

## EFFICIENCY ENHANCEMENT OF SILAGE MAKING FROM FISH WASTES

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### ABSTRACT

*The present study was to investigate the suitability of using fish wastes as raw material for silage making. To describe some of the major engineering and physical aspects of ensiling process, the following factors were considered as follows: four different mixing ratios of fish waste with rice bran, 1.5:1, 2.34:1, 3.35:1 and 4:1; three different formic acid additions 2, 3 and 4%; four diverse pressing pressure 7.85, 12.75, 17.65 and 22.56kPa; two unlike packaging color white and black and three dissimilar ranges of temperature 25 – 35, 35 – 45 and 45 – 55°C during harvesting time. The experimental results showed that the best mixing ratio of fish waste with rice bran was 3.35:1 which gives moisture content of 62.3%wb. The shortest ensiling period of 25 days was achieved at pressing pressure of 22.56kPa, formic acid adding of 4% and black coverage color. However, the ensiling period tremendously decreased under controlled surrounding temperature at a range of 45 – 55°C at the 9<sup>th</sup> day; the pH of silage material was 3.25, total volatile fatty acid was of 1.95g/kg dry matter, Lactic acid bacteria was 6.2g/kg dry matter, crude protein was of 36.12%, maximum temperature observed at the end of fermentation period at the 6<sup>th</sup> day was of 36.1°C, minimum temperature was at the 9<sup>th</sup> day was of 23.4°C at 9<sup>th</sup> day (harvesting day), the intensity of illumination value was of 44.5, 47.3, 53.3 and 58.3 lumen/m<sup>2</sup> at material thickness of 4cm at fermentation time of 3<sup>rd</sup>, 6<sup>th</sup>, 9<sup>th</sup> and 12<sup>th</sup> day respectively.*

**Keywords:** *fish silage, silage techniques, fish silage making, aquaculture, fish wastes*

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## INTRODUCTION

In Egypt the demand for animal protein is expected to increase progressively with each increase in human population. Fisheries sector plays a major role in alleviating protein deficiency and malnutrition, generating employment and foreign exchange earnings in Egypt. Besides, utilization of least-cost fishery wastes into powder by drying as (Abdallah *et al.*, 2017). Making silage from fish can minimize feed cost and thus reduce cost of aquaculture production. Egypt produces from natural resources 335613 ton/year and from fish farmers 1370660 ton/year with a total production of 1706273 ton/year and total fish waste of 230346 ton/year (MALR, 2016). There are some potential for gaining more value from fish wastes. Fish are rich in valuable minerals, enzymes, pigments and flavors that are required by many industries including food, agriculture, aquaculture and pharmaceuticals (Archer *et al.*, 2001). Good silage has a range of Lactic Acid Bacteria of (3.03 – 13.6g/kg dry matter) and Total Volatile Fatty Acid from 1.22 to 3.54g/kg dry matter (Gaafar, 2001 and Hossain, 2014). Fish waste represents half of the raw material volume of the processing industry and is a source of low-cost nutrients (Oetterer, 2002). The pH should be of 4 or lower to prevent bacterial spoilage. Therefore, the silage production tanks are acid resistant (Rose *et al.*, 2003). Silage technology is recognized as being the most useful one for solving wastes problem in fish industry. This procedure is safe, cost effective and eco-friendly too (Hanafy and Ibrahim, 2004). Rice bran contains 18 to 22% lipid. The carbohydrate and ash of rice bran varied from 25.9– 47.1% and 7.7–11.1% respectively (Cicero and Derosa, 2005). The use of fish silage in fish feeding has been widely studied. Due to the similarity of this protein source with the raw material and low cost, especially when compared to fish meal, silage has a high potential use in aquaculture (Goddard and Perret, 2005 and Arruda *et al.*, 2007). Silage can be defined as livestock feed that has been preserved through acidification. The acidic environment required for proper ensiling to take place results via fermentation in the absence of O<sub>2</sub> (Hancock and Collins, 2006). Ensilage processes are examples of without inoculation, Solid-State Fermentation refers to the cultivation of microorganisms on moist solid supports (Chen, 2009). They prepared silage from viscera of

different fish. Silage which made from herring offal contained 13.5% crude protein, 8.7% lipid, 75.4% moisture and 2.6% ash. Silage that made from white fish offal contained 15.0% crude protein, 0.5% lipid, 78.9% moisture and 4.2% ash (**Abowei and Tawari, 2011**). These fish wastes are an important source of proteins and lipids and therefore special efforts are being made to recover these valuable substances (**AMedrzyck and Wandzei, 2013**). A fish generally contains 45% flesh, 24-27% head, 12% skeleton, 3% skin, 4% cut off and 12% viscera including egg, milk and liver of its total body weight (**DOF, 2013**). Some scientist accepted the pH level (3.9 – 4.2). The demand for fish increased with increasing human populations. However, it has been estimated that for each ton of fish eaten, an equal volume of fish material were discarded either as waste or as a low value by product, it contain high amount of protein, lipid and mineral (**Karim et al., 2015**).

The main aim of the current study is to reduce the period of silage harvesting and find unconventional and alternative rations with producing silage from wastes of agricultural and fish production. The specific objectives are drawn as follows:

1. Experimenting four different mixed ratios (1.5: 1 ), (2.34: 1 ) , (3.35: 1 ) and (4: 1 ) fish waste: rice bran , to determine the best mixed ratio for making silage.
2. Studying the effect of three different additions of formic acid (2, 3 and 4%) on the fermentation time.
3. Investigating four different pressing pressures (7.85, 12.75, 17.65 and 22.56 kPa) on the fermentation time.
4. Studying the effect of two covering colors (white and black) on the fermentation time.
5. Investigating the effect of three different ranges of temperature 25 – 35, 35 – 45 and 45 – 55°C on the fermentation time.

### **MATERIALS AND METHODS**

The present work was carried out at the laboratory of Rice Mechanization Center at Meet Eldeebah, Qellin district, Kafr Elsheikh Governorate with co-operation of Sakha Animal Production Research Station and Aquaculture Research Station during the period from February to December 2016.

## Materials

Fish wastes were obtained from Elshakhloubah market, located in Sedi Salem, Kafr Elsheikh governorate, Egypt. They were grinded using mincing machine of 5mm.

Rice bran of variety Sakha 178 was used, in picture bulk solids materials, with a bulk density of  $0.29\text{g/cm}^3$ , Crude Protein 12 – 15%, crude fat 15 – 22%, crude fiber 7 – 11% , crude ash 6.6 – 9.9% , carbohydrate 34 – 52% ( El Kholy *et al.*, 2009 ).

## Experimental Procedures and Measuring Instruments

### Experimental Treatments

Fish waste silage making experiments were conducted as follows:

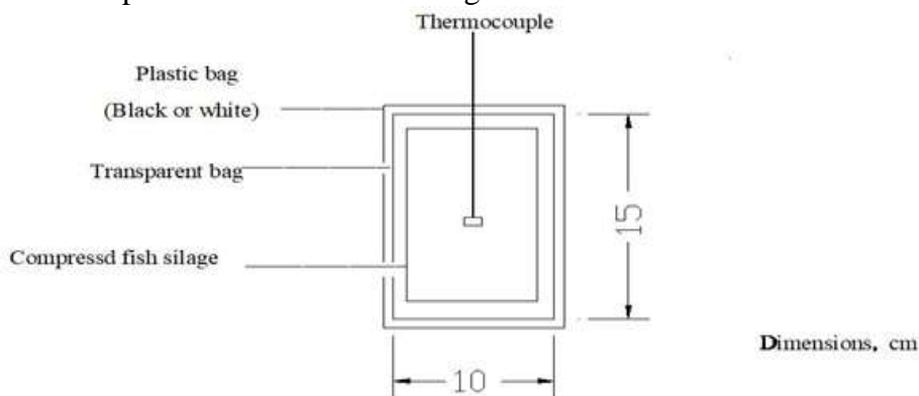
**First Experimental run:** In this experimental run, it was studied of four different mixing ratios 1.5: 1, 2.34: 1, 3.35: 1 and 4: 1, fish waste: rice bran. The mixing ratio 3.35: 1, fish waste: rice bran was selected because it gives moisture content of 62.3%wb and this percentage was recommended with it to make silage and appropriate for microorganisms environment according to previous studies as recommended by **MAFR, 2006**.

**Second Experimental Run:** According to the results obtained by the first experimental run, the optimum mixing ratios 3.35: 1, fish waste: rice bran was achieved. Three factors were studied in this experiment : the effect of three different formic acid additions of 2, 3 and 4% and investigate four different pressing pressures of 7.85 , 12.75 , 17.65 and 22.56kPa by manual pressure piston device with a measurement scale of 50 kg<sub>f</sub> to exclude the air occluded in the porous space of the material under study until maturity and the effect of two packaging material colors ( white and black ) on silage harvesting time .

Pressing Unit was consisted of compression unit and the manually pressure piston device were locally fabricated to measure silage pressure (Pascal). It was manufactured from iron sheets (3mm in thickness). Compression box has dimension of 15, 10 and 10 cm of length, width and height respectively. It was provided with a movable tray to take experimental treatment after compression and it has an iron cover with thickness of 5mm to resist the load of compression and uniformly transfer this load to the material under compression.

Packaging Process consists of two packing bags, inner plastic bag (transparent) and outer one (black or white) and outer packing of plastic bags (black or white) from polyethylene. Seventy two of identical plastic bags (polyethylene) were divided into two halves as: the first half is black and the second half is white above small cylindered plastic bags (double plastic bags). The black plastic bags pigments by dioxins material to give it the black color and containing its material, the properties of white plastic are made from polyethylene. The full capacity of each experimental treatment is about 400g., each experimental treatment is pressed by manual pressure piston device with a measurement scale of 50kg<sub>f</sub> to exclude the air occluded in the porous spaces of the material under study until maturity from the bags and ensiled until maturity. It was used formic acid 85% in the experimental work. For measuring the change in bulk temperature of fish silage through fermentation period, thermocouples were put at the center of each sample and a sealing material was used to completely close the sample to assure full sealing of each sample. Figure 1 presents a schematic diagram for a sample of the used experimental treatment and distribution of the thermocouples inside each sample.

**Third Experimental Run:** In this experimental trial, temperature was considered as an important factor because it kills unwanted microorganisms. Temperature incubator was modified to manage different ranges of temperature as follows: 25 – 35, 35 – 45 and 45 – 55°C and this experimental run is consisting of incubator and control unit.

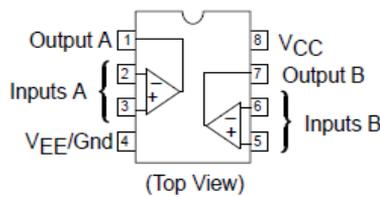


**Figure 1.** Position of thermocouples inside the plastic bags used for silage making experiments

**Incubator**

Three incubation units of wood (15 mm in thickness) with thermal conductivity (heat flux) 0.17W/m.°C, dimensions of 60cm length, 40cm width and 20cm height were installed for this experiment. Each incubator box has a door with a dimension of 60 x 40cm. Each incubator was covered externally by thermal wood film, containing internally an electrical lamp (heating source) of 100 Watt as a heater. Each incubator contains nine experimental treatments of silage mixture (silage bag) and two thermocouples, the first one located at the inside of silage bag to measure the temperature of the silage directly and the second one located inside the incubator to measure the surrounding temperature of silage samples.

**PIN CONNECTIONS**

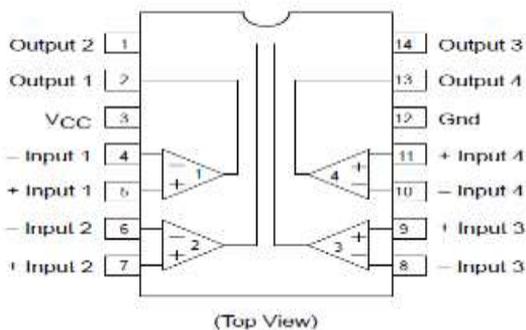


**Figure 2.** Connection diagram of the operational amplifiers LM358



**Figure 3.** Connection diagram of temperatures sensor of LM35

**PIN CONNECTIONS**

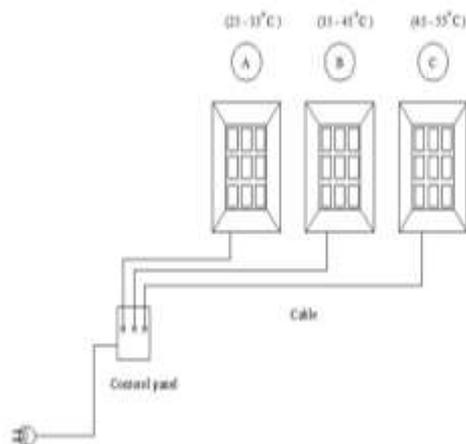


**Figure 4.** Connection diagram of the comparators LM339

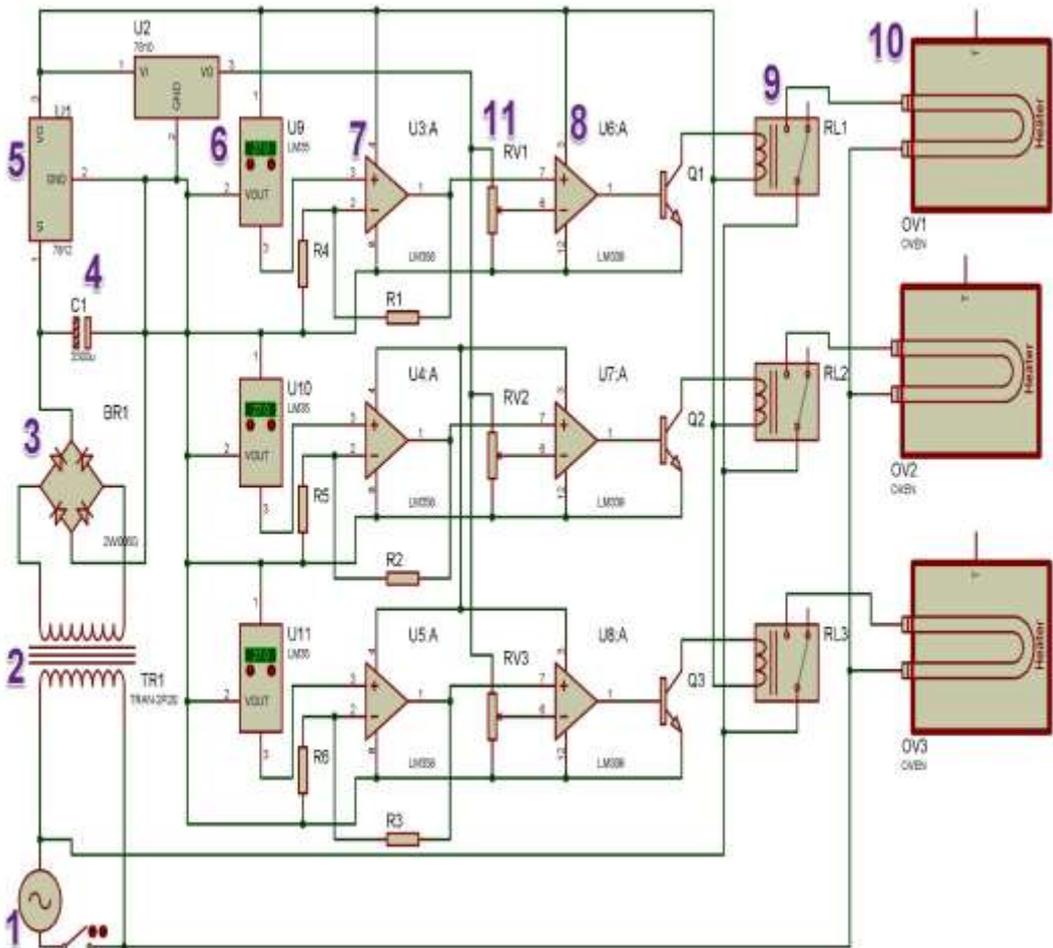
**Control unit:** As shown in Figures 5, 6 and 7, the control unit consists of the instruments that were used in the designed digital temperature of TAC1000HYC100, for temperature calibration and its wireless with USB sensor for reading the temperature within multimeter (10mv=1°C), Figures 2, 3 and 4.



**Figure 5.** Photograph of temperature control panel unit



**Figure 6.** Schematic drawing of the temperature control unit



- |   |                            |   |                                     |    |                                   |
|---|----------------------------|---|-------------------------------------|----|-----------------------------------|
| 1 | Electricity source<br>220V | 5 | Voltage regulator                   | 9  | Relays                            |
| 2 | Transformer<br>220/14V     | 6 | Temperature sensor<br>of LM35       | 10 | Heater                            |
| 3 | Bridge 4A                  | 7 | Operational amplifier of<br>LM358   | 11 | Variable resistance (RV1-<br>RV3) |
| 4 | Capacitors                 | 8 | Differential comparator<br>of LM339 | 12 | Resistor (R1-R6)                  |

**Figure 7.** Schematic and engineering drawing of the control panel component (temperature control)

## **Measurements and Instrumentation**

### **Determination of fish silage quality**

Silage extract was prepared by homogenizing 20g (wet material) from each variety and hybrid silage with 100ml distilled water in a blender for 10 minutes (**Waldo and Schultz, 1956**).

### **Silage temperature during fermentation process**

For both the second and third experimental runs, every sample was used for measuring the fermentation temperature through the ensiling period, the interface analog digital converter model TU-1000 with measuring channels connected to thermocouples (type T).

### **Silage moisture content**

Moisture was determined by placing an accurately weighed known of sample in a pre-weighted porcelain crucible in a hot air electric oven at 105<sup>0</sup>C for about 24 hours until constant weight was obtained.

### **PH value**

PH value was directly measured using Orian 680 digital pH meter.

### **Lactic acid**

Lactic acid was determined by titration with 0.1N sodium hydroxide solution using 0.5ml of phenolphthalein indicator according to the method of **Analytical Chemistry of Foods (1995)**.

### **Total volatile fatty acids**

Total volatile fatty acids were determined according to the method of **Wamer (1964)**.

### **Determination of crude protein**

Nitrogen in the sample was estimated by following the micro kjeldhal method as outlined by **Jackson (1973)**.

### **Optical properties**

Fish silage optical properties was measured by a light source of laser lamb with light spectrum 630: 660nm (5mw) and digital lux meter device to measure the transmission light of silage samples with thickness of 1mm position between two stripes of glass at thicknesses of 2, 3 and 4cm .

## **RESULTS AND DISCUSSION**

### **Effect of mixing ratio (Fish waste: Rice bran) on moisture content of silage process**

Table 1 shows the relationship between the mixing ratio (fish waste: rice bran) and moisture content %. With increasing fish waste at any mixed

ratio increase moisture content, the optimal PH value for silage depends on its moisture content. The achieved mixing ratio of (fish waste: rice bran) was of (2.35:1) which gives moisture content of 62.3%wb was chosen according to (MAFR, 2006).

**Table 1.** Relationship between the mixing ratio (fish waste: rice bran) and moisture content, %

Mixing ratio ( fish waste : rice bran )	MC , % wb
1.5 : 1	52.2
2.34 : 1	56.8
3.35 : 1	62.3
4 : 1	72.4

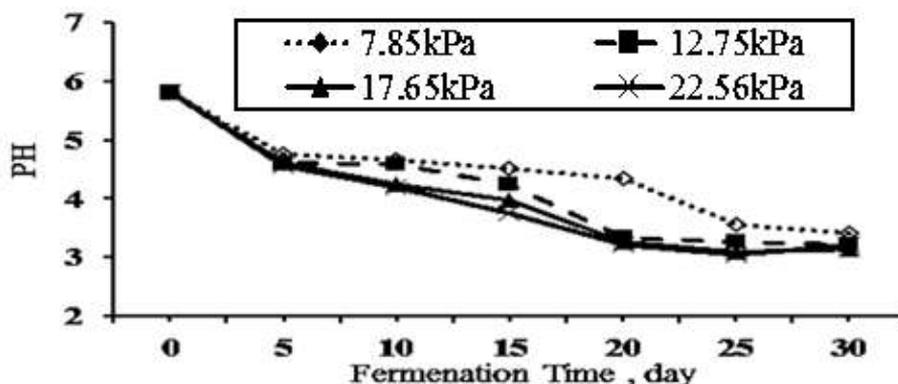
### Effect of pressing pressure on silage pH

pH of all samples increased with time through the first days of fermentation then returned to its normal level at the end of ensiling period as shown Figure 9.

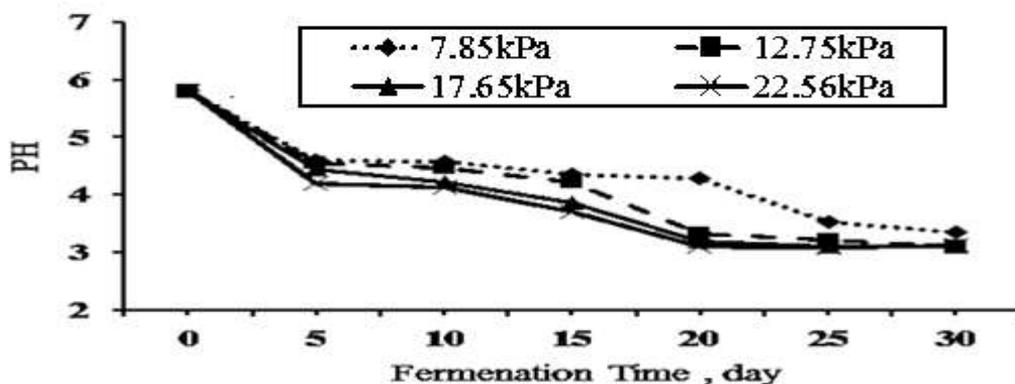
It is observed that at pressing pressure of 7.85kPa. pH value was of 4.6 at the 5<sup>th</sup> day and decreased even 3.35 at 30<sup>th</sup> day while at pressing pressure of 12.75kPa, pH value was of 4.55 at the 5<sup>th</sup> day and decreased even 3.11 at 30<sup>th</sup> day, at pressing pressure of 17.65kPa, pH value was of 4.45 at the 5<sup>th</sup> day and decreased even 3.11 at 25<sup>th</sup> day and at pressing pressure of 22.56kPa, pH value was of 4.2 at the 5<sup>th</sup> day and decreased even 3.11 at 20<sup>th</sup> day.

In general, the fermentation forces are controlled by formation of organic acids, mainly lactic acid by bacteria that grows in the presence of Limon-stone. Sufficient lactic acids may form soluble sugar, which lower the pH of silage and restrict the activity of undesirable microorganisms. Non-limiting microbial fermentation will continue until enough acid is produced to stop bacteria action. Moreover, it is a simple method to predict silage quality, but by itself it is unreliable because the optimal pH value for forage silage depends on the dry matter content. Generally, the prefer level of pH should be lower than 4.2 as mentioned by (Hossain, 2014).

In comparison of white and black coverage colors, the results illustrate that the black coverage color, formic acid addition 4%, and pressing pressure of 22.56kPa were the optimal conditions for making silage.



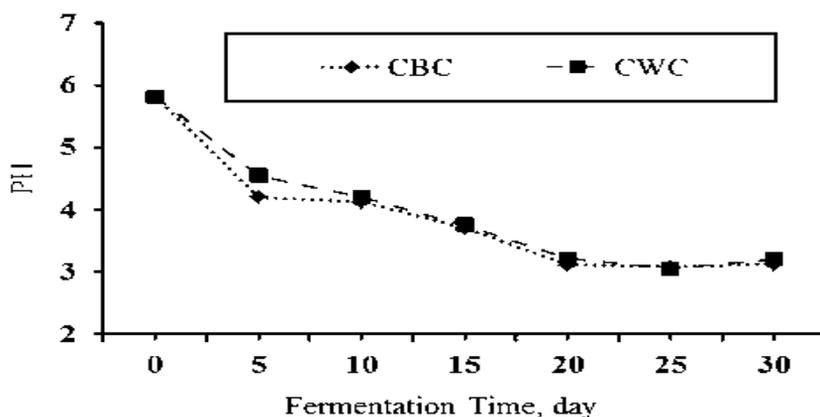
**Figure 8.** Silage pH behavior through the fermentation period at formic acid addition 4% and white coverage color



**Figure 9.** Silage pH behavior through the fermentation period at formic acid addition 4% and black coverage color

**Effect of coverage color addition on silage pH**

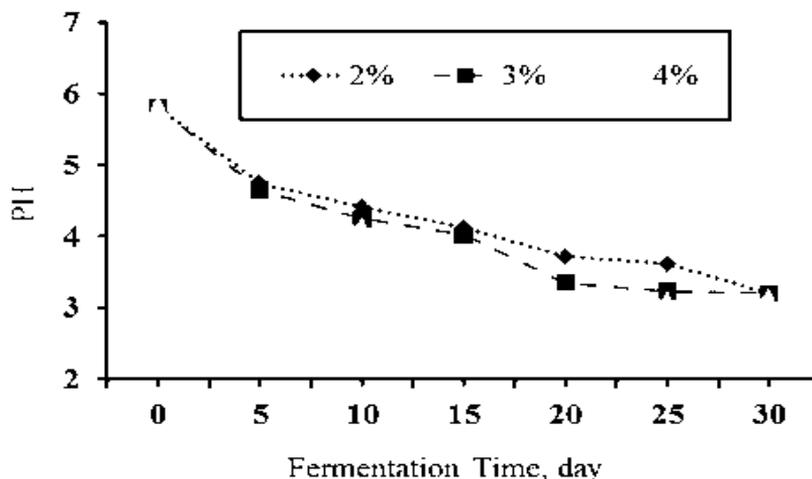
As shown at Figure 10, black coverage color and formic acid addition 4% decreasing pH value, because black coverage color helps on increasing the silage temperature and aerobic microorganism's losses minimum time and accelerates the fermentation. At formic acid addition 4%, PH value was of 4.2 at black coverage color at 5<sup>th</sup> day, 4.55 at white coverage color at 5<sup>th</sup> day, 3.12 at black coverage color (30<sup>th</sup> day), and 3.2 at white coverage color (30<sup>th</sup> day).



**Figure 10.** Silage pH behavior through the fermentation period under different coverage colors, white CWC and black CBC, at pressing pressure of 22.56kPa and formic acid addition 4%

**Effect of Formic acid addition percentage on silage pH**

As shown in Figure 11, it was observed that high pressing pressure of 22.56kPa and formic acid addition 4% , aerobic microorganisms were killed because formic acid addition 4% helps on formation of LAB and decreases pH value. Silage pH was of 4.2 at 5<sup>th</sup> day , 3.12 at 30<sup>th</sup> day at black coverage color.



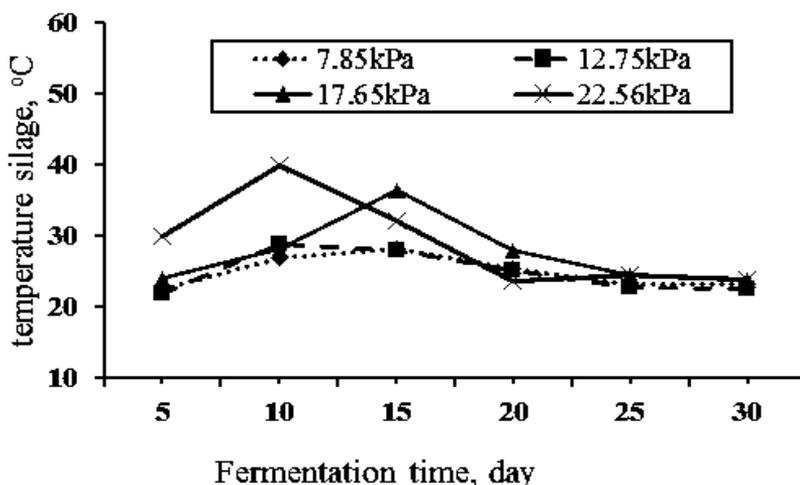
**Figure 11.** Effect Silage pH behavior through the fermentation period under different formic acid addition percentage at pressing pressure of 22.56kPa and black coverage color

**Silage temperature**

Effect of the Engineering variables on physical and chemical characteristics of silage during ensiling process

The bulk temperature of all samples steadily increases with the fermentation time throughout the first days of fermentation process, until reaching its peak value, and then it was decreased to its normal level at the end of ensiling period as shown at Figure 12. Also, it was observed that as the pressing pressure increases at pressing pressure to be of 22.56kPa and formic acid addition increases up to 4%, the pH of silage decreases and the temperature increases for its maximum level during fermentation time which helps to reduce fermentation period due to the extermination of aerobic microorganisms. As shown at Figure 13, formic acid addition 4% and black coverage color, it was observed that, at pressing pressure of 22.56kPa, maximum silage temperature value was of 39.7°C at 10<sup>th</sup> day, minimum silage temperature value was of 29.5°C at 5<sup>th</sup> day.

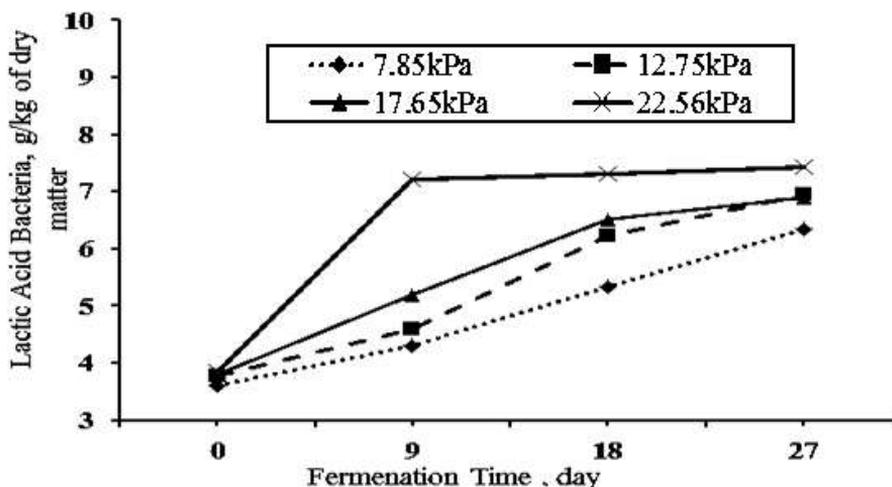
In general, the silage temperature of all treatments not exceed 40°C which considered as excessive heating affecting the silage quality and lowers digestibility of all the produced silage. In the current study it is found that the optimal status was occurred pressing pressure of 22.56kPa, formic acid addition 4% and black coverage color.



**Figure 12.** Silage temperature behavior through the fermentation period at formic acid addition 4 and black coverage color

**Silage Lactic Acid bacteria**

It's observed that as from Figure 13 the effect of different pressing pressures (7.85, 12.75, 17.65 and 22.56kPa) on lactic acid bacteria value at different formic acid additions 4% and black coverage color. As pressing pressure increases from 7.85 to 22.56kPa, lactic acid bacteria increase at all experimental treatments. It is observed that at pressing pressure of 7.85kPa, lactic acid bacteria value was 4.31g/kg of dry matter at 9<sup>th</sup> day and increases even 6.35 at 27<sup>th</sup> day while at pressing pressure of 12.75kPa, lactic acid bacteria value was of 4.58g/kg dry matter at 9<sup>th</sup> day and increases even 6.35g/kg dry matter at 27<sup>th</sup> day, at pressing pressure 17.65kPa, lactic acid bacteria value was of 5.18g/kg dry matter at 9<sup>th</sup> day and increases even 6.95g/kg dry matter at 27<sup>th</sup> day and at pressing pressure 22.56kPa, lactic acid bacteria value was 7.22g/kg dry matter at 9<sup>th</sup> day and increases even 7.42g/kg dry matter at 27<sup>th</sup> day. These results are within the values obtained by (Etman *et al.* 1994 and Gafar, 2001). So the optimal operating conditions were at pressing pressure of 22.56kPa, formic acid addition 4% and black coverage color.

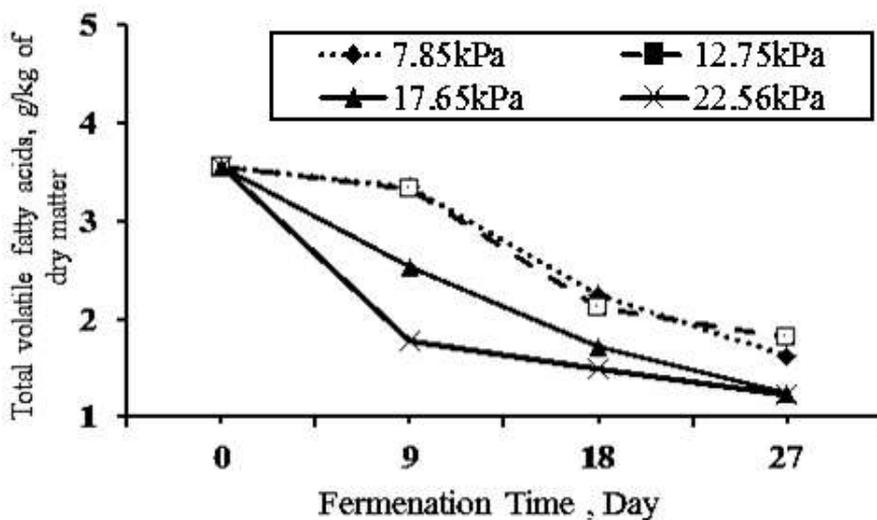


**Figure 13.** Effect of pressing pressure on silage lactic acid bacteria at formic acid addition 4% and black coverage color

**Silage Total volatile fatty acids (TVFA)**

The concentration of Total volatile fatty acids decreases as dry matter content. It was observed that from Figure 14 the effect of different

pressing pressures (7.85, 12.75, 17.65 and 22.56kPa) on Total volatile fatty acids value at formic acid addition 4% and black coverage color. Also, it was observed that increasing the pressing pressure from 7.85 to 22.56kPa, total volatile fatty acids decreases for all experimental treatments. It is observed that at pressing pressure of 7.85kPa, total volatile fatty acid's value was of 3.34 g/kg at 9<sup>th</sup> day and decreased even 1.83 at 27<sup>th</sup> day. While at pressure of 12.75kPa, total volatile fatty acid's value was of 3.38 at 9<sup>th</sup> day and decreased even 1.63 at 27<sup>th</sup> day. At pressing pressure 17.65kPa, total volatile fatty acid's value was of 2.53 at 9<sup>th</sup> day and decreased even 1.24 at 27<sup>th</sup> day and at pressing pressure 22.56kPa, total volatile fatty acid's value was of 1.78 at 9<sup>th</sup> day and decreased even 1.23 at 27<sup>th</sup> day. These results are within the values obtained by (Etman *et al.* 1994 and Gaafar, 2001).



**Figure 14.** Silage Total volatile fatty acids at formic acid addition 4% and black coverage color under different pressing pressure

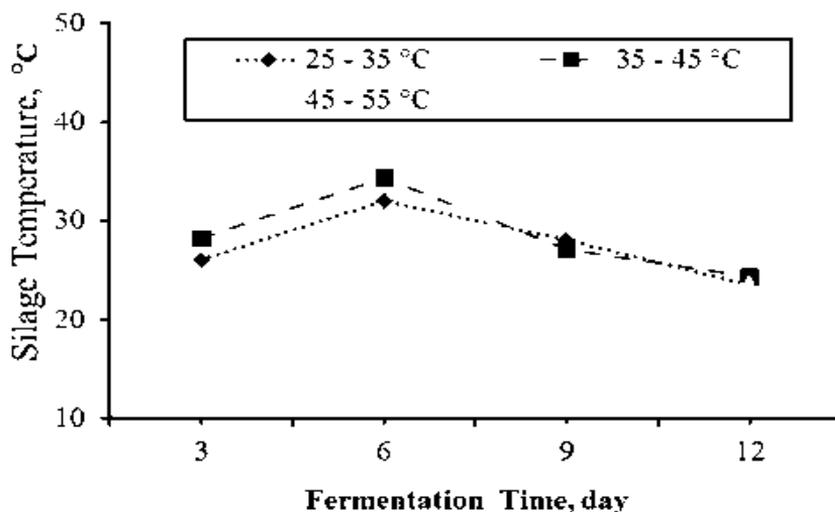
**The results of third experimental set up**

Effects of different ranges of temperature and different fermentation times on silage temperature at pressing pressure 22.56Pa, addition formic acid addition 4% and black coverage color.

As shown in Table 2 , effect of different ranges of temperature and different fermentation times on silage temperature at pressing pressure 22.56kPa, formic acid addition 4% and black coverage color. As shown in Figure 15, it is observed that at silage temperature of (25 – 35)°C, maximum silage temperature value was of 32°C at 6<sup>th</sup> day, minimum silage temperature was of 23.5°C at 12<sup>th</sup> day, at temperature (35 – 45)°C, maximum silage temperature value was of 34.3°C at 6<sup>th</sup> day, minimum silage temperature was of 24.3°C at 12<sup>th</sup> day, at temperature(45 – 55)°C, maximum silage temperature value was of 36.1°C at 6<sup>th</sup> day, minimum silage temperature was of 23.4°C at 12<sup>th</sup> day. So the best range temperature was of (45 – 55)°C because of the high range of temperature accelerates the harvesting silage and decreases the harvest time.

**Table 2.** Effect of different ranges of temperature and different fermentation times on silage temperature at pressing pressure 22.56Pa, formic acid addition 4% and black coverage color.

The ranges of temperature	3 <sup>rd</sup> day		6 <sup>th</sup> day		9 <sup>th</sup> day		12 <sup>th</sup> day	
	Ambient Temperature	Silage Temperature	Ambient Temperature	Silage Temperature	Ambient Temperature	Silage Temperature	Ambient Temperature	Silage Temperature
( 25 – 35 )°C	19.5	26	20	32	20.5	28	20	23.5
( 35 – 45 )°C	19.5	28.2	20	34.3	20.5	27.1	20	24.1
( 45 – 55 )°C	19.5	31.2	20	36.1	20.5	25.3	20	23.4



**Figure 15.** Silage temperature through the fermentation time under

different temperature control ranges at pressing pressure of 22.56kPa, formic acid addition 4% and black coverage color

**Optical properties of silage quality**

The effect of three different ranges of temperature (45 – 55)°C, (35 – 45)°C and (45 – 55)°C, lactic acid bacteria value, pH value, crude protein, Total volatile fatty acids on the intensity of illumination at three thicknesses (2, 3 and 4cm ) were studied.

Table 3 shows that the effect of different fermentation times , different pH values, different thicknesses of silage samples and different silage temperatures on the intensity of illumination. It noticed that decreasing PH value caused increasing in the intensity of illumination at all the investigated variables. The best state was at temperature range of (45 – 55)°C and thickness of 4cm at any fermentation time. The intensity of illumination value was of 44.5, 47.3, 53.3 and 58.3 at thickness 4cm at fermentation time at 3<sup>rd</sup>, 6<sup>th</sup>, 9<sup>th</sup> and 12<sup>th</sup> day respectively.

**Table 3.** Illumination intensity of fish silage under different production conditions

Different ranges of temperature	Fermentation time															
	3 <sup>rd</sup> day				6 <sup>th</sup> day				9 <sup>th</sup> day				12 <sup>th</sup> day			
	pH	Intensity of illumination, lumen/m <sup>2</sup>			pH	Intensity of illumination, lumen/m <sup>2</sup>			pH	Intensity of illumination, lumen/m <sup>2</sup>			pH	Intensity of illumination, lumen/m <sup>2</sup>		
		Thickness, cm				Thickness, cm				Thickness, cm				Thickness, cm		
		2	3	4		2	3	4		2	3	4		2	3	4
( 25-35) °C	4.95	39	41	42.1	4.6	43	47	47.9	3.95	49	51.8	52.85	3.28	51	69	70.3
( 35-45) °C	4.71	40.2	42.2	43.5	4.1	44.5	45.7	46.42	3.52	50.13	52.1	54.1	3.31	53.2	54.91	55.9
( 45-55) °C	4.45	41	43.2	44.5	3.85	45.1	46.2	47.3	3.32	50.3	53.2	55.3	3.25	53.2	55.1	58.3

**CONCLUSIONS**

The obtained results can be summarized as follows:

1. The best mixed ratio was 3.35: 1 and gives moisture content 62.3% wb.
2. At pressing pressure of 7.85kPa, formic acid addition percentage 4 % and coverage with the black color, the PH value was of 3.35, total volatile fatty acids value was of 1.83g/kg dry matter, lactic acid bacteria value was of 6.35g/kg dry matter, silage maximum temperature was 28.2°C, harvest time at 30<sup>th</sup> day.

3. At pressing pressure of 12.75kPa, formic acid addition 4% and coverage with the black color, the pH value was 3.11, total volatile fatty acids value was of 1.36g/kg dry matter, lactic acid bacteria value was 6.91g/kg dry matter, silage maximum temperature was 28.7°C, harvest time at 30<sup>th</sup> day.
4. At pressing pressure of 17.65kPa, formic acid addition 4% and coverage with the black color, the pH value was of 3.1, total volatile fatty acids value was of 1.31g/kg dry matter, lactic acid bacteria value was 6.95g/kg dry matter, silage maximum temperature was 38.03°C, harvest time at 25<sup>th</sup> day.
5. At pressing pressure of 22.56kPa, formic acid addition 4% and coverage with the black color, the PH value was of 3.12, total volatile fatty acids value was of 1.32g/kg dry matter, lactic acid bacteria value was 7.42g/kg dry matter, silage maximum temperature was 39.75°C, harvest time at 20<sup>th</sup> day.

The best experimental treatment was at pressing pressure of 22.56kPa, formic acid addition 4% and black coverage color.

6. At range of control in temperature (45 – 55)°C, the results pH value was of 3.25, total volatile fatty acids was 1.95g/kg dry matter, lactic acid bacteria value was of 6.2g/kg, curde protein was 36.12g/kg dry matter, temperature in the end of fermentation period maximum was 36.1°C, at 6<sup>th</sup> day, minimum was 23.4°C at 9<sup>th</sup> day, harvesting time at 9<sup>th</sup> day.
7. The intensity of illumination value was 44.5, 47.3, 53.3 and 58.3 lumen/m<sup>2</sup> at thickness 4cm at fermentation time 3<sup>rd</sup>, 6<sup>th</sup>, 9<sup>th</sup> and 12<sup>th</sup> day respectively.

The biological value of fish silage and fish silage were found to be very high, since all essential nutrients were present in fairly appropriate concentration. So, it is possible to use the powder fish silage and fish silage in fish feed cost and enhanced aquaculture production.

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الملخص العربي

## تحسين كفاءة إنتاج السيلاج من مخلفات الأسماك

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أوضحت الدراسات السابقة التي أجريت في مصر وجود فجوة كبيرة بين الإنتاج والاستهلاك في الأعلاف الحيوانية وأن المتاح من مكونات الأعلاف لا يكفي إلا ٦٠٪ من الإحتياجات العلفية السنوية ، ويقدر هذا العجز بحوالي ٣,٨ مليون طن وحدة غذائية مهضومة ، مما يتسبب في زيادة أسعار المنتجات الحيوانية. كما اتفقت الدراسات على أن الموارد المألوف إستخدامها في تصنيع العلائق الحيوانية لن تستطيع أن تسد هذا العجز، وأن هناك ضرورة لإستخدام المخلفات والموارد الزراعية الجديدة لإنتاج تراكيب علفية غير تقليدية تلائم أنواع مختلفة من الحيوانات (مجترات - دواجن - أسماك) شرط أن تكون هذه الأعلاف متزنة غذائيا. وتعد الأسماك البديل الجيد والمناسب في الجودة والسعر لسد الفجوة الغذائية في البروتين الحيواني خاصة مع الإرتفاع الكبير في أسعار اللحوم الحمراء والدواجن.

ولما كانت عمية السيلجة هي المعاملة المثلى للتخلص من مخلفات الاسماك بطريقة صحية وأمنه وإقتصادية إلى الحد الذى يسهل معه التعامل مع هذه المخلفات سواء بالسحق أو الفرم لخلطها مع المخلفات الزراعية الأخرى والأحماض العضوية التى تحفظها من التعفن وتزيد من القيمة الغذائية لها وتقديمتها فى صورة مناسبة للأسماك مرة اخرى مما يقلل من تكاليف التغذية فى الإستزراع السمكى.

وكان الهدف العام من الدراسة هو تقليل فترة حصاد السيلاج السمكى وإيجاد أعلاف بديلة تقليدية من مخلفات الإنتاج الزراعي والسمكى.

بينما الأهداف الفرعية هي على النحو التالي :

- (١) دراسة أربعة مستويات من نسب الخلط وهي كالتالى: [(١:١,٥) ، (١:٢,٣٤) ، (١:٣,٣٥) ، (١:٤)] ، [مخلفات الأسماك : رجيع الكون] للتعرف على أفضل نسبة خلط لعمل السيلاج.
- (٢) تأثير ثلاث إضافات مختلفة من الفورمك أسيد (٢ ، ٣ ، ٤)٪ ، على وقت حصاد السيلاج.
- (٣) تأثير أربعة ضغوط مختلفة كالتالي ٧,٨٥ و ١٢,٧٥ و ١٧,٦٥ و ٢٢,٥٦ كيلوباسكال، على وقت حصاد السيلاج السمكى.

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- (٤) تأثير إثنين من لون التغطية (الأبيض - الأسود) على وقت حصاد السيلاج السمكى.  
 (٥) تأثير ثلاث مستويات مختلفة من مدى درجات الحرارة [ (٢٥ - ٣٥) ، (٣٥ - ٤٥) ] ، على حصاد السيلاج السمكى.  
 (٤٥) ، [ (٤٥ - ٥٥) م° ] ، على حصاد السيلاج السمكى.

#### و خلصت الدراسة إلى النتائج التالية:

- (١) أفضل نسبة خلط لعمل السيلاج السمكى (٣,٣٥ : ١) (مخلفات الأسماك : رجيع الكون) لتعطي محتوى رطوبى ٦٢,٣٪ على أساس رطب ، وهى المحتوى الرطوبى الآمن لعمل السيلاج.  
 (٢) عند الضغط ٧,٨٥ كيلوباسكال، عند الإضافة ٤٪ من الفورمك أسيد ولون التغطية الأسود، قيمة PH كانت ٣,٣٥ و قيمة الأحماض الدهنية الطيارة كانت ٨٣,٨٣ ج/كج من المادة الجافة ، وقيمة حامض اللاكتيك كانت ٦,٣٥ ج/كج من المادة الجافة، وكانت درجة الحرارة العظمى ٢٨,٢ م° ، ومدة الحصاد عند اليوم الثلاثون.  
 (٣) عند الضغط ١٢,٧٥ كيلوباسكال، عند الإضافة ٤٪ من الفورمك أسيد ولون التغطية الأسود، قيمة PH كانت ٣,١١ وقيمة الأحماض الدهنية الطيارة كانت ٣٦,٣٦ ج/كج من المادة الجافة، وقيمة حامض اللاكتيك كانت ٦,٩١ ج/كج من المادة الجافة ، وكانت درجة الحرارة العظمى ٢٨,٧ م° ، ومدة الحصاد عند اليوم الثلاثون.  
 (٤) عند الضغط ١٧,٦٥ كيلوباسكال، عند الإضافة ٤٪ من الفورمك أسيد ولون التغطية الأسود، قيمة PH كانت ٣,١ وقيمة الأحماض الدهنية الطيارة كانت ٣١,٣١ ج/كج من المادة الجافة، وقيمة حامض اللاكتيك كانت ٦,٩٥ ج/كج من المادة الجافة، وكانت درجة الحرارة العظمى ٣٨,٠٣ م° ، ومدة الحصاد عند اليوم الخامس والعشرون.  
 (٥) عند الضغط ٢٢,٥٦ كيلوباسكال، عند الإضافة ٤٪ من الفورمك أسيد ولون التغطية الأسود، قيمة PH كانت ٣,١٢ وقيمة الأحماض الدهنية الطيارة كانت ٣٢,٣٢ ج/كج من المادة الجافة، وقيمة حامض اللاكتيك كانت ٧,٤٢ ج/كج من المادة الجافة، وكانت درجة الحرارة العظمى ٣٩,٧٥ م° ، ومدة الحصاد عند اليوم العشرين. وكان أفضل إنتاج للسيلاج السمكى عند ضغط ٢٢,٥٦ كيلوباسكال، عند الإضافة ٤٪ من الفورمك أسيد ولون التغطية الأسود، وهى تعتبر أقل مدة زمنية لإنتاج السيلاج.  
 (٦) عند مستوى التحكم (٤٥ - ٥٥) م° ، قيمة PH كانت ٣,٢٥ وقيمة الأحماض الدهنية الطيارة كانت ٩٥,٩٥ ج/كج، وقيمة حامض اللاكتيك كانت ٦,٢ ج/كج، وكانت درجة الحرارة العظمى للسيلاج ٣٦,١ م° ، درجة الحرارة الصغرى للسيلاج ٢٣,٤ م° ، ومدة الحصاد عند اليوم التاسع ، وأفضل قيمة لشدة الإستضاءة كانت عند نفس مدى درجة الحرارة.

#### التوصيات العملية المستقبلية

بصفة عامة تبين النتائج السابقة ان أفضل نسبة خلط ( ٣,٣٥ : ١) من عفشة الأسماك : رجيع الكون عند ضغط ٢٢,٥٦ كيلوباسكال ، وذلك عند إضافة ٤٪ من الفورمك أسيد ، إستخدام اللون الأسود فى التغطية على أن تكون درجة حرارة الوسط المحيط ( ٤٥ - ٥٥ ) م° حتى يتم إنتاج سيلاج سمكى عالى القيمة الغذائية.