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Effective utilisation of slaughterhouse by-products and disposal of waste by anaerobic biomethanation in small ruminants

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Abstract

Slaughterhouses generate large volume of waste annually. All these wastes produced from the abattoir operations pose a threat to the environment and adversely affect public health. Characterization of waste is important because it helps in selecting the treatment methods. In the present study liquid waste generated during the slaughter of sheep was collected and transferred into the bio-methanation tank of 2 cubic meter capacity. In the output slurry the Nitrogen, Phosphorus, and potassium were 150 ± 20 mg/L, below the detectable level, and 46.5 ± 1.06 mg/L respectively. Before slaughter approximately 125-300 ml of blood was collected from the jugular vein of sheep in a sterile round bottom flask containing the glass beads and it is used for the preparation of blood agar.

Keywords: Slaughterhouse waste, bio-methanation, blood agar plates

1. Introduction

The influence of waste management on the environment is one of the key considerations; when waste is recycled or disposed of properly, this helps to lessen the environment's unfavorable consequences. If slaughterhouse wastewater is released outside into the environment without treatment it leads to environmental pollution. Since the BOD of the blood is very high (1,50,000-2,00,000) mg/L in cattle (Liebmann, 1970; Tritt, 1989) ^[12, 18], it causes serious environmental pollution if it is disposed of outside into the land or water bodies. The Environment (Protection) Act, 1986 was passed by Indian parliament with an objective to protect and improve the environment and environmental conditions. It implements the decisions made at the UN conference on Human Environment that was held in Stockholm in the year 1972. The Water (Prevention and Control of Pollution) Act, 1974 was wisely passed by the Indian parliament with the goal of preserving and restoring the purity of our water bodies. The CPCB is charged with the duty of gathering, compiling, and disseminating technical and statistical data related to water pollution. Therefore, monitoring and surveillance of water quality are crucial. In most of the slaughterhouses in India, effective collection of blood, separation of manure, or effluent treatment methods are not practised and extremely complex effluents are discharged into land or water (Irshad *et al.*, 2015) ^[9] thereby leading to environmental pollution. Blood is an important by-product of sheep and can be a major polluter in the slaughterhouse effluent if not collected and processed efficiently. Effective utilization of the blood will create an additional income source for traders/ farmers. Further, a 2 cubic meter biogas plant facility was provided for handling of liquid waste generated during the slaughter of sheep and goats

1.1 The study was envisaged with the following objective

1. Effective collection of blood during sheep slaughter and utilising it for the preparation of blood agar
2. Disposal of liquid waste during the sheep slaughter by anaerobic bio-methanation and using biogas as fuel.

2. Materials and Methods

2.1 Location of the work

The present work was carried out in the Department of Livestock Products Technology, College of Veterinary Science, Tirupati, Sri Venkateswara Veterinary University, Andhra Pradesh and in collaboration with ICAR-National Meat Research Institute, Chengicherla, Hyderabad, Telangana, India. A total of six sheep were slaughtered at two days interval and two sheep were slaughtered per day. Data were collected regarding the quantity of edible meat and by-products were obtained, inedible waste was generated, and the quantum of water was used is recorded during the slaughter of each sheep on all days of slaughter. The sheep were slaughtered at P-MART (Portable Meat Production and Retailing Facility) of ICAR-NRC on Meat, Chengicherla, Hyderabad during the months of June-July 2022, and the liquid waste obtained during the slaughter of sheep was collected and treated by anaerobic bio-methanation.

In the present work, a simple, inexpensive and easy-to-operate step-down voltage transformer of 50 W capacity which is

used to step down the voltage from 220 V to 110 V and which dispenses electricity of about 110 V (below 150 V) was used for designing electrical stunner. The stunner developed was checked using the clamp meter (Uni Trend Technology Co Ltd, Dongguan City, China). The required current (Amp) was dispensed from the main power source to the animal with the help of applicators (clamps) of an electric stunner. This low-cost stunner was developed by scientists at ICAR-NMRI

In P-MART, during the slaughter of sheep, water was used for sanitary purposes like cleaning of P-MART premises, knives cleaning, utensils cleaning etc., and processing purposes like carcass washing, washing of stomach and intestinal contents. By use of sprayer technology, water utilization in P-MART during sheep slaughter was reduced from 45 litres to 5 litres, and liquid waste generated from all these operations was added to bio-methanation tank. Indiscriminate use of water will enhance the production of liquid waste from the slaughterhouse. Hence, in this work use of water was reduced by using sprayers instead of hose pipe. This has significantly brought down the use of water.



Image 1: Showing the use of sprayer technology for minimizing water utilization

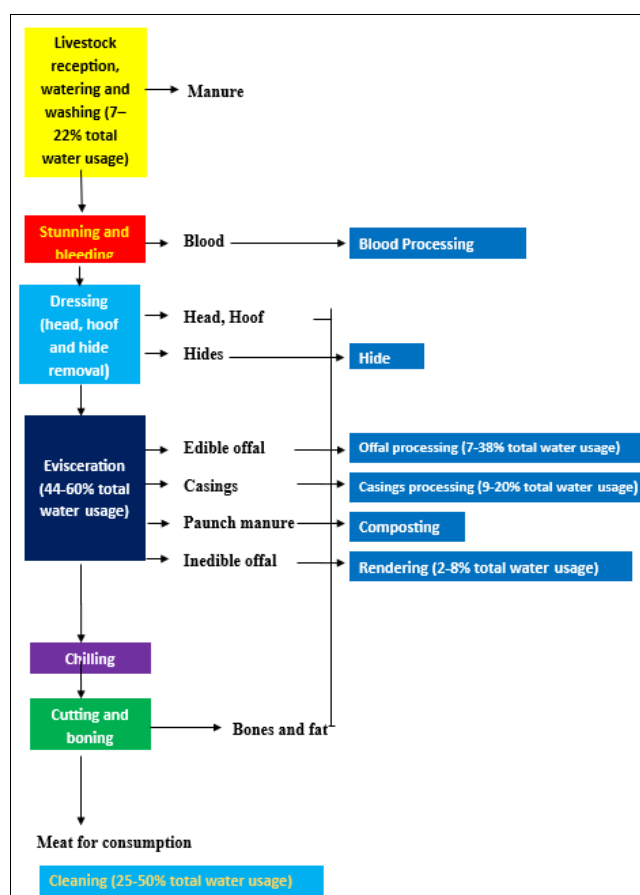


Fig 1: Flow chart of waste generated during slaughter from various operations

2.2 Collection and utilization of blood produced during the slaughter of sheep: Prior to the collection of blood in sheep sterilize the area around the jugular furrow with spirit. From each sheep, around 125-350 ml of blood was collected in an autoclaved round bottom flask containing glass beads from the jugular vein with an I/V scalp vein using a sterile needle. After collection, the round bottom flask containing the glass beads was moved gently and all the fibrin which was present in the blood coat the glass beads and clot formation is prevented and the defibrinated blood was transferred into a sterile glass bottle. Suspend 28 g of blood agar base in 1 liter of distilled water. Heat this mixture to fully dissolve all components. Autoclaved the dissolved mixture at 121°C for 15 min. Allow it to cool to 45-50°C. Add 5% (vol/vol) sterile defibrinated blood to the blood agar base and dispensed into sterile petri plates while liquid.

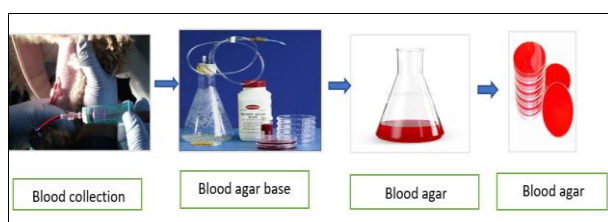


Fig 2: Pictorial representation of blood agar

2.3 Processing liquid waste generated from small scale small ruminant facility (p-mart developed by icar -nrc on meat) using biogas plant

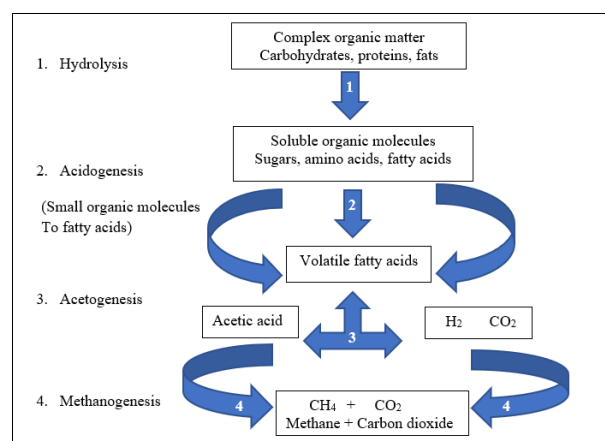
Bio-methanation is a natural process by which organic material is microbiologically converted under anaerobic conditions to biogas and manure (Angelidaki *et al.*, 2011) [3]. Biogas is a mixture of methane (45-75%) and carbon dioxide (25-55%); the actual proportion depending on the substrate used and processes employed. For this purpose, a bio-methanation plant of 2 Cubic meter was established. After initial inoculation and incubation with cattle dung, waste generated from ten sheep and goats were added daily into the bio-methanation plant and the contents were diluted with water in a 1:1 (w/v) ratio and allow it for Anaerobic fermentation for 21 days.

After 21 days, most of the organic matter present in the waste gets degraded and the byproducts obtained after bio-methanation process were biogas and liquid fertilizer. After treatment, the obtained liquid fertilizer was utilized as manure for agricultural and horticultural purposes and the biogas generated was utilized for cooking purposes. The success of a bio-methanation plant depends on several factors, such as the quality of raw material, temperature, the ratio of water to solids, and also on the type of bacterial mass. (CPCB, 2017).

2.3.1 Steps involved in anaerobic Bio-methanation

Anaerobic digestion is the simple, natural breakdown of organic matter into carbon dioxide, methane and water, by two groups of microorganisms, bacteria and archaea. Since many of these are intolerant to oxygen, this process is known as anaerobic digestion. A BOD more than 2000 mg/liter makes it beneficial (Irshad *et al.*, 2015) [9]. It is a two-step fermentation procedure where each stage happens at the same time inside the digester. The most significant of them are volatile fatty acids, which are broken down into simpler molecules by bacteria during the first stage (VFA). In the second stage, methanogenic organisms use the VFA to produce biogas, which is a mixture of methane and carbon dioxide.

2.3.2 Steps involved in anaerobic bio-methanation



2.4 Statistical analysis

The results were subjected to analysis with software (version 22; SPSS) by applying one-way analysis of variance through generalized linear model and the treatment means were ranked using Duncan's multiple range test

3. Results and Discussion

Sheep (*Ovis aries*) and goat (*Capra hircus*) contribute 8.36 and 13.53% respectively to total meat production in India. Preference of consumers for hot meat rather than chilled meat is leading to the propagation of small-scale meat production and retailing practices. There is a need for an innovative intervention to achieve hygienic meat production and retailing. In this work, experiments were undertaken to study the effectiveness of innovative meat production model, Portable Meat Production and Retailing Facility (P-MART), developed by scientists at ICAR-NRC on Meat, Chengicherla, Hyderabad. In addition, associated waste disposal mechanisms using bio-methanation and quality of the liquid fertilizer produced by the bio-methanation process were also studied. Further, profitable utilization of blood, a major pollutant from slaughterhouses, was attempted by preparing blood agars using the blood collected from sheep during the slaughter process.

3.1 Yield of carcass and by-products from sheep

After slaughter of sheep, the yield of carcass and by-products was recorded (Table 1). The mean live weight of six animals slaughtered was 19.47 kgs. The average dressing percentage was 53.27%. The edible by-products obtained from sheep include blood, liver, heart, head, feet, rumen, intestine, lungs, trachea, kidneys, testicles, and spleen. Alonge, (2005) [1] estimated that about 50-54% of cow, 52% of sheep or goat, 60-62% of pig and 68-72% of chicken was utilized for meat and the remaining was disposed as waste. Jayathilakan *et al.*, (2012) [10] stated that in sheep hide account for about 11-12% of the body weight and bone account for about 16% of the lamb carcass. Assan, (2015) [4] dressing% is the ratio between hot carcass weight and live weight of the animal. Therefore, this variable has economic importance. It is highly variable in small ruminants from 36 to 60% because it depends on many factors age weight, breed and gender, and slaughtering method. The results of the present study revealed that dressing percentage was 53.27%. Muthukumar *et al.*, (2021) [16] studied the carcass characteristics on 1332 sheep and revealed that dressing% in all these sheep varied between 46 to 50%. The inedible parts of the slaughtered animals vary for different categories, i.e., 49% for cattle, 47% for sheep and lambs, 44%

for pigs, and 37% for broilers (Meeker and Hamilton, 2006). In case of sheep and goat slaughter houses, the waste generation was 2.5 kg/head which was equivalent to 17% of animal weight (Mozhiarasi and Natarajan, 2022) ^[15]. In the present study, by use of sprayer technology water utilization was reduced from 45 litres as per EEC (Gracey, 1986), to a maximum of 5 litres during sheep slaughter in P-MART. Wastewater generated can also be reduced by conversion to high-pressure, low-volume systems for carcass washing and general sanitation (Johns, 1995) ^[11].

Table 1: Yield of carcass and by-products from slaughter of sheep, (mean $\pm$ se) n = 6

S. No.	Organs	Weight (kg)
1	Live weight	19.47 $\pm$ 1.11
2	Hide weight	1.759 $\pm$ 0.08
3	Head weight	1.19 $\pm$ 0.06
4	Blood weight	0.96 $\pm$ 0.16
5	Rumen $\pm$ intestine (with contents)	3.40 $\pm$ 0.34
6	Lungs $\pm$ Trachea	0.28 $\pm$ 0.03
7	Heart weight	0.09 $\pm$ 0.01
8	Kidneys weight	0.08 $\pm$ 0.01
9	Liver weight	0.31 $\pm$ 0.01
10	Spleen	0.03 $\pm$ 0.00
11	Testicles	0.06 $\pm$ 0.01
12	Hot carcass	10.6 $\pm$ 0.51
13	Dressing%	53.27 $\pm$ 0.01
14	Neck	0.79 $\pm$ 0.03
15	Shoulder	1.47 $\pm$ 0.21
16	Rack	1.28 $\pm$ 0.12
17	Foreshank	2.11 $\pm$ 0.21
18	Loin	1.32 $\pm$ 0.38
19	Leg	3.13 $\pm$ 0.11
20	Stomach weight	0.41 $\pm$ 0.02
21	Intestine weight	0.63 $\pm$ 0.02
22	Weight of GIT contents (kg)	2.36 $\pm$ 0.31

3.2 Preparation of blood agar plates

Blood accounts for about 4% of the live weight and 6 to 7% of the carcass lean meat content of the carcass (Wisner-Pedersen 1988). BOD and COD of the blood were high and it ranges between 1,50,000- 2,00,000 mg/L and 3,75,000 mg/L respectively (Tritt and Schuchardt, 1991) ^[19]. Due to the very high BOD and COD of blood, it is desirable to collect the maximum amount of blood so that wastewater BOD and COD load can be reduced (Johns, 1995) ^[11]. Tons of blood are collected in abattoirs each year, that is either processed into blood meal and sold as low-value animal food and fertilizer or discarded as effluent (Anderson and Yu, 2003) ^[2]. Blood consists of RBC, WBC and Platelets. Apart from this it also contains fibrinogen and albumen which was responsible for clot formation to prevent such clotting huge amount of water was used in the slaughtering operation (Loganath and Mazumder, 2020) ^[13]. Del Hoyo *et al.*, (2008) ^[6] stated that animal blood is a problematic by-product produced from the meat industry because it was released in high volumes, and it was a major pollutant when discarded directly into the environment. Blood can be collected under sterile conditions from the animal during the slaughter and this blood can be used for the preparation of blood agar plates. These blood agar plates were used in microbiological laboratories for the growth of haemolytic organisms.

The results depicted that all the blood agar plates were sterile, and this was proven by a sterility test. For sterility test blood agar plates were incubated in the incubator at 37 °C for 24 hours. In all blood agar plates, no contamination was found. Plates were 100% sterile. Further pathogenic microorganisms like *Streptococcus pneumonia*, *Bacillus cereus*, *E. coli* was streaked on the sterile blood agar plates and the results revealed that these microbes have shown incomplete zone of alpha haemolysis, Complete zone of beta haemolysis and Gamma haemolysis i.e., no haemolysis has occurred on the prepared blood agar plates it was depicted in the Fig 3.

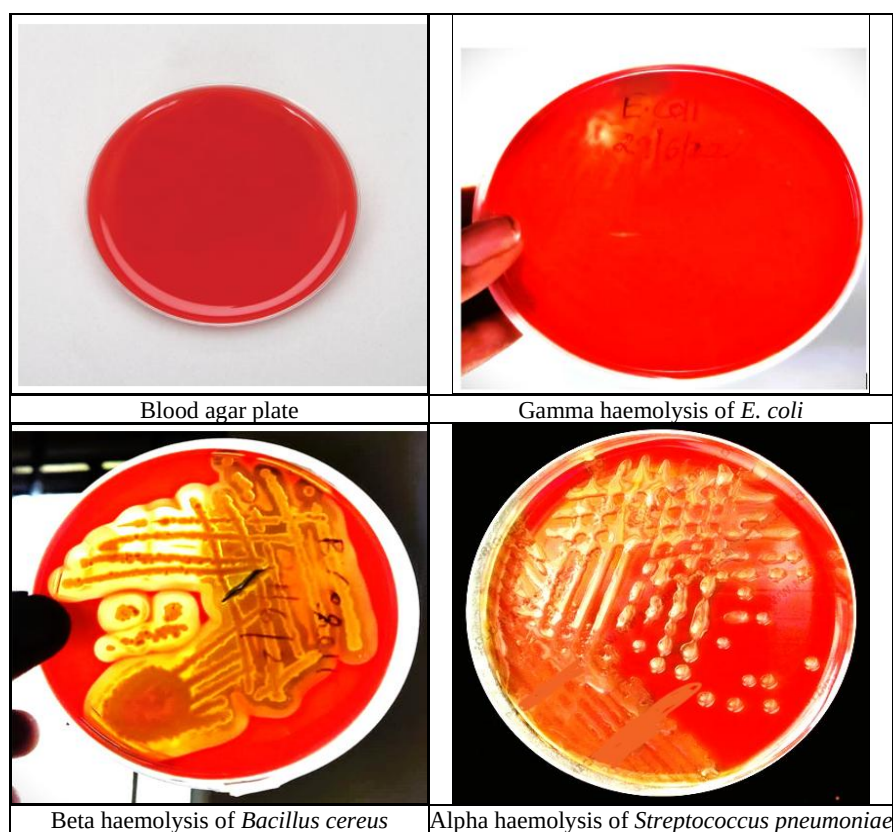


Fig 3: Blood agar plate showing alpha, beta and gamma haemolysis

3.3 Processing of liquid waste generated from small scale small ruminant slaughter using a bio-methanation plant

Type of the waste generated at different slaughter step is given in Table 1. Six sheep of either sex aged about one year were slaughtered (two sheep every day) in P-MART. The entire liquid waste generated (mainly from liquor oozed out from composters, carcass wash water, wastewater generated from cleaning of head and feet after singeing, gastrointestinal tract, floor and walls wash water etc) was immediately transferred to biodigester for anaerobic digestion. Blood cannot be added because it contains too much protein, which will halt the process. It's crucial to keep the pH between 7.0 and 7.2. It can be challenging to restart the process if there is an overproduction of VFA, which will lower pH levels and stops the process. The yield from biogas can be maximized by optimizing the operating parameters such as (pH, total solids, temperature, hydraulic retention time, carbon to nitrogen ratio, agitation, and substrate to inoculum ratio). The by-product of Anaerobic digestion is digested slurry, which can be used as soil conditioners, thus reducing the use of chemical fertilizers.

Biogas is a mixture of methane (45-75%) and carbon dioxide (25-55%). For biogas to be flammable the methane content must be $\geq 40\%$. Apart from methane and carbon dioxide, biogas may also contain small amounts ($\leq 3\%$) of impurities, such as hydrogen sulphide, ammonia, carbon monoxide, and other gases (Monnet, 2003) [14]. The bio-methanation process has strong potential for the production of energy from organic matter and slaughterhouse wastes. It will help to reduce the use of fossil fuels and thus reduce CO₂ and methane emission and transformation of organic waste to very high-quality fertilizer. Biogas production is quantified by measurement of the volume of the produced gas under constant pressure (volumetric method). In present study the yield of biogas produced from slaughter waste of 10 sheep was 2 cubic metres. The generated biogas is used as fuel for cooking purposes and also used for singeing operation during the sheep slaughter. In the output slurry the Nitrogen, Phosphorus, and potassium were 150 ± 20 mg/L, below the detectable level, and 46.5 ± 1.06 mg/L respectively. The slurry can be used as a manure for agricultural purposes.

4. Conclusion

Waste generated from 10 sheep was treated by anaerobic biomethanation process and the byproducts were biogas and liquid fertilizer (slurry). Biogas was used for cooking purposes and liquid fertilizer was used as fertilizer for crops. Blood was collected before the slaughter of sheep and is used for the preparation of blood agar.

5. Acknowledgement

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6. Author's Contribution

Not available.

7. Conflict of Interest

Not available.

8. Financial Support

Not available.

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