Journal of Soil Sciences and Agricultural Engineering

Journal homepage: www.jssae.mans.edu.eg
Available online at: www.jssae.journals.ekb.eg

Effect of some Engineering Factors on The Fish Silage Making

Obaia, A. R.* and M. M. Sh. Refaay

Agric. Eng. Res. Inst. (AEnRI), A.R.C, Giza, Egypt.

Cross Mark

ABSTRACT

The study aims to effect of engineering factors, types of fish waste and types of acid on fish minced to make acid silage met the criteria of low cost and low technology process. The results of experiment (1) showed that, the best treatment for making fish silage was the treatment (conical cutter knife, die of 3 mm diameter and mixing between tilapia fingerlings and catfish), because it gave the highest soluble solids content (14g/100g minced fish), as well as obtaining silage with a high degree of smoothness, which helps the speed of action of the enzymes liquefaction silage. The results of experiment (2) also showed that, the best results when using mineral acid to acidify the silage mixture was obtained with sulfuric acid. These acids produce higher soluble solid content (10.2 g/100g minced fish) and there is little loss of total solid about (1.52 %). The best results when using organic acid was obtained with acetic acid. These acids produce higher soluble solid content (12.3 g/100g minced fish) and there is little loss of total solid about (7.82 %). The best results when using mineral-organic acid combination was produced using sulfuric-acetic acid combination and produced the highest soluble solids content (17g/ 100g minced fish) and loss of total solids about (5 %). The studies indicate that, in general, a good acid silage should be made by adding 3.5 % combination between sulfuric acid and acetic acid until the pH of 4 keeping the mixture at 33 °C for 30 days.

Keywords: Acid fish silage, mincing machine, fish waste, Nile tilapia fingerlings, catfish.

INTRODUCTION

The best alternative way of utilizing fish waste material is the production of fish silage which does not release any off odor during preparation (Pagarkar *et al*., 2005). The product has a good nutritive quality and can be sufficient for animal feeding. This procedure is safe, cost effective, eco-friendly and has a good nutritive quality which can be adequate for animal feeding (Hanafy and Ibrahim, 2004). Fish silage preparation usually depends on the locally available raw materials and conditions (Hasan, 2003).

A way of minimizing the environmental problems generated by the high amount of fish waste is its transformation in a product to be incorporated as ingredient in animal rations (Ristic *et al*.; 2002). A viable alternative would be the production of fish silage, as it is an easy-to-make product which requires low investments. The product has a good nutritive quality and can, therefore, be very useful in animal feeding (Berenz, 2003).

Fish silage is defined as a liquid product produced from the whole fish or parts of it, to which acids, enzymes or lactic acid-producing bacteria are added, with the liquefaction of the mass provoked by the action of enzymes from the fish (FAO, 2007). The enzymes, mainly from the digestive organ, break down protein into smaller soluble unit and the acid helps to speed up their enzyme activity while preventing bacterial spoilage (Al-Abri *et al*., 2014). Fish silage or liquefied fish protein is a mixture of fish liquid by enzymes in the presence of acids. The commonly used acids are formic and mineral acids. The acid acts as bacteriostatic agent by lowering the PH of the fish waste to a point where pathogenic and putrefying organisms are not viable. The enzymes are involved in the breakdown of proteins and lipids to amino acids and free fatty acids respectively. These enzymes are referred to as digestive enzymes (Opara and Al-Jufaili, 2006).

Fish silage can be categorized in two methods, viz. acid silage and bio-fermented silage. Acid silage is produced by mixing fish waste with inorganic (sulfuric acid, hydrochloric acid) and organic acid (formic acid, propionic acid) or mixture of both organic and inorganic acid, while bio-fermented silage is obtained by adding fermentable sugar to fish biomass. Fermentation is carried out by lactic acid bacteria (LAB) which are already present in a fish mass or added externally for successful fermentation (Raa and Gildberg, 1982).

Research has shown that most species of fish can be used for making silage. Fatty fish and fresh fish liquefy more quickly than white fish offal and stale fish and sharks and rays tend to be difficult to liquefy (Tatterson and Windsor, 2006). The process can be increased by heating the mixture. Liquefaction is slow at lower temperatures so the temperature should be at least 20°C (TDRI, 1982). Higher temperatures can inactivate the enzymes responsible for liquefaction, but the materials liquefy rapidly at 40°C (TDRI, 1982). Raw materials stored at 2ºC and 23ºC have to be kept for long periods, sometimes for up to a year, to produce a silage product. Keeping for longer times causes oils in the silage to undergo rapid deterioration and soluble nitrogen content to increase.

Preservation with organic acids can be achieved at slightly higher pH levels so less acid is required and neutralization is not required. Formic acid has some

* **Corresponding author.**
E-mail address: abdoobaia@gmail.com
DOI: 10.21608/jssae.2020.126759

bacteriostatic action and is a good option but more expensive than mineral acids. The pH when adding formic acid should be 3.6-4 (Tatterson & Windsor, 2006).

Study an attempt was made for transformation of fish market waste into silage by using three different methods: Inorganic (98% sulfuric acid with weight percentage of 2.5, 3.5 and 4.5%), organic (98% formic acid with weight percentage of 2.5, 3.5 and 4.5%). The appropriate amount of sulfuric acid, formic acid and molasses for preparation of fish silage were determined as 3.5%, 3.5% and 15% respectively (Palekar *et al*., 2017).

Fish silage can be used in aquaculture feeds. Including 30-35% fish silage in fish diets (Enke *et al*., 2009) increased body weight gain, total body length, final body weight, and specific growth rate. Better production performance without any adverse effects on survival and water quality was also achieved.

The nutritional value of fish silage is in the high protein digestibility due to the fact that protein is already well hydrolyzed and of the presence of lysine and tryptophan in high concentrations as well as of other essential amino acids. After bioconversion, the product is a high-quality autolyzed source of protein which can be used in animal feed and in the development of new foods, thus becoming a source of free amino acids and peptides of high quality, hardly obtained by other technological processes (Borghese, 2008).

Fish waste was converted into fishmeal or utilized in the production of organic fertilizers and composts, which have significant benefits over chemical-based products (Archer *et al*., 2001). Besides, the capital investment is significantly less compared to other fish fertilizer product in market. Fish silage contain more valuables nutrient that is good for plant growth and soil microbes. Pak choy belonging to family Brassicaceace is becoming increasingly popular with gardeners as an alternative to cabbage (Royal Horticulture Society (RHS, 2010).

The aim of the present study was conducted to study the effect of engineering factors, types of fish waste and types of acid on fish minced to make acid silage met the criteria of low cost and low technology process.

MATERIALS AND METHODS

Materials

Two experiments were carried out at Instruments Laboratory of Agricultural Engineering Research Institute., during the august 2020. The experiment (1) to study effect the mincing machine and waste fish types on fish silage production. The experiment (2) to effect the types of acid on fish silage making.

Fish

Fresh fish wastes were procured from Manzala Lake, Dakahlia governorate. Three types of fish waste namely, Nile tilapia, catfish and combination between fingerlings and catfish. A total fish waste of 15 kg was thawed, washed, and grinded into paste using mincing machine for preparation different types of acid silage.

mincing machine

The contents of the mincing machine have been modified in terms of cutter knife unit consists of 4 blades and die, with the stability of the screw conveyor. Two cutter knifes were used. the first conical knife and the second, straight knife. Three types of die were used, The first with a diameter of 3 mm, a number of holes 110, the second with a diameter of 5 mm, a number of holes 100 and the third with a diameter of 7 mm, a number of holes 78. An electric motor of 3 hp (2.24 kW) was conducted operate mincing machine.

Acids

Mineral acids such as (Sulfuric and Hydrochloric) and organic acids such as (Formic and Acetic) were used in this study.

Instruments

InfraRed Thermometer With Laser Pointer

InfraRed Thermometer with Laser Pointer was used to measures room temperature.

Model: (42525A), Range: (-20 to 400 ^{0}c), Accuracy: (± 3% or ± 3^{0}c).

PH meter

The pH was measured using a PH meter, Model: (PHep HI 98107), Range: (0.0 to 14 pH), Resolution: (0.1 pH), Accuracy: (±0.1 pH).

Digital Brix Refractometer

The refractometer was used to rapid and accurate determination of fluid concentrations., Model: (BOE 32195), Range: (0 to 95%), Accuracy: (± 0.5).

Resistive Material Moisture Measuring

The fish silage temperature and moisture content were measured using Resistive material moisture measuring with digital display.

Model: (GMH 3830), Range: (0 to 100% Moisture content and -40- 200 ^{o}C), Resolution: (0.1 % - 0.1^{o}C), Accuracy: (± 0.2%).

Dry matter

Accurately weighed samples were placed on watch glasses or porcelain dishes and dried in 105 ^{o}C oven for 24 hours. The residual material was expressed as dry matter per 100 g of original sample.

Studied factors

Performance description of the mincer was shown by studying the influence of operating treatments as follows:

- Three different of the fish waste namely: Nile tilapia fingerlings (F1), catfish (F2) and mixing between fingerlings, catfish (F3);
- Two cutter knifes, the first is a steel conical K1) and the second is a cast straight (K2).
- Three die hole diameters of (D1=3, D2=5 and D3=7 mm).
- Three acid types (mineral, organic and combination between mineral and organic).

Experimental procedure and measurements

Experimental (1)

For examining the effects of two cutting knife, three die diameter and three type of fish on fish silage production were identified under 18 treatments.

Experimental (2)

For examining the effects of mineral, organic acids and combination between them on fish silage making according to (Carmo *et al.*, 2016 and Palekar *et al.*, 2017). The following acids were used:

1-Mineral acids: sulfuric acid and hydrochloric acid.

2-Organic acid: acetic acid and formic acid.

3- sulfuric acid: acetic acid, sulfuric acid: formic acid, hydrochloric acid: acetic acid and hydrochloric acid: formic acid.

All measurements were done in triplicate. The main experiment was repeated three times and analytical data were averaged.

Silage making using mineral acid

250 gram of minced fish waste was poured in glass container and 98 % sulfuric acid and hydraulic acid with weight percentages of 3.5 % (v/w) and 32.5 mg of Butylated Hydroxy Toluene were added to each sample.

The mixture was stirred regularly with sterile glass rod to ensure through mixing. Samples were kept at average ambient temperature 33 °C for 30 days and stirred every 8 hours. pH changes were measured by pH meter and recorded until it reached a stable level.

Silage making using organic acid

The same above preparing simple but added 98 % formic acid and acetic acid. The mixture was stirred regularly with sterile glass rod to ensure through mixing.

Samples were kept at average ambient temperature 33 °C for 30 days and stirred every 8 hours. pH changes were measured by pH meter and recorded until it reached a stable level.

Silage making using mixing mineral and organic acids

The same above preparing simple but added (98 % sulfuric: acetic acid, 98 % sulfuric: formic acid, 98 % hydraulic: acetic acid and 98 % hydraulic: formic acid).

The mixture was stirred regularly with sterile glass rod to ensure through mixing. Samples were kept at average ambient temperature 33 °C for 30 days and stirred every 8 hours. pH changes were measured by pH meter and recorded until it reached a stable level.

Total solids are made up of soluble solids and insoluble solids. High dry matter content in the soluble solids would then be used as the criterion for identifying the best fish silage as mentioned by (Oulavalichal, 2010).

Statistical analysis

The data were analyzed to test significant difference by applying analysis of variances (ANOVA) tools using SPSS package 20. The significant differences were tested by 5 % level of significances and are mentioned as $p<0.05$ for significances difference.

RESULTS AND DISCUSSION

Experimental (1)

Effect of minced machine treatments and fish types on total dray matter

The effect of fish minced machine treatments (F1K1D1 to K2D3F1) on total dry matter content of Nile tilapia fingerlings are presented in (Table 1). As shown in the table, the obtained ranges of total dry matter were (30.2 to 40.1) g/100 g fish and soluble solids were (7.2 to 11.0) g/100g minced fish. The results in Table (1) also show that, the (F1K1D1) recorded highest values of soluble solids of 11 g/100g minced fish. While (K2D3F1) recorded a lowest value of soluble solids of 7.2 g/100g minced fish.

The highest soluble solids content should be due to the fact that the treatment (F1K1D1) with a conical cutting knife and a die hole with a narrow diameter and less than other die hole, thus it a very fine minced fish that can be fermented by bacteria from the coarser minced fish.

Results of this table indicate that, the total dry matter achieved significant ($P < 0.05$) difference were noticed among of machine treatments. The largest coefficient of variation (CV %) occurred in the soluble solids with 16.90 %, followed, in insoluble solids with 12.93 %, and finally total solids with 12.04 %.

Table 1. Total dry matter content of fingerlings fish minced.

Treatments	Total dry matter (g/100 g)		
	Insoluble solid	Soluble solid	Total solids
K1D1F1	29.1	11.0	40.1
K1D2F1	28.2	10.0	38.2
K1D3F1	30.5	7.6	38.1
K2D1F1	28.5	8.3	36.8
K2D2F1	22.0	8.2	30.2
K2D3F1	23.1	7.2	30.3
F	0.004*	0.022*	0.003*
CV (%)	12.93	16.90	12.04
SE	1.42	0.60	1.75
Average	26.9	8.72	35.62

The effect of fish minced machine treatments (K1D1F2 to K2D3F2) on total dry matter content of catfish are presented in (Table 2). As shown in the table, the obtained ranges of total dry matter were (34.2 to 45.1) g/100 g fish and soluble solids were (9.2 to 12.8) g/100g minced fish. The results in Table (1) also show that, the (K1D1F2) recorded highest values of soluble solids of 12.8 g/100g minced fish. While (K2D3F2) recorded a lowest value of soluble solids of 9.2 g/100g minced fish. The highest soluble solids content should be due to the fact that the treatment (K1D1F2) is gives a fine minced fish that helps bacteria in fermentation.

Results of this table indicate that, the total dry matter achieved significant ($P < 0.05$) difference were noticed among of machine treatments. The largest coefficient of variation (CV %) occurred in the soluble solids with 13.10 %, followed, in insoluble solids with 9.96 %, and finally total solids with 9.65 %.

Table (2) presents the total dry matter related to different treatments of fish mincing machine.

Table 2. Total dry matter content of catfish minced.

Treatments	Total dry matter (g/100 g)		
	Insoluble solid	Soluble solid	Total solids
K1D1F2	32.3	12.8	45.1
K1D2F2	32.6	11.3	43.9
K1D3F2	30.1	9.3	39.4
K2D1F2	28.1	10.4	38.5
K2D2F2	28.8	9.9	38.7
K2D3F2	25.0	9.2	34.2
F	0.004*	0.022*	0.003*
CV (%)	9.65	13.10	9.96
SE	1.15	0.56	1.62
Average	29.47	10.48	39.97

The effect of fish minced machine treatments (K1D1F3 to K2D3F3) on total dry matter content of mixing fingerlings and catfish are presented in (Table 3). As shown in the table, the obtained ranges of total dry matter were (40.7 to 47.1) g/100 g fish and soluble solids were (8.6 to 14.0) g/100g minced fish. The results in Table (1) also show that, the (K1D1F3) recorded highest values of soluble solids of 14 g/100g minced fish. While (K2D3F3) recorded a lowest value of soluble solids of 8.6 g/100g minced fish. The highest soluble solids content should be due to the fact that the treatment (K1D1F3) is gives a fine minced fish that helps bacteria in fermentation.

Results of this table indicate that, the total dry matter achieved significant ($P < 0.05$) difference were noticed among of machine treatments. The largest coefficient of variation (CV %) occurred in the soluble solids with 16.17 %, followed, in insoluble solids with 5.44 %, and finally total solids with 3.73 %.

Table 3. Effect of machine treatments on total dry matter content of combination between (fingerlings, catfish) minced.

Treatments	Total dry matter (g/100 g)		
	Insoluble solid	Soluble solid	Total solids
K1D1F3	33.1	14.0	47.1
K1D2F3	34.0	12.9	46.9
K1D3F3	35.0	10.6	45.6
K2D1F3	32.4	11.9	44.3
K2D2F3	31.8	11.5	43.3
K2D3F3	32.1	8.6	40.7
F	0.004*	0.022*	0.003*
CV (%)	3.73	16.17	5.44
SE	0.50	0.76	0.99
Average	33.07	11.58	44.65

Finally, the results in Tables (1, 2 and 3) also show that, the catfish recorded higher values of (20 %, 12 %) for soluble solids content and total solids, respectively than fingerlings. Also, the fish combination recorded higher values of (10.5 %, 11.7 %) for soluble solids content and total solids, respectively than catfish. The highest value of soluble solids content for all experiment (K1D1F3) was (14g/ 100g minced fish), it was concluded that the best fish type for making fish silage is combination between Nile tilapia fingerlings and catfish.

In general, it was noticed that, the best treatment for making fish silage was the treatment (K1D1F3) (conical cutter knife, die of 3 mm diameter and mixing between tilapia fingerlings and catfish), because it gave the highest soluble solids content (14g/ 100g minced fish), as well as obtaining silage with a high degree of smoothness, which helps the speed of action of the enzymes liquefaction silage

Experimental (2)

Acid fish silage

The following conditions were used to conduct the experiment: 100 g of thawed minced fish was stored in plastic bags at room temperature of 33 °C and PH of 3.5-4 for 30 days. The effect of mineral, organic acid and in combination on silage process was investigated.

Mineral acids

The effect of type of acid on the total dry matter of the treated minced fish was determined for the control (no added acid) and each acid (Table 1). Initial total dry matter of the minced fish was 40 g/100 g. This is converted to soluble matter during the silage process. The insoluble material in the control decreased with processing time, which is represented by an increase in soluble solids.

Table (4) presents that, the total dry matter related to the mineral acid of minced fish. As shown in the table, the obtained value of total solids was 39.4 g/100 g minced fish for sulfuric acid, indicating that no material had been lost even though about 1.52 %, and obtained value of soluble solids of (10.2 g/100 g fish) had been solubilized. The results in table (4) also show that, the obtained value of total solids treated decreased from 40 g/100 g minced fish to 30.5 g/100 g, which represents loss of product for hydrochloric acid, and obtained value of soluble solids of (9.7 g/100 g fish).

Hydrochloric acid induced more drastic changes. The increase in soluble solids content were less than achieved with Sulfuric acid. The odor of samples been acidified to 4 pH was acceptable. Even though visual observations indicate that adding hydrochloric acid produced a liquid silage, Sulfuric acid gave a better-quality silage because it has the highest amount of soluble solids and there was minimal loss of total solids. Biochemical changes occurring during liquefaction convert some of the solids in the bones, scales and flesh to ammonia, soluble peptides and other volatile substances that can evaporate. This represents loss of product. These compounds also produce a very unpleasant odor.

Table 4. The effect of mineral acid on total dry matter in minced fish.

Acid type	Total dry matter (g/100 g)		
	Insoluble solid	Soluble solid	Total solids
Control (day 1)	40	0	40
Control (day 30)	24.2	8.3	32.5
Sulfuric (day 1)	40	0	40
Sulfuric (day 30)	29.5	10.2	39.4
Hydrochloric (day 1)	40	0	40
Hydrochloric (day 30)	20.8	9.7	30.5

Organic acids

Usually less organic acid is required to obtain the fish pH that required to preserve.

Table (5) presents that, the total dry matter related to the organic acid of minced fish. As shown in the table, the highest value of total solids was (37.1 g/100 g minced fish) for acetic acid and produced the obtained value of soluble solids of (12.3 g/100 g minced fish). Samples with acetic acid lost only 7.82 % of the initial solids content.

The results in table (5) also show that, the obtained value of total solids was 34.6 g/100 g minced fish for formic acid and obtained value of soluble solids of (11.6 g/100 g fish). Samples with formic acid lost 16 % of the initial solids content due to biochemical reactions.

Silages produced with organic acids had a similar odor to mineral acid silages and acceptable. Of all the organic acids used, acetic acid gives the highest soluble solids with only slight loss in total solids and hence is the recommended additive. Overall, adding organic acids produced better silages than adding mineral acids.

Table 5. The effect of organic acid on total dry matter in minced fish.

Acid type	Total dry matter (g/100 g)		
	Insoluble solid	Soluble solid	Total solids
Control (day 1)	40	0	40
Control (day 30)	24.2	8.3	32.5
Acetic (day 1)	40	0	40
Acetic (day 30)		12.3	37.1
Formic (day 1)	40	0	40
Formic (day 30)	23.0	11.6	34.6

Acid combination trials

The literature indicates that combining organic and mineral acids produces good silage. This should be due to chemical reactions between the acids. A set of mineral-organic acid combinations investigated to identify how to produce good silage with the minimal acid.

Mineral -Organic acid combinations

Table (6) presents total dry matter related to the combination between mineral and organic acid of minced fish. As shown in the table, the obtained value of total solids was (38.2 g/100 g minced fish) for sulfuric-acetic combination acid and produced the obtained value of soluble solids of (17.0 g/100 g minced fish). Samples with sulfuric-acetic combination lost 5 % of the initial solids content. As shown in the table, the obtained value of total solids was (37.0 g/100 g minced fish) for sulfuric-formic combination acid and produced the obtained value of soluble solids of (16.5 g/100 g minced fish). Samples with sulfuric- formic combination lost 7.82 % of the initial solids content. As shown in the table, the obtained value of total solids was (34.9 g/100 g minced fish) for hydraulic-acetic combination acid and produced the obtained value of soluble solids of (14.8 g/100 g minced fish). Samples with hydraulic -acetic combination lost 13 % of the initial solids content. As shown in the table, the obtained value of total solids was (32.6 g/100 g minced fish) for hydraulic -formic combination acid and produced the obtained value of soluble solids of (13.0 g/100 g minced fish). Samples with hydraulic - formic combination lost 19 % of the initial solids content.

Table 6. The effect of combination mineral and organic acid on total dry matter in minced fish.

Acid type	Total dry matter (g/100 g)		
	Insoluble solid	Soluble solid	Total solids
Control (day 1)	40	0	40
Control (day 30)	24.2	8.3	32.5
Sulfuric -Acetic (day 1)	40	0	40
Sulfuric -Acetic (day 30)	21.2	17	38.2
Sulfuric -Formic (day 1)	40	0	40
Sulfuric -Formic (day 30)	21.2	16.5	37
Hydrochloric -Acetic (day 1)	40	0	40
Hydrochloric -Acetic (day 30)	20.1	14.8	34.9
Hydrochloric -Formic (day 1)	40	0	40
Hydrochloric -Formic (day 30)	19.6	13	32.6

Finally, the results in Tables (4, 5 and 6) also show that, the sulfuric acid recorded higher values of (10.2, 39.7 g/ 100g minced fish) for soluble solid content and total solid, respectively in comparison with the hydraulic acid of (9.7, 30.5 g/ 100g minced fish). The acetic acid recorded higher values of (12.3, 37.1 g/ 100g minced fish) for soluble solid content and total solid, respectively in comparison with the Formic acid of (11.6, 34.6 g/ 100g minced fish). The sulfuric-acetic acid recorded higher values of (17.0, 38.2 g/ 100g minced fish) for soluble solid content and total solid, respectively in comparison with the sulfuric - formic acid of (16.5, 37.0 g/ 100g minced fish). The hydraulic -acetic acid recorded higher values of (14.8, 34.9 g/ 100g minced fish) for soluble solid content and total solid, respectively in comparison with the hydraulic-formic acid of (13.0, 32.6 g/ 100g minced fish).

In general, it was noticed that the best acid type for making fish silage is the sulfuric acid and acetic acid for all experiment 2, because it being the highest value of soluble solid content (17g/ 100g minced fish)

CONCLUSION

The results of the various experimental show that proper liquefaction of minced fish to produce silage occurs when the mixture is at pH 4 and stored at 33 °C for three to 30 days. There should be adequate stirring to ensure homogeneity and remove localized pH variations. The pH should be re- adjusted to 4 to help increase the biochemical reactions occurring. The best treatment for making fish silage is the first treatment (K1D1F3) for all experiment (1), because we get finely minced fish. Also, the fish type (combination between Nile tilapia fingerlings and catfish) was chosen because it gave the highest soluble solids content. The best results when using mineral acid to acidify the silage mixture are obtained with sulfuric acid. These acids produce higher soluble solid content (10.2 g/100g minced fish) and there is little loss of total solid about (1.52 %). The best results when using organic acid are obtained with acetic acid. These acids produce higher soluble solid content (12.3 g/100g minced fish) and there is little loss of total solid about (7.82 %). Results from all the experiments showed that best results were produced using sulfuric-acetic acid combination and produced the highest soluble solids content (17g/ 100g minced fish) and loss of total solids about (5 %). The studies indicate that a good acid silage should be made by adding 3.5 % sulfuric acid and acetic acid until the pH of 4 keeping the mixture at 33 °C for 30 days. The pH should be maintained throughout the process.

REFERENCES

Al-Abri, A. S., Mahgoub, O., Kadim, I. T., Al-Marzooqi, W., Goddard, S. J. and Al- Farsi, M. (2014). Processing and evaluation of nutritive value of fish silage for feeding omani sheep. Journal of Applied Animal Research, 42 (4): 406-413.

Archer, M.R., Watson, R.& Denton, J.W. (2001). Fish waste production in the United Kingdom-The quantities produced and opportunities for better utilization. Seafish Technology 537: 4-5.

Berenz, Z. (2003). Utilización del ensilado de residuos de pescado en pollos. http :// www .fao .org /waicent /faoinfo/agricult/aga/agap/ aph134/cap2.htm. 11p. (25 fev. 2003).

BORGHESI, R (2008). Apparent digestibility coefficient of protein and amino acids of acid, biological and enzymatic silage for Nile tilapia (Oreochromis niloticus). Aquaculture Nutrition, v. 14, n. 3, p.242-248. Disponível em: < http :// onlinelibrary .wiley .com/doi/10.1111/j.1365-2095 .2007 .00523 .x/ abstract>.

Carmo J. R., C. J. Pimenta, M. M. Oliveira, R. M. E. Oliveira, R. E. Orlandi and M. E. Pimenta (2016). QUALITY OF ACID SILAGE FROM TILAPIA (Oreochromis niloticus) FILLETING WASTE DURING STORAGE. International Journal of Current Research. Vol. 8, Issue, 04, pp.29000-29007, April, 2016.

Enke, D.B.S., Lopes, P.S., Kich, H.A., Britto, A.P., Soquetta, M. & Pouey, J.L.O.

F. (2009). Use of fish silage meal in diets for juvenile jundia fish. Ciencia Rural, 39(3), 871-877.

FAO (2007). Animal feed resources information system. http:// www.fao.org.

Hanafy, M. A. and Ibrahim, S. M. (2004). Storage stability of yogurt fermented fish silage. Journal of Egyptian Academic Social and Environmental Development, 5:23–41.

Handling, Preservation and Processing in the Tropics: Part 2. London.

Hasan, B. (2003). Fermentation of fish silage using Lactobacillus pentosus. Journal Nature Indonesia 6 (1):11–15.

Opara, L.U. and S.M. Al-Jufiaili (2006). Status of fisheries pot harvest industry in the Sultaneof Oman: Part 2 Quantification of fresh fish losses. J. Fisher. Int., 1(2-4): 150-156.

Oulavallickal T. (2010). Using Koi Carp to Produce Fish Silage. Master of Engineering. The University of Waikato, New Zealand.

Pagarkar, A. U., Basu, S., Mitra, A. (2005). An evaluation of the suitability of croaker fish (Otolithus sp.) waste product silages in feed Macrobrachium rosenbergii. Biosciences, Biotechnology Research Asia, 3(2):297-306.

Palkar N. D., J.M. Koli, S.B. Patange, S.T. Sharangdhar, R.K. Sadavarte and A.E. Sonavane (2017). Comparative Study of Fish Silage Prepared from Fish Market Waste by Using Different Techniques. *Int.J.Curr.Microbiol.App.Sci* (2017) *6*(12): 3844-3858.

Raa, J., and Gilberg, A., (1982). Fish silage: a review. Journal of the Food Science and Nutrition 61: 383-419.

RHS (Royal Horticulture Society) (2010). Speedy Pak Choi. Retrieved 9 February 2014 from http://www.rhs.org.uk/Plants/RHS-Publications /Journals /The- Garden/ Past- Issues /2011 - issues /June /Speedy-pak-choi

Ristic, M.D.; Filipovic, S.S.; Sakac, M.L.J. (2002). Liquid protein feedstuffs from freshwater fish byproducts as a component of animal feed. Romanian Biotechnological Letters, 7, 729-736.

Tatterson, I.N.& Windsor, M. L. (2006). Fish Silage. Journal of the Science of Food and Agriculture25: 369-379.

TDRI (Tropical Development and Research Institute). (1982). Fish silage. Fish

تأثير بعض العوامل الهندسية على تصنيع سيلاج الأسماك

عبدالوهاب رمضان عبيه و محمد منصور شلبى رفاعى
معهد بحوث الهندسة الزراعية، الدقى، الجيزة

في الدراسة الحالية تم إجراء تجربتين في معمل الأجهزة بمعهد بحوث الهندسة الزراعية خلال أغسطس 2020. التجربة الأولى لتأثير آلة الفرم على إنتاج سيلاج الأسماك. التجربة الثانية لتأثير نوع الحامض على إنتاج سيلاج السمك. الهدف من هذه الدراسة هو تأثير العوامل الهندسية ونوع مخلفات الأسماك ونوع الحامض على الأسماك المفرومة لإنتاج سيلاج حمضي يفي بمعايير التكلفة المنخفضة والعملية التكنولوجية المنخفضة. كانت العوامل المدروسة عبارة عن عدد 2 سكين قاطع ، الأولى مخروطية من الصلب والثانية مستقيمة من الزهر وثلاثة أقراص تشكيل بأقطار 3 و 5 و 7 مم. ثلاثة أنواع من مخلفات الأسماك وهي إصبعيات البلطي النيلي وسمك القراميط وخلط الاصبعيات مع القراميط. ثلاثة أنواع من الأحماض (المعدنية والعضوية والمختلطة بين المعدنية والعضوية). أظهرت نتائج التجربة الأولى أن أفضل معاملة لعمل سيلاج السمك هو المعاملة (سكين قطع مخروطي ، قرص تشكيل بقطر 3 مم والخلط بين إصبعيات البلطي وسمك القراميط)، لأنها أعطت أعلى محتوى من المواد الصلبة الذائبة (14 جم/ 100 جرام سمك مفروم) وكذلك الحصول على سيلاج بدرجة نعومة عالية مما يساعد على سرعة عمل انزيمات تسييل السيلاج. أظهرت نتائج التجربة الثانية أنه تم الحصول على افضل النتائج عند استخدام الاحماض المعدنية مع حمض الكبريتيك، حيث تنتج هذه الأحماض محتوى صلبًا ذائبًا أعلى (10.2 جم / 100 جم سمك مفروم) وهناك خسارة قليلة في إجمالي المواد الصلبة حوالي (1.52٪). تم الحصول على أفضل النتائج عند استخدام الأحماض العضوية مع حمض الأسيتيك، حيث تنتج هذه الأحماض محتوى صلبًا ذائبًا أعلى (12.3 جم / 100 جم سمك مفروم) وهناك فقد ضئيل في المواد الصلبة الكلية حوالي (7.82 ٪). تم الحصول على أفضل النتائج عامة عند استخدام مزيج حامض الكبريتيك والأسيتيك وأنتجت أعلى محتوى من المواد الصلبة الذائبة (17 جم / 100 جم سمك مفروم) وفقد للمواد الصلبة الكلية حوالي (5٪). نستنتج من هذه النتائج إلى أنه يمكن عمل سيلاج حمضي عن طريق إضافة 3.5٪ من خليط حمض الكبريتيك - حمض أسيتيك حتى يصبح الرقم الهيدروجيني للأسماك المفروم 4.0 والحفاظ على الخليط عند 33 درجة مئوية لمدة 30 يومًا.