# Elaboration and Characterization of Biological Devil Fish Silage (*Plecostomus* Spp) with *Lactobacillus* spp. and Molasses as An Additive, in The Lower Basin of The Balsas River in The State of Guerrero, Mexico

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**Abstract:** The objective of the present study was to evaluate the nutritional and microbiological quality of the biological devil fish silage (*Plecostomus* spp) and determine which of the molasses proportions (30, 50 and 70%) and devil fish (65, 45 and 25%), in two modalities (whole and headless) and two physical forms (ground and chopped) inoculated with 5% of *Lactobacillus* spp. (commercial yogurt), is suitable to be used in animal feeding. For this purpose, twelve treatments with three replicates were evaluated during 40 days. A completely randomized design was used with a factorial arrangement 2×2×3 (two fish modalities, two physical forms, and thee levels of molasses inclusions) and the comparison of the averages was realized using the Tukey test. The variables evaluated were: pH, nutritional characteristics (dry matter, crude protein, ether extract, and ash), organoleptic (odor, color, consistence) and microbiological test. The pH showed stability within 72 h, but only until the fifth day, this variable was normalized. After forty days of measuring, the treatments with more acceptable pH values (<0.05) were: ground headless devil fish with 50% molasses (4.14), the whole ground fish with 30% molasses (4.16), the whole ground fish with 50% molasses (4.20), the headless ground fish with 30% molasses (4.30), the headless chopped fish with 50% molasses (4.44) and the headless chopped fish with 30% molasses (4.57). The nutritional characteristics presented by the microsilos with 30% molasses are placed in the group with the best averages ($P<0.05$), followed by the microsilos with 50% molasses and finally those with 70% molasses. Regarding the crude protein, the microsilos with 30% molasses, headless chopped fish, whole chopped fish, headless ground fish and with whole ground fish presented more elevated values (37.78, 35.09, 32.88 and 31.91% respectively) ($P<0.05$). In relation to the crude fat the highest averages ($P<0.05$), were presented by the treatments with whole chopped fish with 30% molasses, (8.5%), with whole chopped fish with 50% molasses (7.47%) and with headless chopped fish with 30% molasses (5.73%). For ash, the treatments with whole chopped fish with 30% molasses (31.07), with whole ground fish with 30% molasses (26.75%) and headless ground fish with 30% molasses (26.09%) were the treatments with the best results ($P<0.05$). As to the organoleptic characteristics the twelve treatments manifested pleasant odors (alcoholic-acid, alcoholic molasses) pasty- liquid consistence and light brown to dark brown color. The microbiologic analysis showed that differently from the treatment with whole chopped fish with 30% molasses that presented values superior to those allowed by the Official Mexican Norm NOM-027-SSA1-1993; the rest of the treatments were found in the acceptable range, which indicates that this product is completely innocuous and functional for animal feeding.

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**Keywords:** *Plecostomus* spp, biological silage, lactic bacteria.

## 1. Introduction

*Plecostomus* spp. known locally as toad or devil fish is an invasive fish (Fam. *Loricariidae*) appeared in the Mexican freshwater bodies in the 90's and has at present became a serious problem for the small scale fisherman in the state of Guerrero and other parts of Mexico. In other places, efforts have been made to develop a by-product with value added, such as fish flour; used as food in aquaculture farms or as fertilizers (Mendoza *et al*., 2007). Likewise, techniques of conservation like silage have been developed for meat products, such as animal corpses, fish waste, and bycatch of commercial fishing (Padilla, 2005; Llanes *et al*., 2007). For the fish silage and its waste, various techniques have been developed, among them; the acid silage with mineral acids (hydrochloric, sulfuric and phosphoric), organic acids (acetic, formic) and a combination of them. Biological conservation techniques have also been developed with the use of substrate (molasses, yucca flour) and the use of fermentative bacteria (*Lactobacillus* and *streptococcus*) as well as some fungi (Copes, 2006; Cisneros, 2004; Cordova, 2006; Padilla, 2005). The fish biological silage is a protein feed, of high humidity and of easy preservation that can be defined as a pasty-liquid product obtained from the action of enzymes on whole, parts or waste fish, and it is commonly used as a component of feeding rations for animals (Balsinde *et al*., 2003). Basically the elaboration process consists of mixing the ground or chopped fish with an energetic source of carbohydrates of easy fermentation and low cost (molasses) and adding certain microorganisms based on *Lactobacillus plantarum*, *Streptococcus*, *Candida lipolitica*, etc., which convert sugars into lactic acid, preserving the fish by limiting the activity of putrefactive bacteria. The optimum temperature for the fermentation is between 35 and 40 $^{o}$C (Avdalov *et al*., 1989). Avdalov *et al*., (1989) mentioned two of the most outstanding characteristics of biological fish silage, being one, a protein that hydrolyzes between the 75 and 85%, being 60% of this protein in the form of polypeptides and 40% as free amino acids (essential and non-essential), and the second one that the digestibility is close to 100%. Within the nutritional characteristics are variables according to the species of fish silage that even sometimes within the same species there are variations, depending on the part being analyzed and other factors such as the season, type of feeding, grade of gonad maturation and sex. In other words, the composition of the silage of fish is very similar to the used raw material (Fernandez *et al*., 2011).

Therefore, the present study aimed to evaluate the nutritional and microbiological quality of the biological devil fish (*Plecostomus* spp) silage with different molasses proportions (30, 50 and 70%) and devil fish (65, 45 and 25%), in two forms (whole and headless) and two physical forms (ground and chopped) inoculated with 5% of *Lactobacillus* spp. to be used in animal feeding.

**2. Materials and methods**

For the elaboration of the biological devil fish silage, samples obtained from the lower basin of the Balsas River in the state of Guerrero, Mexico mainly in two specific points: Nuevo Galeana, municipality of Cutzamala de Pinzon and Nuevo Balsas, municipality of Cocula, both in the state of Guerrero. Microsilos of 1.5 kg were elaborated where the devil fish was placed as: a) whole fish and b) headless fish; with two modalities of physical treatment: i) ground, ii)hand chopped. Molasses was used as a source of fermentable carbohydrates with different percentages of inclusion (30, 50 and 70%), to which was added *Lactobacillus* spp as a acidifying agent at 5% (using commercial yogurt) (table 1). Each treatment had 3 replicates and was shaken three times a day during two minutes the first three days and was kept saved at room temperature not less than 30 $^{o}$C during forty days. The variables were evaluated under the following regimen, pH and organoleptic characteristics every twelve hours the first three days, after that at completing the fifth day they were evaluated every five days; and the nutritional and microbiological characteristics at the end of the fortieth day. A completely randomized design was used with a factorial arrangement 2×2×3 (two fish modalities, two physical forms, and thee levels of molasses inclusions) and the comparison of the averages was realized using the Tukey test. The elaboration and establishment of microsilos was in the laboratory of Bromatology of the Faculty of Veterinary of the Autonomous University of Guerrero.

**Results And Discusion**

In relation to pH, the twelve treatments form various groups statistically different ($P<0.05$), since from the 0 hour is seen that exists interaction of averages, showing that the pH in that time are unstable and relatively high. At the end of 72 hours, the pH showed certain stability but it was not until the fifth day; it was observed that this variable normalized, reaching the desired levels in the twelve treatments. At the end of the forty days of measuring, it was observed that of the twelve treatments, the ground headless with 50% molasses (4.14), the whole ground with 30% molasses (4.16), the ground whole with 50% molasses (4.20), the headless ground with 30% molasses (4.30), the headless chopped with 50% molasses (4.44), and the headless chopped with 30% molasses (4.57) were the treatments with the most acceptable pH values ($P<0.05$) (Table 2). According to these pH results it can be determined that the treatments mentioned before are stable and fit to be used in the diet of domestic animals, since the pH is one of the parameters with greater importance that has to be controlled during the whole process and storage of the biological fish silage; since it reflects the development of the process, the quality of the silage and manifests any change that can affect the product. According to that quoted by Fagbenro and Jauncey (1995), the stability of biological silage is obtained with values of pH lower than 4.5. Such values agree with that found by other authors, since in their researches they report silages with pH values that range from 4.18 to 4.39 (Cira *et al*., 2002; Plascencia *et al*., 2002; Vidotti *et al*., 2002; Leon, 2003; Gonzalez and Marin, 2005) in this interval is registered the pH by the silages of this study.

The treatments with 70% molasses behaved differently since their pH was higher with levels from 5.8 for the whole chopped, 5.21 for the headless ground, 5.30 for the whole ground and 5.71 for the headless chopped, being superior to those reported by Ramirez *et al*. (2008) where the pH was of 4.90. However, despite the high pH, these microsilos never presented unpleasant odor nor alterations in their consistence, presenting lower levels of CFU/ml.

In this case it would have to be mentioned and highlighted the characteristics of molasses as a conservative, since in these silages more than half of the ingredients are composed of molasses (70% molasses, 25% devil fish, 5% natural yogurt), and according to Fajardo and Sarmiento (2007), who mention that within the content of molasses exist phenols and volatile compounds. On this point Castro (1993) mentioned that the phenols present in molasses come from the fibrous part of the sugar cane and these derive from the hydrocinamic and parahydroxibenzoic acid; in other words, from the fermentative point of view some phenols present inhibitory activity on the growth of microorganisms and others such as the p-cumaric and telluric are capable of totally inhibiting the bacteria growth. This characteristic in many cases of fermentation some phenols would result undesirable at concentrations of 0.5g/l.

It should be emphasized that during the experimental storage of the fish silages, room temperature ranged from 30 to 35 $^{o}$C. Concerning this, Areche and Berenz, (1990) quoted that the optimum incubation of yogurt bacteria is between 40 and 45 $^{o}$C, though they can also develop at 30 $^{o}$C or less, but under these conditions fermentation takes place slower (five days) (Llanes *et al*., 2007).

As to nutritional characteristics of the microsilos of devil fish in Table 3, it can be observed that the twelve treatments studied form diverse groups statistically different ($P<0.05$), where the microsilos with 30% molasses were placed within the group with highest averages, followed by the microsilos with 50% molasses and finally those with 70%; this phenomenon does not repeat in the content with dry matter. Due to the percentages of inclusion of each ingredient, in the twelve treatments, a high content of humidity was to be expected and transformed into dry matter it yields low percentages of this, being the headless chopped fish with 70% molasses the treatment with the lowest dry percentage with 2.52%, followed by the whole chopped fish with 50% molasses with 3.72% of dry matter and finally the treatment of headless ground fish silage with 30% with 3.88% ($P<0.05$). At the far end, we placed the treatments with higher percentages of dry matter, being the whole ground with 70% molasses with 11.02%, the whole ground with 30% with 9.54 and finally the whole chopped with 70% molasses with 8.74% of dry matter; the rest of the treatments were placed in the middle of these two groups ($P<0.05$). These results don't match with those reported by Padilla *et al*. (1996), who obtained 55.6% of dry matter. In the same way the results obtained in this study are inferior to those reported by Copes *et al*. (2006) being of 24% of dry matter in their biological fish silage. On the other hand, it is important to emphasize the said content of humidity of the biological devil fish silage, since the presence of carbohydrates in the silage (molasses) and the humidity results in a suitable medium for the development of lactic bacteria, giving the product benefic qualities in digestion, improving the natural microbial population in animals (Jorgensen, 1962) and stability to the product (Berenz, 1998).

In the microsilos with 30% molasses an important feature of the devil fish is appreciated, its high content of crude protein, being the treatment with headless chopped fish (37.78%) the one that registered a percentage higher than the others ($P<0.05$), followed by the treatment with whole chopped (35.09%), afterward, the treatment with headless ground (32.88%) and finally the treatment with whole ground with 31.91%. Such results are attributed mainly to the proportions of fish and molasses used to elaborate the microsilos, being 65% fish and 30% molasses; since differently from the microsilos with 50% and 70% molasses, more than half of the ingredients is not devil fish.

Meanwhile, Balsinde *et al*. (2003), in the biological silver carp with 15% molasses obtained 16.9% of crude protein, such result matches only with some of the microsilos with 70% molasses, while the treatments with 30% and 50% molasses were higher than those obtained by those authors. The same occurred with the results of crude protein obtained by Avdalov *et al*., (1989); since elaborating two biological silages with white bream and waste of hake reported 13.01% and 11.05%, respectively.

In relation to the crude fat the highest averages were obtained by the treatments with whole ground fish and 30% molasses with 8.5, 7.47% of the whole chopped with 50% molasses and headless chopped with 30% molasses with 5.73%. These results were lower than those established by several authors that have elaborated biological fish silages, since most of the treatments were, by far, inferior to the averages mentioned before, as reported by Rodrigues and Diaz (2005), of 15.50% of crude fat; Mattos *et al*. (2003) with 5.1% and 13.8% reported by Olaya, (2005). On the other hand, Toledo and Llanes (2006) mentioned as benefic this characteristic, arguing that the low content of fat avoids problems of rancidity during a long period or storage.

Another important point to emphasize is the high content of the ash that turn into available minerals, to this can be attributed that the devil fish is formed by bone; since, differently to other biological silages with fish waste or tilapia; these show inferior levels of ash than those found in the microsilos of devil fish, such is the case of Mattos *et al*. (2003), who report 5.9% ash in a biological fish silage, so does the found by Belli (2009), since it mentions 7.80% of ash.

As to the organoleptic characteristics, in table 4 it can be observed that all the microsilos with 30% molasses presented a dark brown hue and ended in a light brown hue, similar to cinnamon, its odor was changed progressively, from a fermented but pleasant odor, going through a vinegar smell and finally with an alcoholic-acid odor, these microsilos presented a considerable change, since after 24 and 36 hours their volume increased, in some sort of bubbling layer. This phenomenon was more evident in the ground modalities, where their smell was marked fermented as well.

These microsilos presented changes in their fermented scent at 12 hours from the mixture being made, differently to those microsilos with 50% and 70% molasses, since the aroma of these was still similar to that of the molasses. As to its consistence, the ground microsilos was pasty with a thin liquid layer on the surface, as to the microsilos with chopped fish a more liquid consistence was observed, this due to the chopped process. These results are in agreement to those reported by Toledo and Llanes (2006), where they mentioned that the odor of biological silage slightly as fish and vinegar, classifying it as pleasant and with no evidence of rotting. In the case of the color, it didn't chance hue (cinnamon color) regarding to the consistence, it was mentioned as pasty, which only matches the ground silages.

The table 4 shows the treatments with 50% molasses, and regarding their coloring it was darker from the beginning to the end of the experimental process, without presenting any change. Its odor in the first few hours of starting didn't present any changes, it was until after 36 hours of starting when it had a slight change to fermented with bubbling aspect, increasing in appearance and volume. This effect was more marked in the ground modalities and as to the consistence they presented the same changes as the microsilos with 30% molasses. There were no changes in any of the replicates of these silages as to contamination.

Table 1. Treatments used for the elaboration of the biological devil fish silage in diverse physical modalities, molasses at different percentage of inclusion and *Lactobacillus* spp.

| MOLASSES 30% | | | | MOLASSES 50% | | | | MOLASSES 70% | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FISH 65% | | | | FISH 45% | | | | FISH 25% | | | |
| WHOLE | | HEADLESS | | WHOLE | | ESCABEZADO | | WHOLE | | HEADLESS | |
| GRO-UND | CHO-PPED | GRO-UND | CHO-PPED | GRO-UND | CHO-PPED | GRO-UND | CHO-PPED | GRO-UND | CHO-PPED | GRO-UND | CHO-PPED |
| YOGURT 5% | | | | YOGURT 5% | | | | YOGURT 5% | | | |
| T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 | T11 | T12 |

Table 2. Behavior of pH in biological devil fish silage with different physical forms of conservation and different levels of molasses inclusion.

| MEASSURING TIME | MOLASSES (30%) | | | | MOLASSES (50%) | | | | MOLASSES (70%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WHOLE | | HEADLESS | | WHOLE | | HEADLESS | | WHOLE | | HEADLESS | |
| | GROUND | CHOPPED | GROUND | CHOPPED | GROUND | CHOPPED | GROUND | CHOPPED | GROUND | CHOPPED | GROUND | CHOPPED |
| 0 h | 6.12$^{bc}$ | 6.63$^{a}$ | 6.18$^{b}$ | 5.46$^{fg}$ | 5.94$^{cd}$ | 6.30$^{b}$ | 5.90$^{cd}$ | 5.28$^{gh}$ | 5.54$^{ef}$ | 6.22$^{b}$ | 5.72$^{de}$ | 5.18$^{h}$ |
| 12 h | 7.04$^{a}$ | 6.42$^{bcd}$ | 6.81$^{ab}$ | 5.59$^{ef}$ | 6.41$^{bcd}$ | 6.24$^{cd}$ | 6.59$^{abc}$ | 5.24$^{fg}$ | 6.26$^{cd}$ | 6.03$^{de}$ | 6.57$^{abc}$ | 5.08$^{g}$ |
| 24 h | 6.89$^{a}$ | 5.23$^{e}$ | 6.78$^{a}$ | 5.61$^{d}$ | 6.71$^{ab}$ | 5.03$^{ef}$ | 6.75$^{a}$ | 5.36$^{de}$ | 6.15$^{c}$ | 4.78$^{f}$ | 6.38$^{bc}$ | 5.16$^{e}$ |
| 36 h | 6.54$^{ab}$ | 4.92$^{def}$ | 5.93$^{c}$ | 5.26$^{de}$ | 6.81$^{a}$ | 4.79$^{ef}$ | 6.57$^{ab}$ | 5.40$^{d}$ | 6.60$^{ab}$ | 4.61$^{f}$ | 6.17$^{bc}$ | 5.17$^{de}$ |
| 48 h | 3.87$^{h}$ | 4.97$^{bcd}$ | 4.30$^{g}$ | 4.58$^{fg}$ | 4.77$^{def}$ | 4.83$^{cdef}$ | 5.19$^{ab}$ | 5.34$^{a}$ | 4.72$^{def}$ | 4.65$^{ef}$ | 4.96$^{bcde}$ | 5.13$^{abc}$ |
| 60 h | 4.02$^{g}$ | 5.19$^{ab}$ | 4.18$^{fg}$ | 4.39$^{ef}$ | 4.58$^{de}$ | 5.09$^{abc}$ | 4.79$^{cd}$ | 5.31$^{a}$ | 4.86$^{bcd}$ | 4.89$^{bcd}$ | 4.86$^{bcd}$ | 5.17$^{ab}$ |
| 72 h | 3.95$^{d}$ | 5.21$^{ab}$ | 4.03$^{d}$ | 4.61$^{c}$ | 4.49$^{c}$ | 4.95$^{bc}$ | 4.57$^{c}$ | 5.44$^{a}$ | 4.81$^{bc}$ | 4.82$^{bc}$ | 4.81$^{bc}$ | 5.49$^{a}$ |
| Day 5 | 4.30$^{e}$ | 5.10$^{abc}$ | 4.33$^{de}$ | 4.54$^{de}$ | 4.31$^{e}$ | 4.78$^{bcd}$ | 4.33d$^{e}$ | 4.58$^{de}$ | 5.13$^{ab}$ | 4.67$^{cde}$ | 5.07$^{abc}$ | 5.52$^{a}$ |
| Day 10 | 3.82$^{ef}$ | 5.10$^{a}$ | 3.72$^{f}$ | 3.97$^{e}$ | 3.86$^{ef}$ | 4.78$^{cd}$ | 3.70$^{f}$ | 3.74$^{f}$ | 4.89$^{ab}$ | 4.61$^{d}$ | 4.86$^{bc}$ | 5.08$^{ab}$ |
| Day 15 | 3.78$^{b}$ | 5.05$^{a}$ | 3.92$^{b}$ | 3.44$^{b}$ | 3.77$^{b}$ | 4.72$^{a}$ | 3.73$^{b}$ | 3.44$^{b}$ | 4.92$^{a}$ | 4.61$^{a}$ | 4.92$^{a}$ | 4.67$^{a}$ |
| Day 20 | 3.86$^{b}$ | 5.01$^{a}$ | 3.88$^{b}$ | 3.68$^{b}$ | 3.95$^{b}$ | 4.67$^{a}$ | 3.70$^{b}$ | 3.46$^{b}$ | 4.88$^{a}$ | 4.65$^{a}$ | 4.85$^{a}$ | 4.84$^{a}$ |
| Day 25 | 3.76$^{bc}$ | 5.04$^{a}$ | 3.92$^{b}$ | 3.82$^{bc}$ | 3.77$^{bc}$ | 4.66$^{a}$ | 3.63$^{bc}$ | 3.40$^{c}$ | 4.82$^{a}$ | 4.64$^{a}$ | 4.80$^{a}$ | 4.82$^{a}$ |
| Day 30 | 4.17$^{d}$ | 5.52$^{a}$ | 4.06$^{d}$ | 3.76$^{e}$ | 4.20$^{d}$ | 5.14$^{b}$ | 4.08$^{d}$ | 3.44$^{f}$ | 5.24$^{b}$ | 5.25$^{b}$ | 5.23$^{b}$ | 4.76$^{c}$ |
| Day 35 | 4.71$^{b}$ | 4.85$^{b}$ | 4.83$^{b}$ | 4.89$^{b}$ | 4.74$^{b}$ | 4.81$^{b}$ | 4.66$^{b}$ | 4.14$^{b}$ | 5.74$^{a}$ | 5.74$^{a}$ | 5.75$^{a}$ | 5.95$^{a}$ |
| Day 40 | 4.16$^{d}$ | 5.62$^{ab}$ | 4.30$^{d}$ | 4.57$^{d}$ | 4.20$^{d}$ | 5.11$^{c}$ | 4.14$^{d}$ | 4.44$^{d}$ | 5.30$^{abc}$ | 5.18$^{bc}$ | 5.21$^{bc}$ | 5.71$^{a}$ |

$^{abcdefgh}$ Averages with different letters in the rows are statistically different ($P<0.05$)

As it can be observed, these treatments with 70% molasses experimented less changes unlike those treatments with 30% and 50% molasses, its color was darker from the beginning to the end of the experiment, same with its odor, in which the molasses smell was never lost, having a slight odor of alcohol; as to its consistence it was more aqueous-liquid. It is also important to emphasize that its odor had a slight change after eight hours of making the mixture and in is appearance looked a little bubbling. In this way, its pH can be related, since these treatments stayed on top of that reported in the microsilos with 30% and 50% molasses, but none had neither unpleasant odors, nor contamination, and when the microbiological analysis was made no contamination by bacteria or undesirable fungi was found. With these results was confirmed the criteria exposed by Dominguez (1988) and Diaz *et al*. (1992) that molasses of sugarcane increase the osmotic pressure of the medium causing a conservation of this type of protean minerals by dehydration.

In the table 5, the microbiological characteristics of devil fish silage can be seen, about it, the Official Mexican Norm (NOM-027-SSA1-1993) of goods and services for fishing products, fresh-refrigerated fish and frozen fish establishes maximum values of aerobic mesophile of $10^6$ CFU/g; and according to this, the whole chopped silage with 30% molasses, excided the maximum values established by said norm, while the rest of the treatments are innocuous for animal feeding. These results match those reported by Toledo (2006); Bello (1994); so the same, Holguin et at. (2009) report microbiological characteristics similar to those found in the silages with devil fish in the present experiment.

Table 3. Nutritional composition of biological devil fish silage (*Plecostomus* Spp), *Lactobacillus* sp. and molasses at different percentages of inclusion.

| CONTENT (%)* | MOLASSES (30%) | | | | MOLASSES (50%) | | | | MOLASSES (70%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WHOLE | | HEADLESS | | WHOLE | | HEADLESS | | WHOLE | | HEADLESS | |
| | GROUND | CHOPPED | GROUND | CHOPPED | GROUND | CHOPPED | GROUND | CHOPPED | GROUND | CHOPPED | GROUND | CHOPPED |
| Dry matter | $9.54^{ab}$ | $5.74^{ab}$ | $3.88^{ab}$ | $6.59^{ab}$ | $5.33^{ab}$ | $3.72^{ab}$ | $5.02^{ab}$ | $4.78^{ab}$ | $11.02^{a}$ | $8.74^{ab}$ | $6.90^{ab}$ | $2.52^{b}$ |
| Crude protein | $31.91^{a}$ | $35.09^{a}$ | $32.88^{a}$ | $37.78^{a}$ | $20.90^{bc}$ | $25.05^{b}$ | $20.80^{bc}$ | $22.31^{bc}$ | $12.48^{d}$ | $16.29^{cd}$ | $13.76^{d}$ | $17.06^{cd}$ |
| Crude fat | $2.83^{bc}$ | $8.50^{a}$ | $3.13^{bc}$ | $5.73^{ab}$ | $2.03^{bc}$ | $7.47^{a}$ | $1.40^{c}$ | $2.83^{bc}$ | $1.73^{bc}$ | $4.97^{abc}$ | $2.00^{bc}$ | $1.70^{bc}$ |
| Ash | $26.75^{b}$ | $31.07^{a}$ | $26.09^{b}$ | $20.87^{cd}$ | $17.80^{ef}$ | $21.87^{c}$ | $20.14^{cde}$ | $18.21^{def}$ | $15.96^{f}$ | $15.95^{f}$ | $15.78^{f}$ | $15.94^{f}$ |

$^{abcdefgh}$ Averages with different letters in the rows are statistically different ($P<0.05$)

Table 4. Organoleptic characteristics of biological devil fish silage (*Plecostumus* sp) with different proportion of molasses and different physical forms.

| | MOLASSES (30%) | | | | MOLASSES (50%) | | | | MOLASSES (70%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WHOLE | | HEADLESS | | WHOLE | | HEADLESS | | WHOLE | | HEADLESS | |
| | GROUND | CHOPPED | GROUND | CHOPPED | GROUND | CHOPPED | GROUND | CHOPPED | GROUND | CHOPPED | GROUND | CHOPPED |
| Color | | | | | | | | | | | | |
| Day 0 | Dark brown | Dark brown | Dark brown | Dark brown | Dark brown | Dark brown | Dark brown | Dark brown | Dark brown | Dark brown | Dark brown | Dark brown |
| Day 40 | Light Brown | Light Brown | Light Brown | Light Brown | Light Brown | Light Brown | Light Brown | Light Brown | Light Brown | Light Brown | Light Brown | Light Brown |
| Odor | | | | | | | | | | | | |
| Day 0 | Pleasant | Pleasant | Pleasant | Pleasant | Pleasant | Pleasant | Pleasant | Pleasant | Pleasant | Pleasant | Pleasant | Pleasant |
| Day 40 | Alcoholic-Acid | Alcoholic-Acid | Alcoholic-Acid | Alcoholic-Acid | Alcoholic | Alcoholic | Alcoholic | Alcoholic | Molasses | Molasses | Molasses | Molasses |
| Consistence | | | | | | | | | | | | |
| Day 0 | Pasty | Dense | Pasty | Dense | Pasty | Aqueous | Pasty | Aqueous | Aqueous | Liquida | Aqueous | Liquid |
| Day 40 | Pasty | Liquid | Pasty | Liquid | Pasty | Liquid | Pasty | Liquid | Dense | Aqueous | Aqueous | Liquid |

Table 5. Microbiological characteristics of the silages elaborated with devil fish, *Lactobacillus* sp. and molasses as and an additive at different percentages of inclusion.

| TREATMENTS | | CFU/ml |
|---|---|---|
| MOLASSES 30% | GROUND WHOLE | $1 \times 10^6$ |
| | GROUND HEADLESS | NEGATIVE |
| | CHOPPED WHOLE | $56 \times 10^6$ |
| | CHOPPED HEADLESS | NEGATIVE |
| | | |
| MOLASSES 50% | GROUND WHOLE | $7 \times 10^6$ |
| | GROUND HEADLESS | $1 \times 10^6$ |
| | CHOPPED WHOLE | NEGATIVE |
| | CHOPPED HEADLESS | NEGATIVE |
| | | |
| MOLASSES 70% | GROUND WHOLE | $1 \times 10^6$ |
| | GROUND HEADLESS | $4 \times 10^6$ |
| | CHOPPED WHOLE | $2 \times 10^6$ |
| | CHOPPED HEADLESS | NEGATIVE |

## 4. Conclusions

The biological silage of devil fish (*Plecostomus* spp.), showed satisfactory results with inclusion of 30% molasses, and 5% natural yogurt (*Lactobacillus* sp.), in all the physical modalities, since the levels of crude protein range between 31.91% and 37.78%, dry matter between 3.88% and 9.54%, the ash between 20.87% and 31.07% and crude fat between 2.83% and 8.50%.

The inclusion of 30% molasses was the source of carbohydrates of easy fermentation and 5% lactic bacteria (*Lactobacillus* sp.) it resulted to be an excellent relation, since it achieve to establish optimal levels of pH for the conservation of devil fish silage in a short time, pleasant organoleptic characteristics and innocuous for animal health. According to this, the biological devil fish (*Plecostomus* spp) silage is considered an excellent alternative of use for animal feeding in Mexico.

**5. Acknowledgements**
Authors would like to express their gratitude to the CONACYT-GUERRERO for financial support of this research.

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2/11/2015