses which generated lucrative products, but have attendant unmanageable waste problems, can become unaffordable because of prohibitive disposal cost (Rodríguez, Fuentes and Díaz, 2003).

Environmental goods (natural resources and biophysical conditions) have gradually turned into an economic variable. Its consideration in the context of industry performance leads to redesign the processes of production in line with the so-called integral environmental technology.

So, it is important to assess the ensiling characteristics of fresh OFW from Valencia variety in order to propose its better utilisation for silage making.

### MATERIALS AND METHODS

#### Plant material

Fresh OFW of Valencia variety from the plant of Contramaestre in Cuba’s Eastern region was used for the silage experiments during dry season from January to April.

#### Chemical analysis and laboratory silage

To assess ensilability, three methods were followed up: I) The water soluble carbohydrates content, II) A biological rapid fermentation test with chopped biological material in aqueous suspension, and III) Silage preparation was modelled in microsilos.

Chemical parameters to characterize the fresh OFW before ensiling and fermentation to characterize the silage quality were determined as described Revuelta (2000), Kovásits (1985) and Weissbach & Laube (1964).

#### Experimental design

Treatments were: OFW without additives, OFW plus 0,5% urea, OFW - Leucaena (1:1), and OFW - fish (* Oreochromis aureus*) of non-commercial size desintegrated (2:1).

The experiment was analyzed as a simple design completely randomised with five-replication for each treatment.

### RESULTS AND DISCUSSION

The 45 % of orange fruits of Valencia variety on basis of fresh weight are available as by-product (bagasse, peel and seed), which is considered as solid wastes in the processing plant of Contramaestre to produce juice (Table 1).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Yield, g / kg FM</td>
<td>450</td>
</tr>
<tr>
<td>2) Dry matter, g / kg FM</td>
<td>182.5</td>
</tr>
<tr>
<td>3) Ash, g / kg DM</td>
<td>63.0</td>
</tr>
<tr>
<td>4) Crude protein, g / kg DM</td>
<td>53.8</td>
</tr>
<tr>
<td>5) Crude fibre, g / kg DM</td>
<td>164.0</td>
</tr>
<tr>
<td>6) Ethereous extract, g / kg DM</td>
<td>20.4</td>
</tr>
<tr>
<td>7) Water soluble carbohydrates, g / kg FM</td>
<td>45.80</td>
</tr>
<tr>
<td>8) Fructose, g / kg DM</td>
<td>75.8</td>
</tr>
<tr>
<td>9) Glucose, g / kg DM</td>
<td>50.2</td>
</tr>
<tr>
<td>10) Sucrose, g / kg DM</td>
<td>74.2</td>
</tr>
<tr>
<td>11) pH (initial)</td>
<td>4.74</td>
</tr>
<tr>
<td>12) pH (Pieper test after 44 hours of incubation)</td>
<td>3.10</td>
</tr>
<tr>
<td>13) pK</td>
<td>3.10</td>
</tr>
<tr>
<td>14) (a) mL NaOH 0,25 mol / L to pH= 5.0</td>
<td>8.6</td>
</tr>
<tr>
<td>15) (b) mL NaOH 0,25 mol / L to pH= 6.0</td>
<td>10.2</td>
</tr>
<tr>
<td>16) Index of fermentation quality = a / b</td>
<td>0.84</td>
</tr>
<tr>
<td>17) Alcohol, g / kg FM</td>
<td>41.8</td>
</tr>
<tr>
<td>18) NH₁ – N in % total N</td>
<td>5.4</td>
</tr>
<tr>
<td>19) Aerobic stability test, g CO₂ / kg FM</td>
<td>35.2</td>
</tr>
</tbody>
</table>

Before ensiling: 1 – 12, After ensiling: 13 - 19
The chemical and bromatological composition of fresh and fermented OFW has shown that this plant material is a potential feed source in animal livestock. So, its use in feeding formulas for ruminant or monogastric animals is an attractive proposition from technical, environmental and economical points of view (Alvir et al., 2001, Itavo et al., 2000 a,b,c, Dominguez, 1995, and Valenciaga et al., 2005).

The results obtained by Moreno et al. (2000) suggest that orange peel, which is an agricultural waste, could have a potential use in the elaboration of fish feed.

The main energy – yielding nutrient in citrus is carbohydrate; citrus contains the simple carbohydrates (sugars) fructose, glucose and sacarose, as well as citric acid which can also provide a small amount of energy. The predominant type of soluble fibre in citrus is pectin (Friedel, 2002).

Their chemical properties are very desirable for making silage. This is due to the adequate amount of water soluble carbohydrates (WSC) and low pH. Thus, the spectacular 200 fold drop of colony forming units of yeast and fungi numbers in the ensiling material compared to before ensiling, enhances the positive effect of the ensiling process upon the hygienic status of orange silage (Volanis et al., 2004).

In addition, ensiling citrus waste has advantages over traditional drying, in that less energy is used, cost of processing is much reduced and there is improvement of palatability.

This waste is palatable to cattle and mature cows, when they are accustomed to the feed, consume about 10-15 kg per day. Because of the high water content and the perishable nature of the waste, economically it can only be used near to the processing plant.

The fresh OFW had a low dry mater, crude fibre and crude protein content and a high water soluble carbohydrate concentration. The biological rapid fermentation test (Pieper, 1992) indicated a high potential acidity of fresh OFW (pH < 3.6) favourable for a natural conservation process, probably due to the content of citric and other organic acids present in the fruit.

Efficient silage fermentation is characterized by a fast pH decline during the initial stages of ensiling. The OFW silage used had a characteristic acid smell typical of very well preserved silage, but alcohol odour was detected (Table 1).

The fermented food showed a low pH and proteolysis and a high index of fermentation quality (> 0,76) and alcohol content. In this case occurred the aerobic deterioration without the visible growth of mould over the surface of the silage samples during the aerobic silage test.

Micro-organisms such as mould, bacterial and yeast would cause the aerobic changes. Similar fermentative characteristics such as pH and alcohol content presented the sugar beet silage (Laube cited by Nehring, 1972).

The pH is a key criterion to evaluate silage fermentation. Proteolysis is inhibited more strongly by pH than by osmolarity (Bickel et al., 2006).

Generally the lower the pH, the better preserved and more stable is the silage. The critical pH that affects growth of clostridium depends on the water activity of the fermentation medium; with decreasing water activity the sensitivity of these micro-organisms to acidity increases. Therefore, the dry matter content of the forage affects the pH required for a quality silage.

The products of fermentation and the osmolarity can be used as indicators of silage quality (Zierenberg, Friedel and Gabel, 2002).

Alcohol is a common, usually minor fermentation product in ensiled forages, the major product being lactic acid. Occasionally, high levels of alcohol are found in silages. The micro-organisms responsible for alcohol fermentation as well as the implications of feeding alcohol silages to Livestock remain to be investigated in our conditions.

Addition of urea or fish prior to ensiling prevented high alcohol levels of the fermented OFW (Table 2). It is important because high contents of alcohol in silages can limit the intake.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) pH-Value (Pieper Test after 44 hours of incubation)</td>
<td>3,25</td>
<td>3,90</td>
<td>4,06</td>
</tr>
<tr>
<td>2) pH-Value ( Silage )</td>
<td>3,51</td>
<td>4,20</td>
<td>4,17</td>
</tr>
<tr>
<td>3) ml NaOH 0,25 mol/L to pH=5,0 (a)</td>
<td>5,7</td>
<td>4,6</td>
<td>6,1</td>
</tr>
<tr>
<td>4) ml NaOH 0,25 mol/L to pH=6,0 (b)</td>
<td>7,2</td>
<td>7,3</td>
<td>9,3</td>
</tr>
<tr>
<td>5) a/b</td>
<td>0,79</td>
<td>0,63</td>
<td>0,66</td>
</tr>
<tr>
<td>6) NH3-N, %</td>
<td>0,011</td>
<td>0,039</td>
<td>0,024</td>
</tr>
<tr>
<td>7) Alcohol, %</td>
<td>1,00</td>
<td>2,46</td>
<td>0,22</td>
</tr>
<tr>
<td>8) Crude protein, % DM</td>
<td>13,37</td>
<td>13,50</td>
<td>30,70</td>
</tr>
</tbody>
</table>

A: OFW plus 0.5% urea, B: OFW - Leucaena (1:1), C: OFW - fish (2:1)

The dois of potassium sorbate (0.05 % - 0.2%) inhibited the alcoholic fermentation in silages, but this additive is even expensive (Friedel, 2002).

In order to increase farm incomes from livestock in developing countries, an adequate low-cost feeding system must be developed (Chedly et al., 1999). Making silage from agricultural and agro-industrial such as citruspulp and fishery by-products is a system, which offers considerable potential to improve farm incomes and profits.

CONCLUSIONS

In conclusion, direct ensiling technology without using additives is an alternative method that can provide a well-preserved forage at a low cost to be used as animal feed for longer periods of time; but it is shown here a high bioconversion process of the soluble carbohydrates into alcohol compounds typical of alcoholic fermentation silage pathway. On the other hand, silage treatments with OFW plus 0.5% urea and OFW - fish (2:1) have adequate chemical properties and can be recommended to farmers.
REFERENCES


