



Utilization of Tuna Waste Silage as a Novel Pig Feed Ingredient

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Abstract

Tunas are commercially important fishes, widely distributed throughout the tropical and temperate waters. During processing and development of various value added products from tuna, large quantity of solid waste is generated in the form of viscera, gills, dark muscle, head, bone and skin. In this study, waste generated from tuna processing was converted into a liquid protein source by ensilation and its performance as a novel protein source for pigs was evaluated. Feed was prepared by mixing rice bran and tuna waste silage in 7:3 ratio and drying at 60°C in an electrical drier for 12 h. The feed has crude protein 20%, crude fat 22%, ash content 8% and moisture content of 7%. The feed was found to be rich in essential dietary amino acids (lysine, tryptophan, threonine and methionine) and fatty acid (oleic and linoleic acid). Feeding trials on thirty six weaned large white Yorkshire piglets by incorporating tuna waste silage for a period of 104 days showed that this can be used as an efficient feed for pigs.

Keywords: Tuna waste, silage, Pig feed, fatty acids, amino acids

Introduction

Human population has surpassed 7 bn mark towards the end of 2011 and is projected to reach 9 bn by 2050 (UNFPA, 2012). According to recent reports, 0.87 bn people in world are chronically under-nourished (The State of Food Insecurity in the

World, 2012). Agriculture and animal husbandry have an undisputed role in achieving global food security. Food from animal sources are recognized as having high energy density and as good source of high-quality protein and other nutrients (Gibson, 2011). Evidence from the Nutrition Collaborative Research Support Programme (NCRSP) for Egypt, Kenya and Mexico indicated that, intake of food from animal sources enhances physical and cognitive development in children (The State of Food and Agriculture, 2013). Among the various livestock species, piggery is most potential source of meat production and more efficient feed converter after the broiler chicken. Pigs have also been used as a source of bristles and manure. Due to their similarities with human physiology, pigs are being largely used as experimental animals for biomedical research. Feed is the major factor which governs the cost of production in swine production and accounts 60 to 75 % of the total cost (John, 1995). There is an ever increasing necessity to find a cheap and efficient protein source for pig culture practices.

Tunas are commercially important fishes, widely distributed throughout the tropical and temperate waters. During the process of conversion to loins and various other value added products, large quantity of solid waste is generated from tuna in the form of viscera, gills, dark muscle, head, bone and skin. Guerard et al. (2002) reported that fish canning industries produce solid wastes which can be as high as 70% of the original material. Protein-rich by-products from the canning industry like dark meat have limited use due to their colour, susceptibility to oxidation and off flavor. During loin preparation 50-55% of the material is wasted. The aim of the study was to convert the waste generated from tuna processing to a liquid protein source by ensilation and evaluation of its performance as a novel protein source for pigs.

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Materials and Methods

Tuna processing waste were collected from seafood processing factories situated in Cochin, Kerala, India and brought to the laboratory in iced condition. They were chopped into small pieces and mixed with formic acid at the rate of 3.5% (W/V) until the colour changed to pale brown. The container was kept closed with intermediate stirring for seven days until the solid particles are digested and uniform slurry is obtained. It was manually mixed with rice bran at 3:7 ratio and was dried in an electrical drier at 60°C for 12 h.

Determination of moisture, crude fat, crude protein and ash content were carried out according to AOAC (2000). Amino acid composition except tryptophan was analysed using a High Performance Liquid Chromatograph (LC 10AS model Shimadzu) by following the procedure described by Ishida et al. (1981). Tryptophan content was determined according to the procedure of Sastry & Tammura (1985). Isolation and purification of fatty acid was according to Folch et al. (1957), followed by esterification as per Metcalfe et al. (1966). The corresponding fatty acid methyl esters were analysed in a Perkin Elmer Autosystem XL Gas Chromatograph attached to flame ionization detector. Samples were analysed in triplicates and values are reported as mean±standard deviation.

Feeding trials were conducted on piglets at Kerala Agricultural University, Thrissur, India to evaluate the efficacy of the developed feed. Trials were conducted on thirty six (18 male and 18 female) weaned Large Yorkshire piglets for a period of 104 days. The piglets were divided into three groups with 6 males and 6 females in each group. Three dietary treatments were randomly allotted to the groups, T1 (standard ration with yellow maize (65%), soyabean meal (18%), wheat bran (5%) and dried fish (10%), T2 (ration with 50% protein of dried fish replaced by the newly developed feed) and T3 (ration with 100% of protein of dried fish replaced by the newly developed feed). Animals were fed twice daily with a ration of 1.5 kg feed day⁻¹. Piglets in each replicate were housed in separate pens in the same shed with facilities for feeding and watering. All animals were maintained under identical management conditions. Feed conversion ratio (FCR) was estimated as the amount of feed (F) in grams necessary to increase the total body wet weight (W) by one gram (FCR=F/W). Data analyzed statistically

by one-way ANOVA (IBM SPSS Statistics version 20). Post-hoc comparisons were carried out with Tukey's multiple comparison test. Significance of differences was defined at $p < 0.05$.

Results and Discussion

Proximate composition of the pig feed developed from tuna waste silage is shown in Table 1. Crude protein accounted 20.20% of the feed. Protein or amino acids are required for muscle and milk production in pigs and serve as a component of hide, hoof, hair, hormones, enzymes and blood. Deficiency of protein in feed results in mobilization of protein from various tissues to maintain the functions of more vital tissues (Chiba, 2010). In a typical farrow to finish operation for pigs weaned at 4 weeks, the maximum protein requirement is 20% (John, 1995). Crude protein content in the prepared feed is meeting the requirement. Excess protein in diet is not recommended as it is unutilized and excreted as urea (Peter et al. 2007). More over McCracken & Stockdale (1989) have reported approximately 9% drop in the mean daily feed intake when protein content in the feed increased from 21 to 24%. Lipids in pigs serve as reserve energy source and as carriers of fatty acids and fat soluble vitamins (Chiba, 2010). Lipid deficiency in pigs can result in skin lesions and retardation of sexual maturity. Crude fat accounted 22.5% of the feed and ash content contributed 8.5%. Carbohydrates serve as the primary energy source in the diet of pigs. Surplus carbohydrates supplied is converted to fat and stored as reserve energy source. Carbohydrates formed 41.68% of the present feed.

Table 1. Proximate composition of pig feed developed from tuna waste

Parameters	Composition (%)
Moisture	7.13±0.53
Crude Protein	20.20±0.35
Crude Fat	22.5±0.9
Ash Content	8.5±0.2
Carbohydrates	41.68 ±1.31

Amino acid profile of pig feed developed from tuna waste is shown in Table 2. The amino acid found in least abundance relative to body requirement is called first limiting amino acid. In a typical pig's

diet, lysine is usually the first limiting amino acid, followed by tryptophan, threonine and methionine (Peter et al. 2007). Severe deficiency in the dietary limiting amino acid and an excessive supply of total protein or some essential amino acids depress feed intake and growth performance (Henry, 1985). The recommended dietary intake for these limiting amino acids are; lysine (1.10% of the diet), tryptophan (0.18% of the diet), threonine (0.69% of the diet), methionine (0.32% of the diet). Essential amino acids contributed 50.48% of the total amino acid content of the pig feed with lysine contributing the highest (10.34%). Glycine was the most abundant non-essential amino acid found in the feed.

Table 2. Amino acid profile of pig feed developed from tuna waste

Amino acid	Percentage of total amino acids
Aspartic acid	9.59±0.21
Threonine*	5.12±0.16
Serine	5.21±0.12
Glutamic acid	7.89±0.18
Proline	6.27±0.28
Glycine	12.15±0.49
Alanine	7.18±0.35
Valine*	4.1±0.34
Methionine*	1.87±0.22
Isoleucine*	5.04±0.42
Leucine*	9.26±0.35
Tyrosine	1.22±0.28
Phenylalanine*	6.26±0.71
Histidine*	3.2±0.14
Lysine*	10.34±0.06
Arginine*	4.87±0.35
Tryptophan*	0.421±0.03

* Essential amino acids for pigs

Fatty acid profile of pig feed developed from tuna waste is shown in Table 3. The feed was found to be rich in poly unsaturated fatty acids linoleic acid (31% of total fatty acids) and DHA (4% of total fatty acids). Palmitic acid (19% of total fatty acids) and stearic acid (4% of total fatty acids) were the most

abundant saturated fatty acids present. Oleic acid contributed 36% of the total fatty acids. National Research Council (1998) has identified linoleic as the single most essential fatty acid for pigs and recommends a minimum level of 0.1% in diet. Enser (1984) and Christensen (1985) have also reported optimum performance and efficient feed utilization in pigs fed 0.1% linoleic acid in diet. The feed prepared from tuna waste had very high proportion of linoleic acid (31.34%).

Table 3. Fatty acid profile (% of total fatty acids) of pig feed developed from tuna waste

Fatty acids	% of total fatty acids
Saturated fatty acids (SFA)	
C14 Myristic acid	1.79±0.04
C16 Palmitic acid	18.58±0.73
C18 Stearic acid	4.14±0.09
C20 Arachidic acid	0.56±0.06
C15:0 Penta decanoic acid	0.52±0.06
C17:0 Hepta decanoic acid	0.41±0.04
C23:0 Tricosanoic acid	0.19±0.07
C24:0 Cis 15 tetracosanoic acid	0.20±0.02
Monounsaturated fatty acids (MUFA)	
C16:1 Palmitoleic acid	0.45±0.05
C18:1n9 Oleic acid	35.81±1.05
C20:1 Cis 5- Eicosenoic acid	0.45±0.03
Polyunsaturated fatty acids (PUFA)	
C20:5n-3 EPA	0.52±0.04
C22:6n-3 DHA	3.69±0.1
C18:3n-3 Linolenic acid	0.63±0.06
C18:2n-6 Linoleic acid	31.34±0.8
C20:3 Eicosatrienoic acid	0.58±0.02
C24:6 Tetracosahexaenoic acid	0.16±0.02

Results of the feeding trials of pig feed developed from tuna waste are shown in Table 4. There was no significant difference in initial and final body weight between the three treatments ($p < 0.05$). Average daily weight gain of the pigs belonging to three treatments also were homogenous ($p < 0.05$). No significant difference was observed in food conversion ratio between three treatments ($p < 0.05$).

Table 4. Results of feeding trials with feed from tuna waste

	T1	T2	T3
Initial body weight (Kg)	14.46±0.19 ^a	14.30±0.52 ^a	14.24±0.93 ^a
Final body weight (Kg)	70.04±2.71 ^a	70.46±2.30 ^a	67.77±3.01 ^a
Total weight gain (Kg)	55.58±2.56 ^a	56.16±1.99 ^a	53.53±3.27 ^a
Average daily weight gain (Kg)	0.535±0.03 ^a	0.540±0.02 ^a	0.515±0.03 ^a
Feed conversion ratio	2.87 ^a	2.84 ^a	3.01 ^a

Different superscripts in the same row indicate significant differences between means ($p < 0.05$).

However it must be noted that, cost of feed per kg body weight gain of pig was ₹ 50.84, 46.98 and 45.05 for T1, T2 and T3 respectively. It can be inferred that pig feed made from tuna waste at a lower production cost can be as effective as the usual feed used in pig farming, which will provide considerable economic benefit to the farmers.

Pig feed developed from tuna waste was found to be rich in essential nutrients which are indispensable in a healthy diet for pigs. Performance of the feed was found to be comparable with that of regular diets. Preparation of the feed is relatively simple and can be done by a layman in the farm itself. It does not involve costly raw materials. Conversion of waste into silage helps in its preservation without any additional energy requirement and also ensures round the year supply of the raw material. However nutrient requirement for pigs may vary depending on the stage of culture operation. Mixing ratios of rice bran and silage can be adjusted to suit the particular requirement without any wastage.

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