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PRODUCTION OF POWDER FISH SILAGE FROM FISH MARKET WASTES

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ABSTRACT

This study was undertaken to investigate the suitability of using fish market wastes (viscera) as raw material for powder fish silage production. Fish viscera contained 14.01±0.68% protein, 20.00±1.04% lipid, 4.75±0.64% ash, 60.62±2.15% moisture and 0.62±0.08% Nitrogen Free Extract (NFE). The pH of fish viscera was 6.21±0.07. For liquid fish silage production, 2, 3, 4 and 5% formic acid were added in blended viscera, of which 4% formic acid was found better that had a pH value of 3.77±0.07. Liquid silage contained 12.00±0.89% protein, 17.26±1.49% lipid, 3.73±0.81% ash, 66.41±3.07% moisture and 0.60±0.09% NFE. For neutralizing liquid fish silage, various concentrations, viz. 1, 2, 3, 4, 5 and 6% Na_2CO_3 were added. The pH value (6.32±0.01) was better when mixing with 4% Na_2CO_3. To produce powder fish silage 20, 30, 40 and 50% rice bran were mixed in liquid fish silage. Powder silage made with 30% rice bran was found better to improve the nutritional quality of the product that contained 20.84±0.12% protein, 33.73±0.14% lipid, 14.05±0.27% ash, 10.83±0.19% moisture, 6.61±0.10% crude fiber and 13.94% carbohydrate. The pH value was 6.54±0.01. After preparation, powder fish silage was packaged. The packaged powder fish silage was then stored for 4 months at room temperature (20-30^{0}C). After four months of storage, the contents of protein, lipid, ash, moisture, crude fiber, carbohydrate and pH reached at 20.30±0.13, 32.41±0.16, 13.49±0.33, 10.98±0.28, 6.32±0.07, 16.50% and 6.76±0.09, respectively. It was found that nutritional value of powder fish silage was very high and can be used in fish feed to reduce feed cost and enhance aquaculture production.

Keywords: Fish market wastes, powder fish silage preparation, quality of fish feed, room temperature storage.

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INTRODUCTION

Fish market wastes (viscera, fin, skin and flesh) contain high amount of protein, lipid and minerals. There is a need for developing methods for use of these valuable wastes into human food or animal feed to reduce aqua-production costs and increase benefit. Considering the easy method involved and low-cost inputs required, fish wastes can be advantageously upgraded into powder fish silage. Fish silage is 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, 2003). Liquid silage can be dried with rice bran to prepare powder silage. Powder fish silage can be vitally used as a feed supplement in aquaculture to convert nutrients into flesh. Inclusion of fish silage in fish diets increased body weight gain, total body length and specific growth rate without any adverse effects on survival and water quality (Enke et al., 2009). About 12% of the total fish weight is viscera i.e. 3,00,000-4,00,000 metric tons of viscera can be obtained every year from the fish produced in Bangladesh. By using these viscera, it is possible to produce 2,00,000 metric tons powder fish silage, market value of which is about 5,000 million taka @ 25 taka per kg. Thus, it is possible to reduce the pressure of fish meal in fish feed by converting wastes into powder fish silage. In this experiment, a noble approach is proposed to produce good quality of powder silage with increased nutritional value and long shelf life.

METHODOLOGY

Duration of the study, period and place

The study was conducted for a period of 1 year from May 2013 to May 2014, in the Fish Processing Laboratory of the Department of Fisheries Technology of Bangladesh Agricultural University, Mymensingh, Bangladesh.

Preparation of powder fish silage

Fish wastes (mixed viscera of rui, catla, mrigal, tilapia and pangas) collected from fish markets were blended with an electric blender. Immediately after blending, different concentration of formic acid (2, 3, 4 and 5%) were added. The mixture was stirred to mix acid can mix properly and then kept for several days (5, 4, 3 and 2 days with 2, 3, 4 and 5% formic acid respectively) at room temperature (25-30°C) for complete liquefaction. Now various concentrations of Na_2CO_3 (1, 2, 3, 4, 5 and 6%) were added to the liquid neutralize the pH at 6.0-7.0. Thus the liquid silage was prepared where rice bran at different compositions (20, 30, 40, and 50%) was mixed. The mixture was dried under the sun for two days. Dried product was ground in an ordinary flour mill and dried by an electric oven at 35^0C for few hours so that the

moisture content was adjusted to 10-12%. Powder silage thus prepared was packaged in air-tight polythene packets with packet sealing machine. Packets were clearly labeled according to existing regulations and with a sell-by or consume-by date. Packets were stored in clean and dry plastic container at room temperature for a year but shelf life of the product was rigorously monitored for 4 months.

Analytical procedures

Analysis of crude protein, lipid, ash, moisture, crude fiber and carbohydrate were carried out according to AOAC (2000) methods with slight modifications while NFE was measured by substracting the sum of total protein, lipid, ash, moisture and crude fiber from 100. The pH was measured by using a microprocessor pH meter.

Data analysis

The data obtained were analyzed and graphically presented by MS Excel 2007.

RESULTS AND DISCUSSION

Proximate composition of silage and its ingredients

Fish viscera contained 14.01±0.68% protein, 20.00±1.04% lipid, 4.75±0.64 ash, 60.62±2.15% moisture (Table 1). The value of protein obtained in the present study was in consistent with Bechtel (2003), who obtained 13.0-15.3% protein in fish viscera. Similar result was also given by Mahboob and Sheri (1998), Mesa and Magie (2004), Ahmad et al. (2012), Taheri et al. (2013) and Permata et al. (2014). The value of lipid obtained was in consistent with Bechtel (2003), who obtained an average of 19.1% lipid in fish viscera. The value of ash obtained in the present study was in consistent with that of Mahboob and Sheri (1998), who obtained 3.96-6.95% ash in viscera of Indian major carps. The moisture data was in consistent with Bhaskar and Mahendrakar (2007), who obtained 58.6% moisture in viscera of Indian major carp *Catla catla.* In another study conducted by Mahboob and Sheri (1998), it was found that Indian major carp viscera contained 65.24-81.17% moisture, which also supports the present result. Moisture data indicated that 39.38% dry matter was present in fish viscera. Similar result was given by Rahmi et al. (2008), who obtained 39.40% dry matter in fish viscera.

Dry viscera contained an average of 32.38±1.19% protein, 47.10±0.92% lipid, 10.20±1.10% ash, 9.16±1.25% moisture and 1.15±0.40% Nitrogen Free Extract (NFE) (Table 1). Almost similar results were given by Folador et al. (2006).

Rice bran contained an average of 9.32±0.06% protein, 17.94±0.35% lipid, 18.67±0.12% ash, 9.65±0.14% moisture and 44.42% NFE (Table 1). The value of protein in rice bran obtained in the present study was in consistent with Okai et al. (2003), who obtained 5.23-9.74% protein in rice bran. Similar result was obtained by Rashid et al. (2013). The value of ash obtained in the present study was in agreement with Mahmud et al. (2012), who obtained 14.79 to 18.84 % ash in rice bran. Similar

result was also given by Cicero and Derosa (2005). The value of NFE content obtained in rice bran was in consistent with Okai et al. (2003), who found 44.07 and 47.01% NFE in rice bran obtained from medium and long grain respectively. Similar results were also given by Rosniyana et al. (2009).

Liquid silage contained an average of 12.00±0.89% protein, 17.26±1.49% lipid, 3.73±0.81% ash and 66.41±3.07% moisture (Table 1). The value of protein obtained in the present study was in consistent with Rahmi et al. (2008) and Abowei and Tawari (2011). The values of ash obtained in the present study were in consistent with Abowei and Tawari (2011). The values of moisture obtained in the present study were also in consistent with Rahmi et al. (2008).

The nutrient contents of liquid silage were similar to raw viscera. There were slight decrease in protein, lipid, ash and NFE contents in liquid silage than viscera, might be due to breakdown of nutrient components during hydrolysis. This can also be attributed to the low pH, which enhanced the action of fish digestive and muscle enzymes on fish nutrients. Whereas, the moisture content of liquid silage is slightly higher than viscera. It might be due to liquefaction of viscera during silage preparation.

It was found that the powder fish silage has a good nutritive value. It was fortified with protein, lipid, ash, crude fiber and carbohydrate contents. The protein, lipid, ash, moisture, crude fiber and carbohydrate contents of powder silage were 20.84±0.12, 33.73±0.14, 14.05±0.27, 10.83±0.19, 6.61±0.10 and 13.94%, respectively (Table 1). The quantity of protein obtained would be suitable for the growth of fish and other aquatic animals. The values of lipid were slightly higher but if De-oiled Rice Bran was used, then lipid content will be reduced. It was, however, expected that it would not be harmful for animals as major portion of fish lipid consist of unsaturated fatty acid. The ash content would be very suitable to fulfill the mineral requirements of fish and other animals. The moisture data said that there would be no chance of mold attack in the feed prepared from silage and the product may be kept stable at room temperature for long time. The NFE was not very high but within the suitable range for growing fish and other animals.

pH of silage and its ingredients

The pH of fresh fish viscera was found to be 6.21±0.07 (Table 2). The value of pH obtained in the present study was in consistent with Bhaskar and Mahendrakar (2007), who found a pH value of 6.18 in viscera of Indian major carp *Catla catla*. The pH of rice bran was nearly neutral. The pH values of liquid silage made with 4% formic acid was 3.77±0.07. The pH obtained was, although, most suitable for silage production but a lower dry matter (33.59 g/100 g) was obtained. When pH of fish silage was increased, the dry matter content was also increased. The highest dry matter content obtained was 39.38 g/100 g of original viscera sample, which occurred when the pH was at 6.21±0.07. A further disadvantage of higher pH is the rapid microbial spoilage (Oulavallickal, 2010). Most of the bacteria are neutrophiles, with

an optimal growing pH between 5.5 and 8.0 whereas most fungi prefer a pH range between 4 and 6. After excluding samples kept at the higher pH on grounds that they may not be microbiologically safe or stable, the values for dry matter content indicated that processing at pH 3.5 or pH 4 would to be satisfactory because these samples had the higher solid content. These findings also supported the idea that appropriate pH for making fish silage should be 3.5-4.0, as also obtained by Oulavallickal (2010). The pH value of powder silage (6.54±0.01) was found to be nearly neutral. So, it would not affect the ingestion rate of the feed (Mousavi et al., 2013).

Effect of formic acid content on silage preparation

Time required to prepare fish silage from viscera depends on the quantity of formic acid added to blended viscera and temperature of the environment. At 25-30°C temperature, fish viscera took 5, 4, 3 and 2 days for complete liquefaction into fish silage with 2, 3, 4 and 5% formic acid, respectively (Table 3). Increasing the amount of formic acid decreased the time required to prepare fish silage. On obvious reason, at 5% formic acid, lowest time was required for liquefaction of viscera. But 5% formic acid would also increase cost of production and ultimately, the feed cost. It was possible to liquefy viscera by using 2% formic acid but it would require more time to complete the silage production. There was a risk of bacterial contamination also. So considering all the limitations and options, it was found reasonable to prepare fish silage with 4% formic acid that would, at the same time, minimize cost and save production period.

Initial pH of liquid fish silage varied with the quantity of formic acid added to blended viscera. Maintenance of acidity in fish silage had the added advantage of keeping the product more hygienic and safe by inhibiting the growth of pathogenic organisms. In the present study, the pH of the viscera decreased significantly from the initial pH of 6.21±0.07 to 3.22±0.09 with respect to progressive increase in concentration of 2 to 5% formic acid. At the end of the silage preparation, the pH levels of silages were recorded to be 4.72±0.07, 4.32±0.03, 3.73±0.04 and 3.22±0.09 at 2, 3, 4 and 5% formic acid respectively. It was found that the pH of fish silage made with 4% formic acid was within the standard range of 3.6 to 4.0. Silage made with 2% formic acid had a pH of 4.72±0.07 which exceeded the standard range. On the other hand, silage made with 5% formic acid had a lower pH than the standard range. Incorporation of 5% formic acid would increase the cost and again more Na_2CO_3 would be required to neutralize the pH. These would further increase feed cost. Therefore, considering the optimum time to be required to prepare fish silage with acceptable pH value, in order to keep the cost minimum but quality high, it was observed rational to prepare fish silage with 4% formic acid.

Role of Na_2CO_3 in neutralizing liquid silage

With increasing quantity of formic acid, there is a need to neutralize liquid silage to make it edible for fish and animals. The pH value of liquid fish silage

increased with increasing value of sodium carbonate. In the present study, the pH of liquid silage increased significantly from the initial value of 3.77±0.07 to 6.81±0.11 with respect to progressive increase in concentration of 1 to 6% Na_2CO_3. The pH level of silage was recorded to be 4.47±0.07, 5.34±0.26, 5.89±0.08, 6.32±0.01, 6.58±0.18 and 6.81±0.11 at 1, 2, 3, 4, 5 and 6% Na_2CO_3, respectively (Figure 1). The rate of neutralization was not uniform with the quantity of Na_2CO_3 . The rate of neutralization was increased up to 2% and then decreased slowly. Addition of 4% Na_2CO_3 transformed the pH value of liquid fish silage to nearly neutral, making it safer to feed the animals. It was possible to make it totally neutral (pH 7) by adding more sodium carbonate. But the cost of feed production would be increased with increasing quantity of Na_2CO_3. In order to keep the cost of feed at reasonable level, it was observed effective to neutralize liquid silage at 4% Na_2CO_3.

Effect of rice bran on powder silage quality

Different trials were made to ensure 20% protein in powder fish silage. For this purpose different combination of rice bran were used. Proximate composition of powder fish silage made with different quantity of rice bran by weight of liquid silage is given in Table 4. With decreasing the quantity of rice bran, the levels of protein, lipid and moisture were increased but that of ash and NFE were decreased. From table 4, it was found that at 40 and 50% rice bran the nutrient contents became very low. At 30% rice bran it was found that the protein content was enhanced to about 20% and other nutrient contents were also comparatively acceptable for animal feeding. It was possible to increase protein content more by decreasing the quantity of rice bran to 20%. But it might be difficult to dry the wet mixture due to lesser content of dry matter and there would be a probability of mold attack. The product with lower rice bran will not be stable for long time use. Therefore, considering all options and limitations, it was found rational to prepare powder fish silage with 30% rice bran by weight of liquid silage.

Comparative analysis of ingredients and silage

As far as the materials are concerned, viscera, formic acid, sodium carbonate and rice bran were used for preparing powder fish silage. Fish viscera although contained valuable nutrients, it is not possible to use as feed directly without processing. Rice bran contained lower level of protein which would not fulfill the nutritional requirements of many domesticated animals. As a result, rice bran cannot be used as feed singly. Therefore to provide a nutritionally balanced diet, fish viscera and rice bran were used for preparing powder fish silage. On average 665.57±1.76 g powder silage could be prepared by using 1000±0.0 g viscera, 40±0.0 ml. formic acid, 39.41±0.14 g sodium carbonate and 307.41±1.08 g rice bran (Table 5). So, preparation of 1 kg powder fish silage required 1502.47 g viscera, 60.10 ml. formic acid, 59.21 g sodium carbonate and 461.87 g rice bran.

Self life of powder silage

To observe the quality changes of powder fish silage during storage, proximate composition, pH and physical characteristics were observed for four months. Most of the compositions of packaged powder silage were unchanged during the storage period. A slow decrease in protein, ash, crude fiber and lipid, and a slow increase in carbohydrate and moisture were observed during the storage. The protein contents were recorded to be 20.70±0.19, 20.61±0.18, 20.43±0.31 and 20.30±0.13% in the 1st, 2nd, 3rd and 4th month, respectively (Table 6). These data indicate that protein content of powder silage can be stable for long time, perhaps up to one year without any change in quality. The mineral content in term of ash decreased from an initial value of 14.05±0.27 to 13.91±0.11, 13.73±0.29, 13.62±0.12 and 13.49±0.33% in the 1st, 2nd, 3rd and 4th month, respectively. The crude fiber content decreased from an initial value of 6.61±0.10 to 6.56±0.08, 6.50±0.08, 6.43±0.13 and 6.32±0.07% in the 1st, 2nd, 3rd and 4th month, respectively. Result of ash and crude fiber contents in the present experiment showed no significant variation with respect to increase in storage life. The lipid content was recorded to be 33.45±0.31, 33.03±0.28, 32.77±0.35 and 32.41±0.16% in the 1st, 2nd, 3rd and 4th month, respectively. The rate of lipid degradation was slightly higher than protein, ash and fiber content. Results display a significant decrease of lipid content in powder fish silage with corresponding increase of storage. The moisture level increased from an initial value of 10.83±0.19 to 10.87±0.30, 10.84±0.24, 10.92±0.15 and 10.98±0.28% in the 1st, 2nd, 3rd and 4th month, respectively. The results indicated the importance of proper packaging that make powder fish silage nutritious. The carbohydrate content was recorded to be 14.51, 15.29, 15.83 and 16.50% in the 1st, 2nd, 3rd and 4th month, respectively.

The pH value of powder fish silage after four month of storage remained almost unchanged. The pH value was recorded to be 6.58±0.03, 6.63±0.02, 6.71±0.06 and 6.76±0.09 in the 1st, 2nd, 3rd and 4th month, respectively (Table 6). Data indicated that the quality of powder fish silage was almost similar to that of the initial product before packaging.

The physical characteristics of powder fish silage was monitored for 1 year but rigorously analysed for 4 months though physical and sensory observations, the results being presented in table 7. No change in physical quality was observed during storage for four month. The powder silage remained highly dried all along the storage period with no sign of moisture absorbance and mold attack. The product obtained a lovely sweet flavor with appealing fragrance. The color remains bright brown all along the storage.

CONCLUSION

Fish viscera could be a suitable substitute for costly fishmeal in producing high quality and nutrient-rich powder fish silage. Powder fish silage could be stored up to 1 year without the loss of major nutrient components. It was found possible to

partially replace expensive fish meal in fish and animal feed preparation. Powder fish silage should be tested for the growth performance of fish and other animals in farm culture condition. Research needed to be carried out on appropriate packaging of such product for local marketing.

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Table 1. Proximate composition of silage and its ingredients

Ingredients/Silage	Composition (%)				
	Protein	**Lipid**	**Ash**	**Moisture**	**NFE***
Viscera (wet weight basis)	14.01±0.68	20.00±1.04	4.75±0.64	60.62±2.15	0.62±0.08
Viscera (Dry weight basis)	32.38±1.19%	47.10±0.92	10.20±1.10	9.16±1.25	1.15±0.40
Rice bran	9.32±0.06	17.94±0.35	18.67±0.12	9.65±0.14	44.42±2.60
Liquid silage	12.00±0.89	17.26±1.49	3.73±0.81	66.41±3.07	0.60±0.09
Powder silage	20.84±0.12	33.73±0.14	14.05±0.27	10.83±0.19	20.55±0.65

Mean± SD of eight samples; NFE* (Nitrogen Free Extract) = {100- (protein+ lipid+ ash+ moisture) %}

Table 2. pH of silage and its ingredients

Ingredients/Silage	pH
Viscera	6.21±0.07
Rice bran	6.92±0.22
Liquid silage	3.77±0.07
Powder silage	6.54±0.01

Mean± SD of eight samples

Table 3. Time required to prepare liquid fish silage with different quantity of formic acid added

Formic acid (%)	Time required (Days)	Temperature (^{o}C)
2	5	
3	4	25-30
4	3	
5	2	

Table 4. Proximate composition of powder fish silage made with different quantity of rice bran

Rice bran (%)	Composition (%)				
	Protein	**Lipid**	**Ash**	**Moisture**	**NFE***
20	21.75±0.19	34.71±0.28	13.36±0.23	11.68±0.17	18.50±0.92
30	20.84±0.12	33.73±0.14	14.05±0.27	10.83±0.19	20.55±0.35
40	19.87±0.12	32.88±0.21	14.28±0.14	10.17±0.25	22.80±0.48
50	18.73±0.25	30.74±0.19	14.55±0.25	9.66±0.21	26.32±0.76

Mean± SD of three replicates; NFE* (Nitrogen Free Extract) = {100- (protein+ lipid+ ash+ moisture) %}

Table 5. Quantity of raw materials and ingredients used in final fish silage preparation

Lots	Viscera (g)	Formic acid added @ 4 ml. /100 g viscera (ml.)	Liquid silage obtained (g)	Sodium carbonate added @ 4 g /100 g liquid silage (g)	Sodium carbonate mixed liquid silage (g)	Rice bran (g)	Powder silage obtained (g)
1	1000	40	985.53	39.42	1024.95	307.49	665.81
2	1000	40	989.07	39.56	1028.63	308.59	667.15
3	1000	40	984.84	39.39	1024.23	307.27	664.50
4	1000	40	980.95	39.24	1020.19	306.06	663.72
5	1000	40	990.03	39.60	1029.63	308.89	668.55
6	1000	40	983.71	39.35	1023.06	306.92	665.52
7	1000	40	987.34	39.49	1026.83	308.05	666.07
8	1000	40	980.75	39.23	1019.98	305.99	663.25
Average	1000 ±0.0	40± 0.00	985.28 ±3.45	39.41 ±0.14	1024.69 ±3.58	307.41 ±1.08	665.57 ±1.76

Mean± SD of eight samples

Table 6. Change in proximate composition and pH of packaged powder silage during storage

Storage period (month)	Composition (%)						pH
	Protein	Lipid	Ash	Moisture	Fiber	Carbohy-drate	
0	20.84±0.12	33.73±0.14	14.05±0.27	10.83±0.19	6.61±0.10	13.94	6.54±0.01
1	20.70±0.19	33.45±0.31	13.91±0.11	10.87±0.30	6.56±0.08	14.51	6.58±0.03
2	20.61±0.18	33.03±0.28	13.73±0.29	10.84±0.24	6.50±0.08	15.29	6.63±0.02
3	20.43±0.31	32.77±0.35	13.62±0.12	10.92±0.15	6.43±0.13	15.83	6.71±0.06
4	20.30±0.13	32.41±0.16	13.49±0.33	10.98±0.28	6.32±0.07	16.50	6.76±0.09

Mean± SD of three replicates

Table 7. Physical quality of powder silage during storage

Storage life (month)	Moistness*	Occurrence of mold	Flavor	Color**
0	1	Nil	Sweet	5
1	1	Nil	Sweet	5
2	1	Nil	Sweet	5
3	1	Nil	Sweet	5
4	1	Nil	Sweet	5

*Moistness scale: 1 to 5 with 1 being very dry and 5 being highly moist; ** Color scale: 1 to 5 with 1 being ashy dark and 5 being bright brown.

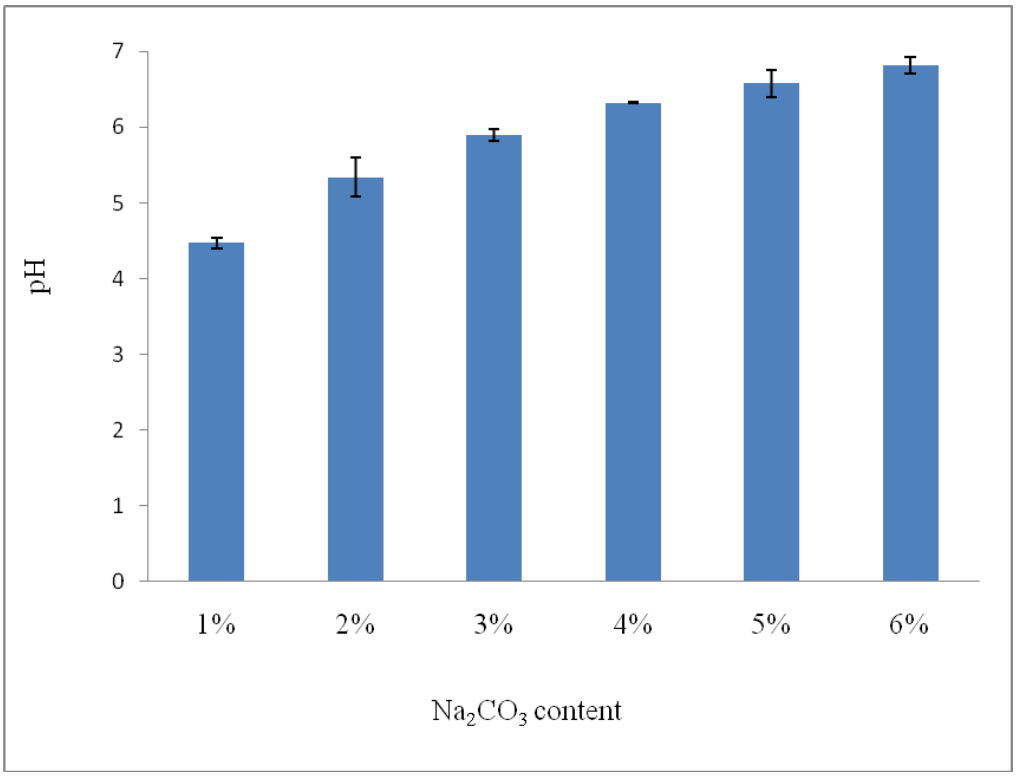

Figure 1. Changes in pH of liquid silage during neutralization with Na_2CO_3