

**Assessment of Poultry Feather Waste as a Feed Ingredient for
Animal Feed and Its Business Opportunity: A Study on North**

Dhaka City

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**DEPARTMENT OF AGRIBUSINESS AND MARKETING
SHER-E-BANGLA AGRICULTURAL UNIVERSITY**

DHAKA- 1207

JULY 2021

**Assessment of Poultry Feather Waste as a Feed Ingredient for
Animal Feed and Its Business Opportunity: A Study on North Dhaka
City**

BY

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*A thesis submitted to
The Department of Agribusiness and Marketing,
Sher-e-Bangla Agricultural University, Dhaka-1207
In partial fulfillment of the requirements for the degree of*

**MASTER OF SCIENCE
IN
AGRIBUSINESS AND MARKETING
SEMESTER: JANUARY-JUNE, 2021**

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CERTIFICATE

This is to certify that the thesis entitled ‘**Assessment of Poultry Feather Waste as a Feed Ingredient for Animal Feed and Its Business Opportunity: A Study on North Dhaka**’ submitted to the Faculty of Agribusiness Management, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Agribusiness And Marketing**, embodies the result of a piece of bona fide research work carried out by **S. M. AL- MUNIM**, Registration Number:14-06302, under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information received during the course of this investigation has duly been acknowledged.

Dated:
Dhaka, Bangladesh

.....
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**DEDICATED
TO MY
BELOVED
PARENTS**

ACKNOWLEDGEMENT

*Alhamdulillah, thanks be to Allah for his gracious generosity and great mercy, which provide the author with the chance to finish the research necessary for partial completion of the **Master of Science degree**.*

*The author is obliged and grateful to **his parents**, who hoped for his success on a daily basis, and without whose love, compassion, inspiration, and sacrifice this work would not have been done.*

*The author wishes to express his heartfelt appreciation and indebtedness to his supervisor, **Dr. A. M. Shahabuddin**, Professor & Dean, Faculty of Fisheries, Aquaculture & Marine Science, Sher-e-Bangla Agricultural University, for his active, sincere, inventive, and unflinching guidance, unflinching interest, constructive criticism, valuable suggestions, and helpful comments throughout this research. Without his assistance, the author may not be able to finish the study.*

*The author wishes to express his profound admiration and gratitude to his co-supervisor, **Sauda Afrin Anny**, Assistant professor, Department of Agribusiness and Marketing, Sher-e-Bangla Agricultural University, for her guidance, constructive direction, affectionate encouragement, and kind cooperation throughout the research.*

The author wishes to express gratitude to the shopkeepers of markets of Dhaka North City Corporation, business owners of feed business for their generous assistance and cooperation; without their willingness to contribute information, this study would not have been feasible.

The Author

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ABBREVIATION

ACPD	Apparent Crude Protein Digestibility
BBS	Bangladesh Bureau of Statistics
BSS	Bangladesh Sangbad Sangstha
BDT	Bangladesh Taka
BWG	Body Weight Gain
BLRI	Bangladesh Livestock Research Institute
CP	Crude Protein
DAE	Department of Agriculture Extension
DAM	Department of Agricultural Marketing
DM	Dry Matter
DNCC	Dhaka North City Corporation
EHPF	Extensively Hydrolyzed Poultry Feather
<i>Et al.</i>	All Others
FAO	Food and Agriculture Organization
FCR	Food Conversion Ratio
FI	Food Intake
FFYP	Fifth Financial Year Period
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GOs	Government Organizations
g	Gram
HC	High Court
HFM	Hydrolyzed Feather Meal
HPBM	Hydrolyzed Poultry By Product Meal
HSC	Higher Secondary School Certificate
Kg	Kilogram
Kcal	Kilocalorie
KII	Key Information Interview
MS	Master of Science
MMT	Million Metric Tons
min	Minute
Mt	Metric tons
Mn	Million
NGOs	Non-Government Organizations
SSC	Secondary School Certificate
TK	Taka
TMR	Transparency Market Research
US\$	United States Dollar
%	Percent

ABSTRACT

As the demand of chicken consumption is high and rising, the amount of poultry market waste is also increasing by multiple times, which creates an alarming situation of polluting environment. By processing this waste into feather meal and poultry waste meal, manufacturers can contribute to meet the demand of protein for feed production and establishing a pricing structure. Therefore, this study was conducted to assess the present scenario of poultry feather waste, how to use it as an animal feed ingredient and its business opportunity. A survey was conducted in the 21 randomly selected poultry markets of Dhaka North City Corporation. Samples of feather and poultry waste were collected for laboratory analysis. The results found that in general in each shop producing 100 kg poultry wastes among which 2 kg is feather waste. It was estimated that Dhaka North City producing 473.7 tons of poultry waste among which 8.7 tons are feather, that are discarded as waste (survey data). Simplified processing techniques for feather meal has been developed. It was observed that 1 kilogram of feather waste can produce about 500 grams of product, presenting a considerable economic opportunity in comparison to other feed ingredients. Furthermore, the generated product has a high nutritional value while having no negative environmental impact. Proximate analysis showed that the final product contained Moisture 11.25%, Crude Protein 86.53%, Total Ash 7.31%, Crude fiber 0.73%, Crude Fat 5.03%. The total cost of producing per kilogram of feather meal is about 28 BDT which is much lower than present market price (60 BDT). There is opportunity to create yearly 1 million US\$ business from the wasted feather in Dhaka city. Thus, using market waste for feather meal production could be a new opportunity to convert waste into resource and significant contribute to economy of the country significant

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

The problem of poultry waste disposal has been exacerbated by the centralization of poultry processing. This, combined with concerns about the world's protein demands and, more lately, man's struggle with the environment, has been a powerful motivator for the creation of poultry byproducts. While there is minimal question about the utilization of offal and blood by-products in feedstuffs, the same cannot be said for feathers. Feathers, horn, hooves, and hair are keratinous proteins with minimal nutritional value in their natural state. Keratin-type proteins, on the other hand, can be made digestible and acceptable in animal feeds with the right processing (Calvin, 1972).

Feather meal is an excellent source of protein for aquaculture feeds. It was reported that an excellent performance was observed in academic and commercial-scale trials at high inclusion levels of feather meal. Dhaka is one of the fastest growing mega cities with estimated population around 20 million (Kabir, 2015). Rapid growth of population, increasing urbanization and economic development of the people, the number of markets is increasing sharply. It is assumed that these markets producing large volume of poultry processing waste. These waste generally are dumping in the open space as a cheaper and easiest way. These large volumes of poultry waste are easily perishable and can create environmental pollution quickly. A scientifically approved environmental technology can produce these wastes as a resource that have a good market price.

Fish is a major source of animal proteins for more than 1 billion individuals around the world. Fish accounts for at least 30% of their animal protein consumption. (Omojowo and Omojasola, 2013; Elsaidy, Abouelenien & Kirrella, 2015). In Bangladesh, fish is the second most valued agricultural produce, and its production supports millions of people's livelihoods and employment. As a result, fish culture and consumption have significant ramifications for national wealth and food security (Ghose, 2014).

Aquaculture is the farming of fish and other aquatic organisms, with the term 'farming' implying some type of intervention to enhance productivity and some form of private

ownership of the stock under intervention (Beveridge and Little, 2002). Littoral shrimp farms cover 0.29 million hectares of inland closed (culture) water fishery bodies (National Fisheries Policy, 1998). It has proven to be an effective strategy for enhancing fish output, as seen by higher fish stocking density and the use of artificial feeding (Agboola, Yossa & Verreth, 2019). Feeding is prohibitively expensive; as a result, attention has been drawn to alternate methods of water enrichment, such as the use of poultry waste.

Feather meal (FM) is one of the poultry by-products which contain high protein content (80-85 percent) and commercially available. With some chemical treatments, it can be a good source of the sulphur-containing amino acids (Spinelli, 1980; Onifade et al., 1998; Bertsch and Coello, 2005). Besides, the cost of feather meal is approximately two thirds the costs of other animal proteins in the market and it is readily available from many sources (Bishop et al., 1995).

Feather meal contained high amount of protein. Animal protein especially fish meal is an important ingredient for animal feed that contain high amount of protein, lipid, vitamins and minerals. It is important to increase the protein level in the fish feed, an easily digestible ingredients and accelerate fish growth. It is prepared after drying and separating oil from the fish body. Normally small fishes and shellfishes are using to prepare fish meal. However, feather meal can also be used for the preparation of fish feed. Feather meal is a product prepared through acid hydrolysis of feather. Dry powdered feather can be prepared drying under sun or in the dryer.

According to Transparency Market Research (TMR), the global feather meal market would be worth US\$ 359.5 million in 2020. According to the analysis, the market is estimated to reach US\$ 820 million by 2030, growing at an annual rate of 8.6% ("Feather Meal Market | Global Industry Report, 2030", 2021).

Feather meal's excellent nutritional value will encourage farmers to switch to organic fertilizers as a cost-effective alternative to harmful fertilizers. It is found that 175 thousand tons of feather meals were produced in Europe in 2014. This suggests that investors have a significant chance in this industry, and that the Asia Pacific market could be even bigger ("Feather Meal Market | Global Industry Report, 2030", 2021).

It was reported that in the Dhaka city among the total waste, 70% is organic and biodegradable (Prodhan 2021). Poultry market waste is one of the major organic wastes produced in the city market. This large volume of the organic waste still unmanaged and unutilized due to the proper study and management procedure. This large volume of the intestine contained more than 70 to 80% of water, for this reason it is difficult to manage the waste in a shortest possible time. These wastes are easily perishable and can produce bad smell to the environment. Hence produce toxic gases and spread different types of disease organisms. For this reason, it is important to develop a sustainable management procedure for the poultry waste that is scientifically approved for the use.

Among the major cities, the capital city Dhaka is one of the mega cities of the world and a most populous as well as the 2nd worst city in the world for living. The city is the home of about 20 million people (Kabir, 2015). Rapid and unplanned urbanization is causing many problems like rapid growth of slums, pressure on infrastructural services along with different social problems. Dhaka city produces around 6000 tons of domestic waste every day, a major issue concerned is the management of municipal waste for the City Corporations (Kabir, 2015). Yet the Dhaka City Corporation collects less than half of it. The rest remains on roadsides, in open drains and in low-lying areas. It is predicted that the amount would be the several times higher in the 10 years. Among the total waste 70% is organic and biodegradable. Among this large volume of the organic waste, poultry market waste is a significant part that is still unmanaged and unutilized due to the proper scientific study.

1.2. Justification of the study

In Bangladesh, municipal trash management has long been regarded as one of the most serious environmental issues. Because the country's economy is rapidly expanding, the amount of waste produced has expanded as well, and many of the existing waste disposal sites have reached their carrying capacity. Also, aquaculture being the second most valued agricultural produce and its production supports millions of people's livelihoods and employment. This, combined with concerns fish feed being prohibitively expensive; finding the alter use of poultry waste and turning them into fish or livestock feed has been

considered. This proposed study will analyze the present condition and business opportunity of poultry feather waste as an animal feed ingredient.

1.3. Limitation of the study

It was not possible to analyze all poultry market situation in DNCC. Due to a lack of adequate data in Bangladesh, makes it extremely difficult to make a good assessment of the poultry waste sector.

1.4. Specific objectives of the study

1. To illustrate the present status and condition of the poultry market waste produced in the North Dhaka city.
2. To assess the scope and business opportunity of the poultry feather waste.
3. To develop the protocol for the processing of feather meal as an ingredient of animal feed.

CHAPTER TWO

REVIEW OF LITERATURE

2.1. Introduction

The literature review is an unavoidable part of the study that enriches the concept about research. It helps to fabricate the research paper. Various books, reports, journals, magazines, seminar papers those focus on the issue have been studied during the preparation of this research.

2.2. Poultry farms in Dhaka city

In Bangladesh, the total number of chicken farms (a rough estimate) is likely the only statistic available. There is some countrywide breakdown available for the location of these farms, but data is clearly not detailed enough to be used for any fair assessment (Waste Concern, 2005). However, because commercial chicken meat and eggs are mostly consumed in cities, these farms are located within 20 to 50 kilometers of the outskirts of major cities. Dhaka, the capital city and by far the greatest commercial center, would certainly have the highest share of the urban centers. It is reasonable to suppose that at least half of the country's total farms are located within 100 kilometers of Dhaka. Because Dhaka is so well connected, it is relatively easy to supply the city from as far as 100 kilometers away. Savar, Sreepur/Bhaluka, and Keraniganj are three chicken farm locations that have been found. As a result, it's safe to estimate that more than 90% of the Dhaka region's poultry waste (about 50% of Bangladesh's total) will be available in these three places. The establishment of chicken waste utilization units could be aimed at these sites (Waste Concern, 2005).

2.3. Poultry waste

Poultry waste includes litters from broiler and layers, hatchery debris, dead birds, feathers, and other debris commonly generated in chicken farms during waste handling procedures are referred to as poultry wastes. Whereas broiler litter is a mixture of manure, bedding material, wasted feed, feathers in certain situations, dirt (Jacob et al., 1997; Prabakaran & Valavan, 2021). Hatchery wastes, manure (bird excrement), litter (bedding materials), and

on-farm mortalities are all products of poultry production. Offal (feathers, entrails, and organs of killed birds), processing wastewater, and bio-solids are all produced during the processing of poultry. Chicken industry creates a large volume of waste from hatcheries, poultry farms, processing plants, and other sources, all of which pose health risks by polluting the air, water, and land. Processing and recycling these trashes provide more options for disposal (Prabakaran & Valavan, 2021).

The use of poultry waste as manure and other farm animal excrement as fish feed is not a novel concept. Manuring fish ponds was known in China in the fourth and fifth centuries B.C. as a method of enhancing fish productivity. (1949, Neess; Usman, Ogbe, Oguche, Momoh & Omale, 2019). In China, combining fish farming with cattle and agricultural production is a long-standing tradition. The use of chicken waste in aquaculture is very new, and the present interest in manure as a feedstock stems mostly from the challenge of waste management in intensive livestock and poultry operations (Usman, Ogbe, Oguche, Momoh & Omale, 2019).

Bangladesh's commercial poultry business is quickly expanding, with a 5.3 percent yearly increase in chicken population. (GoB, 2010; Hossen, Hoque & Nahar, 2015).

By-products from poultry and animals, such as poultry meat flour, feathers, and blood meal, are essential sources of protein for animal feed. They are high in basic amino acids, vitamins, and minerals, and they are nearly free of anti-nutrients, unlike plant proteins (Beketov, Kozlov, Nikiforov-Nikishin & Platonov, 2020).

However, the qualitative qualities of dry animal feed are relevant to this subject. The future of hydrolyzed feather meal, which has improved digestion and absorption, is of particular importance to aquaculture (Beketov, Kozlov, Nikiforov-Nikishin & Platonov, 2020).

2.4. Poultry waste in Bangladesh

Small and large-scale chicken farms are rapidly increasing in Bangladesh, producing meat, eggs, and job opportunities. At the same time, it generates a considerable amount of waste materials. Bangladesh now has 123 million hens (FAO, 2002) and around 50,000 poultry farms (FFYP, 2003). However, according to another census, 12.89 percent of poultry birds

were obtained from non-farm sources, 51.95 percent from small farms, 27.43 percent from medium farms, and 7.73 percent from large farms (BBS, 2003). Although a tiny amount of chicken waste is used for fish and agricultural production by farmers, the waste products of these farms pollute the environment (Waste Concern, 2005).

2.5. Poultry waste management in Bangladesh

In Bangladesh, municipal trash management has long been regarded as one of the most serious environmental issues. Because the country's economy is rapidly expanding, the amount of waste produced has expanded as well, and many of the existing waste disposal sites have reached their carrying capacity (Waste Concern, 2005).

Small farmers are able to cope with waste by composting it on their own property. In most situations, though, the garbage is sold. Existing disposal methods have been identified as follows (Waste Concern, 2005):

- (1) Dumping on low ground in and around the poultry farm
- (2) Sold to farmers as fertilizers
- (3) Sold off as fish feed
- (4) Sold off as cooking fuel
- (5) Sold off to compost manufacturers
- (6) Used in digesters

2.6. Environmental impacts of poultry waste dumping

In Bangladesh, poultry waste management is almost non-existent, or at best, haphazard. The problem of poultry waste has gotten so serious in recent years that many efforts are being made to find a cost-effective solution. The problem was largely disregarded until the wastes generated by chicken farms exceeded the capacity of the local ecology to absorb them (Waste Concern, 2005). However, like with other related environmental challenges, the pollution burden of poultry waste in particular parts of concentrated farms has grown to the point that poultry farm owners are beginning to recognize the problem and, for the first time, are willing to pay for proper disposal (Waste Concern, 2005).

Table 2.1: Major Environmental Impacts of Existing Poultry Waste Disposal Practices
(Source: Waste Concern, 2005)

No.	Disposal Methods	Major Environmental Impacts	Mitigation Measures
1	Dumping on low ground in and around the poultry farm	Problems with Odor, Water Contamination and Insects /vermin	Practice should be Discouraged
2	Dumping on heaped pile and allowed to compost	Odor, water pollution and Insects/vermin	Proper composting technique should be taught to the farmers
3	Sold off as fish feed	Water pollution and over fertilization	BOD testing and controlled discharge should be practiced
4	Sold off as cooking fuel	Indoor air pollution	Adequate ventilation should be ensured
5	Sold off to compost manufacturers	Minimal, only slight problem during transportation	Use of covered trucks to minimize odor and spillage
6	Used in digesters	Minimal, but only if all handling measures are adopted	Proper handling in all stages of the operation



Figure 2.1: Environmental Impacts of Dumping Poultry Waste on Low Grounds in Areas Adjoining the Poultry Farm (WASTE CONCERN, 2005)



Figure 2.2: Environmental Impacts of Dumping Poultry Waste on Heaped Piles (WASTE CONCERN, 2005)

2.7. Global Aquaculture

Aquaculture, the aquatic equivalent of agriculture, has exploded in popularity in recent decades, producing nearly as much fish and shellfish as fisheries (FAO, 2014). In the future, aquaculture will be the primary technique of collecting additional food from our aquatic surroundings. The consumption of resources such as land (or space), water, seed, and feed, their transformation into products valued by society, and the subsequent release into the environment of greenhouse gases and wastes from uneaten food, fecal, and urinary products, chemotherapeutants, as well as microorganisms, parasites, and feral animals are all factors that have an impact on biodiversity in aquaculture. Negative effects can be direct, such as the release of eutrophication substances, toxic chemicals, pathogens, diseases, and parasites into wild populations, and the introduction of exotic and genetic material into the environment, or indirect, such as habitat loss and niche space changes in food webs. Fishmeal and fish oil—an important source of protein and fatty acids in diets for many fish and shrimp species—are now collected in considerable amounts to create fishmeal and fish oil (16 mmt in 2012, FAO, 2014). The volume used for non-food purposes is gradually decreasing, but the aquaculture industry's high demand may lead to unsustainable fishing practices, which could have significant effects for fish stocks and marine food webs (Cao et al., 2015).

Aquaculture has progressed significantly in recent decades. In 2016, global fish production totaled 171 million tons (production and cultivation), with aquaculture accounting for 80 million tons, or 46.8% of the total amount (Beketov, Kozlov, Nikiforov-Nikishin & Platonov, 2020).

2.8. Aquaculture in Bangladesh

Bangladesh is surrounded by abundant inland lakes and river systems, making it one of the world's best sites for fisheries and aquaculture. In reality, Bangladesh is one of the top ten fish producers in the world. Inland aquaculture production 5th and open water capture 3rd (FAO 2016). Between 1985 and 2000, Bangladesh's aquaculture production increased by 28

percent, from 0.12 million tonnes to 0.66 million tonnes on average. Despite this, Bangladesh has only realized a small portion of its potential for output (Ghose. B, 2014).

Inland capture fisheries, inland aquaculture, and marine fisheries are the three main types of fisheries. Inland aquaculture accounts for 55% of total output. Fish is a great source of animal protein, and its production creates jobs, makes money, and helps people get out of poverty. 4.92 percent of overall GDP and 5.7 percent of total export earnings are made up of this contribution. The sector directly or indirectly employs around 12 million people, including 1.4 million women (BBS, 2004).

2.9. Status of the Aqua feed industry in Bangladesh

The industrial aquafeed business produced an estimated 50,000 t of aquafeed per year, primarily for pangasius intense culture, monosex Nile tilapia, and the Thai climbing perch strain (Barman and Karim, 2007). Between 2005 and 2007, shrimp and prawn feed output totaled over 10,000 t per year. A large portion of aquafeed was either farm-made or generated by small-scale feed manufacturers, in addition to industrially produced feeds (Jeleel et al., 2019). A large portion of aquafeed was either farm-made or generated by small-scale feed manufacturers, in addition to industrially produced feeds. Bangladesh's yearly aquafeed consumption is estimated to be around 230,000 t. (Barman and Karim, 2007). For general feeding of fish, a wide variety of feed materials, and both local and imported, are utilized separately or mixed (Jeleel et al., 2019).

2.10. Fish feed

Global aquaculture is expected to grow by 50% by 2030 (Falch, 2014), and aquaculture, like any other terrestrial farming activity, is completely reliant on the availability and delivery of nutrients. Feed accounts for roughly 40%–60% of overall expenditures in aquaculture operations, and increasing fish productivity necessitates an increase in feed inputs as well (Agboola, Yossa and Verreth, 2019). In most developing nations, quality feed ingredients, notably fishmeal and fish oil, are scarce, and reliance on imported feed supplies raises production costs, especially for smallholder farmers (Agboola, Yossa and Verreth, 2019).

2.11. Feather meal as fish feed

Feather meal is made from the feathers left over after a chicken has been slaughtered. Feather meal is used as a fertilizer and a source of nutrition for farm animals. Broiler, turkey, and other poultry processing plants produce feathers as a by-product. Feathers make about 3-7 percent of the weight of a live bird, therefore they provide a significant amount of protein (Soni et al., 2017; Collins et al., 2014).

Table 2.2: Typical Compositional Components of Feather Meal (Source: Ewing, 1997)

Components	Amount
Dry Matter	90%
Crude Protein	83%
Digestibility	75% min
Fat	6%
Ash	4%
Crude Fiber	0.60%
Available Lysine	1.80%
Methionine + Cysteine	4.90%
TME _n	3.07 Kcal/g (12.8 MJ/kg)

Feather meal (FeM) is one of the rendered protein ingredients that are commonly used in fish feeds at levels of 3 – 7% (Bureau, 2010). It is a surprisingly valuable protein supply for aquaculture feeds and has established exceptional overall performance in educational and commercial-scale trials at excessive inclusion levels. In the compound feed industry, feather waste from the chicken processing industry could be used as a protein source. Improvements in existing processing technologies for hydrolyzing feather proteins to make them more digestible for non-ruminant animals have resulted in the availability of high-quality

hydrolyzed feather meal, which could be a viable economic option for livestock feed ingredients. Feather meal's feeding value is influenced not just by its protein level, but also by the amount of energy it contains ("Feather Meal Market | 2021 - 26 | Industry Share, Size, Growth - Mordor Intelligence", 2021).

Because feathers are made up of >90% protein and are rich in hydrophobic amino acids like cystine, arginine, and threonine, they are also processed to feather meal for use as animal feed, organic fertilizers, and feed supplements. The hydrothermal process, in which feathers are digested under high pressure at high temperature, is one of the most prevalent techniques of feather meal production. Hydrothermal treatment, on the other hand, causes the degradation of important amino acids such as methionine, lysine, tyrosine, and tryptophan, resulting in poor digestibility and nutritional value (Tiwary and Gupta, 2021).

2.12. Energy value of Feather meal

Feather meal's feeding value is influenced not only by its protein level, but also by its energy content. The link between energy and nutrients is critical for poultry and animal nutritionists; if the energy content of feather meal is underestimated, its inclusion in diets may result in larger calorie-protein ratios, which may contribute to excess fat buildup in the body. The energy content of feedstuffs, particularly FM in terms of TMEn, is said to be highly dependent on their chemical makeup. The amount of metabolisable energy in well-processed feather meal is mostly determined by the fat content of the raw materials (Collins et al., 2014).

2.13. Feather meal can be an integral part of poultry diets

Reduced production costs may be one way to ensure a steady supply of broiler meat at lower prices throughout the year. Feather meal can be used to meet the needs for growth-promoting protein in a cost-effective manner (Feather meal and its nutritional impact, 2017). In well-balanced diets, hydrolyzed feather meal can be added up to 6% of the ration for broilers, 7% for layers, and 5% for turkeys without causing any negative effects on production or health. Broiler hens' mean body weights, feed intake, and feed conversion ratio were not affected by adding up to 3.0% processed, water boiled feather meal to their diets. Birds fed diets

containing 0, 1.5, and 3 percent feather meal had larger (P0.05) carcass yields than those fed the 4.5 percent feather meal diet, according to carcass data from slaughtered chickens. (Feather meal and its nutritional impact, 2017)

2.14. Feather meal market overview

According to Transparency Market Research (TMR), the global feather meal market would be worth US\$ 359.5 million in 2020. According to the analysis, the market is estimated to reach US\$ 820 million by 2030, growing at an annual rate of 8.6% ("Feather Meal Market | Global Industry Report, 2030", 2021).

Feather meal's excellent nutritional value will encourage farmers to switch to organic fertilizers as a cost-effective alternative to harmful fertilizers. It is found that 175 thousand tons of feather meals were produced in Europe in 2014. This suggests that investors have a significant chance in this industry, and that the Asia Pacific market could be even bigger ("Feather Meal Market | Global Industry Report, 2030", 2021).

2.15. Scope and possibility of business of poultry market waste and the feed

The survey analysis shows us that, the amount of waste generation in poultry market is huge, where feather is a great part. Rather than throwing away these wastes, turning them into product can help achieve a great part in economy and saving our environment. Also, from the secondary data reviewing it is learned that proper nutrient rich fish feed is costly and also the feather from poultry industry is rich with protein elements that are regularly used in fish diets. Feather meal (FM) is a commercially accessible by-product of poultry with a high protein content (80-85 percent). It can be a good source of sulphur-containing amino acids after various chemical treatments (Spinelli, 1980; Onifade et al., 1998; Bertsch and Coello, 2005).

2.16. Nutritive value of feather meal to influence feather meal market

To determine the impact of raw materials and processing conditions on protein escape, digestibility of proteins, and other feed value defining metrics, animal by-product meals were obtained. Feather meal is a substantial by-product of the poultry industry when processed at a rendering facility. Feather waste from the poultry processing industry could one day be used as a protein source in animal feed. Feathers are high in keratin, a protein that accounts for 7% of the weight of a living bird, offering a significant bulk that can be transformed into a profitable meal. Furthermore, the usage of feather meal as a great source of escape protein in comparison to oil meals will increase demand for feather meal ("Feather Meal Market | 2021 - 26 | Industry Share, Size, Growth - Mordor Intelligence", 2021).

2.17. Feather meal as alternative to other fishmeal

For several years, aqua feed companies have been increasingly interested in feather meal. It offers unquestionable nutritional benefits as a protein source, not only in terms of protein content and digestibility, but also in terms of cost savings when used to replace fishmeal in aquaculture feed ("Feather Meal Market | 2021 - 26 | Industry Share, Size, Growth - Mordor Intelligence", 2021). It is a highly useful source of protein for aquaculture diets, and it has demonstrated good performance in academic and commercial experiments at high inclusion levels. The findings suggest that feather meal has a high nutritional value for trout, and that fish meal can be used in place of chicken by-product meal without sacrificing growth, feed intake, or feed efficiency. The capacity of feather meal to replace dietary fish meal protein in the diet of carp will increase desire for feather food ("Feather Meal Market | 2021 - 26 | Industry Share, Size, Growth - Mordor Intelligence", 2021).

2.18. Growth and trends in the feather meal market

The market for feather meal is divided into organic and conventional types, as well as animal feed and agrochemical industries ("Feather Meal Market | 2021 - 26 | Industry Share, Size, Growth - Mordor Intelligence", 2021).

The global feather meal industry is a highly niche sector, with a modest number of small and medium-sized businesses accounting for a very small portion of the market. As a result, there is a lot of competition. The fragmented character of the industry is mostly due to the growth of regional markets and local players in various regions of the world. The two regions with the most competitive activity are Asia-Pacific and North America ("Feather Meal Market | 2021 - 26 | Industry Share, Size, Growth - Mordor Intelligence", 2021).

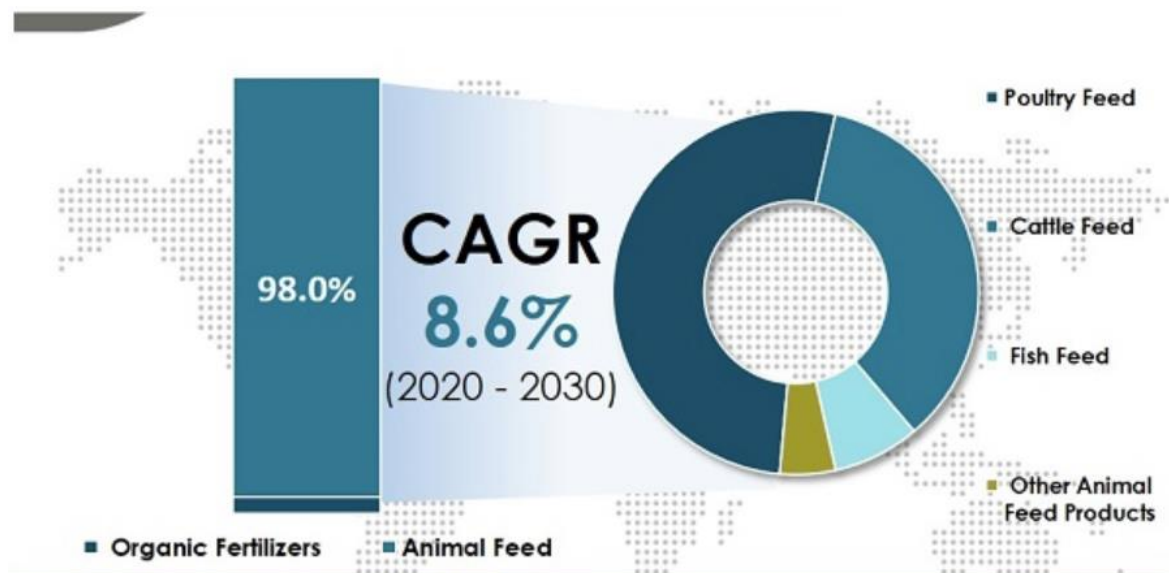


Figure 2.3: Global Feather Meal Market Share (Source: Transparency Market Research)

2.19. Growing organic fertilizers market accelerating feather meal market

Organic farming, which emphasizes the use of organic fertilizers, has proven to be a profitable bet for the agricultural industry as a safe and ethical option for customers, owing to the growing popularity of organic foods. Organic fertilizers are gaining appeal due to several environmental benefits, such as better soil structure and water conservation, in addition to ethics. Organic fertilizer adoption is boosted by raising farmer understanding of the nutritional benefits of plant-based and animal-based fertilizers, as well as their function in promoting earthworm growth and other plant-based microbiological activities. Organic animal by-product fertilizers are gaining popularity over plant-based alternatives due to their strong adsorbent and water retention capacities, which improve soil fertility (Feather Meal Market to Reach Valuation of ~US\$ 820 Mn by 2030, 2021).

Many varieties of commercial organic fertilizers are available for use in certified organic crop growing. Liquid shrimp, pelleted poultry manure, pelleted seabird guano, Chilean nitrate, feather and blood meal, and other goods are examples. Feathers are collected and then subjected to high temperatures and pressure before being ground into a fine powder. After drying, they are packed for use in fertilizer mixes, animal feed, and other applications. Feather meal is a high-nitrogen organic fertilizer that can be used in place of many commercial liquid fertilizers (Feather Meal Market to Reach Valuation of ~US\$ 820 Mn by 2030, 2021).

2.20. Impact of COVID-19: feather meal market

Despite the fact that demand for animal feed has remained largely consistent, the coronavirus epidemic has significantly impacted supply. China, a key organic soybean supplier, has caused challenges for global organic feed producers because to its harsh measures to combat the Covid-19 epidemic. Furthermore, logistical challenges in China hampered the availability of containers and vessels, as well as the shipment of additional micro-ingredients. The governments have ordered the partial closure of their international ports, leading the animal feed supply chain to be further disrupted (Feather Meal Market to Reach Valuation of ~US\$ 820 Mn by 2030, 2021).

The animal feed sector has been severely damaged by restaurant closures across the country. The substantial shift in consumer purchasing patterns caused by the COVID-19 pandemic has compelled businesses to reassess their policies and tactics. Poultry and aquaculture production are two of the worst-affected industries. This will have an impact on the growth of the feather meal market for the next 1-2 years, with demand projected to fall for a year or two before stabilizing over the next few years. (Feather Meal Market to Reach Valuation of ~US\$ 820 Mn by 2030, 2021).

CHAPTER THREE

MATERIALS AND METHODS

For research, all the work should be done in a sequence. A proper methodology should be formulated for this. Methodology reveals the entire process that was followed for the completion of the study successfully. Analysis of step by step and each step's supervision is essential for accomplishing the whole research. Intensive studies have been carried out for unveiling the facts and problems of the study area. Based on the objectives of the study, a diagnostic framework was adopted to organize the scattered ideas and views.

This chapter discusses attributes of study area and materials and methods followed within the research work. This chapter also includes of sampling sites selection, sample size determination, survey and interview procedure for sample analysis, secondary data collection and data interpretation.

3.1. Study Area

Dhaka is Bangladesh's capital and largest metropolis. With a population of 20 million people in 2015, it is the world's tenth-largest and fourth-most densely populated city (Kabir, 2015). The study was conducted in Dhaka North City Corporation (DNCC), which consists of 54 wards covering 26 Thanas. DNCC is located in the northern section of Dhaka City. It has an area of 196.22 km² and is located between 23°44' and 23°54' East Latitude and 90°20' to 90°28' North Longitude (Alam, Hossain & Elahi, 2020).

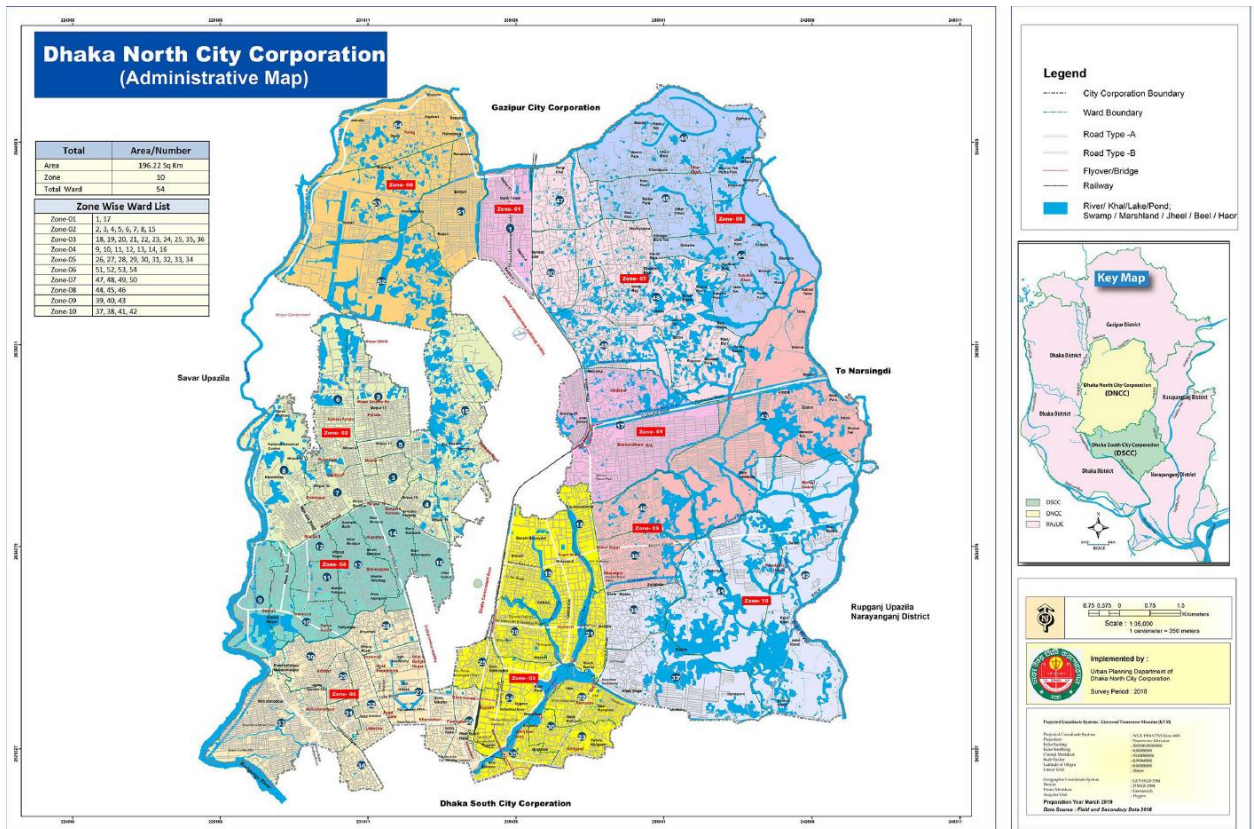


Figure 3.1: Location of Study Area-Dhaka North City Corporation (Source: Dhaka North City Corporation, 2021)

3.2. Selection of the study area

As for the specific research purpose the study area required to be the area within Dhaka city poultry markets. Selection of the study area was done through secondary material review and visit to DNCC office. Also transact walking and Key Informant Interview (KII) helped to determine the study area.

Dhaka, the capital city and by far the greatest commercial center, would certainly have the highest share of the urban centers. It is reasonable to suppose that at least half of the country's total farms are located within 100 kilometers of Dhaka. Because Dhaka is so well connected, it is relatively easy to supply the city. So markets of Dhaka reasonably produce most of the poultry waste that is the main concern of the study to convert this waste into resource.

3.3. Study Timeline

The research work included primary data collection through reconnaissance survey, questionnaire survey, key informant interview, transect walk poultry waste collection from market was done in between June 2020 and May 2021. Also, laboratory analysis and optimization of the protocol through laboratory trial were done in this period.

Table 3.1: Timeline of the Study

Activity	2020						2021					
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Review Objectives and Questionnaire												
Study Area Selection and Data Collecting												
Data Processing and Analysis												
Finalize the result & prepare the report												

3.4. Methods

Methodology is the rational as well as organized part of the study to guide scientific exploration. According to Miller, J. (2009), methodology is defined as “a system of ways of doing, teaching or studying something”. A method involves a process or technique in which various stages or steps of collecting data or information are explained. Dictionary of social science defined, methodology as “the systematic and logical study of the principals guiding scientific investigation”. For good accomplishment of the research work a well-arranged methodology is extremely needed. “A body of methods, rules, and postulates employed by a discipline: a particular procedure or set of procedures” defined the Merriam webster’s 11th online dictionary.

At the very beginning of the study the problem was single out. The type of interest or aspects of subject matter were estimated carefully. The problem was rephrasing meaningful terms from an analytical view. The field and scope of study were assessed according to problem definition. The research problem was formulated within the potential of doing the job accurately. Several things, which are relevant to the present study, have played an incremental role for developing the concept about the study. It is necessary to grow up a wide concept of the different issues of the thesis which are achieved by -

- Visiting the study area.
- Surveying literature.
- Lecture and meeting of experienced research fellow.

Literature was collected from different journals, books, seminar papers, reports, magazines, thesis papers, local elite persons, officers of different GOs and NGOs and unpublished documents. It is also to mention that my concept knowledge was enriched by the lecture and meeting of experienced research fellow. Finally, the study on the Assessment of Poultry Feather Waste as a Feed Ingredient for Animal Feed and Its Business Opportunity was conceptualized. The flow chart of the step-by-step methodological framework of the study is presented in Figure 3.2.

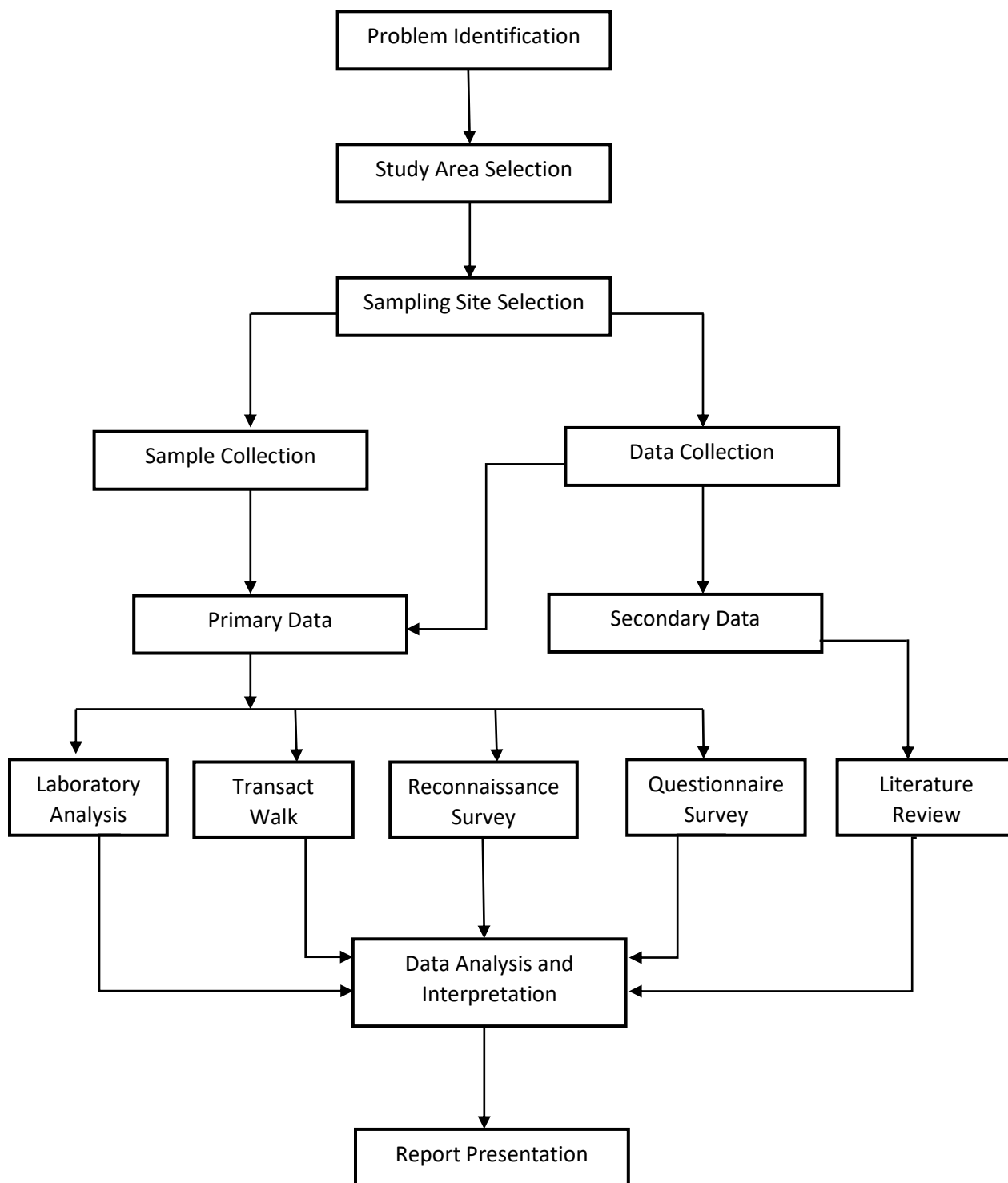


Figure 3.2: Flow Chart of the Methodological Framework of the Study.

3.4.1. Data collection procedure

The research is based on both primary and secondary sources of information. To get primary data, a variety of methodologies were used, including reconnaissance survey key informant interviews, questionnaire surveys, transact walks, and personal poultry market observation. Secondary data were collected from DNCC Office, Website, books, newspapers and research journals.

3.4.2. Reconnaissance survey

Reconnaissance survey was done at the beginning of the research work for selection of market and survey site and determination of existing situation of the study area. About 15 pilot surveys has been completed. The list of the kitchen market is collected from the city corporation which are situated in Dhaka North City Corporation and also there are some unstructured markets which are not in the list.

To check the reliability with actual field conditions, draft questionnaire had done pre-test in the field before going to take final interview from the respondent. The errors of the draft questionnaire were corrected, mistakes and failures were also modified and changed and extra questions were excluded to prepare a final questionnaire according to the study objectives. Final questionnaire was then free from omissions and commissions and ready for final interview to the respondent in the study area.

3.4.3. Questionnaire preparation

After performing the preliminary survey, a structured questionnaire was prepared. The questionnaire was made to collect the required information regarding all those indicators and other relevant information. At first, a draft questionnaire was prepared and reviewed. After many reviews a final questionnaire was prepared for the shop owners, which was structurally divided into several parts. The first part of the questionnaire was used to identify the existing socioeconomic condition and the household status of the farmers. The second part of the questionnaire was to recognize the types and uses of poultry wastes, and amount of waste producing through each day and their disposal rate and upcycling rate.

3.4.4. Determination of sampling technique and sample size

As there is no official data or published paper on the number of poultry shops in DNCC, population number is determined 5000 after consulting with each market authorities. Simple random sampling technique has been applied as sampling procedure. Taken 5000 total poultry shops, the following equation the sample size has determined -

$$n_o = \frac{z^2 pq}{d^2} \dots\dots\dots (2.1)$$

(Berensen and Levine, 1992)

Where,

- z = Normal variety and which has 2.005 for 95.5% confidence interval
- p = Target proportion. In this case, I assumed the target proportion, p = 0.45
- p + q = 1, therefore, q = 0.55 and
- d = Desired error, here it is taken = 10% = 0.1

The initial sample size is therefore:

$$n_o = \frac{(2.005)^2 \times 0.45 \times 0.55}{(0.1)^2} = 99.49$$

This sample size is adjusted by using the following formula —

$$n = \frac{n_o}{1 + \frac{n_o}{N}} \dots\dots\dots (2.2)$$

(Berensen and Levine, 1992)

Where,

- n = Required sample size, and
- N = Size of total poultry shops in DNCC = 5000

$$n = \frac{99.49}{1 + (99.49/5000)} = 98.50 \approx 99$$

From the available market list, 20 markets were randomly chosen and 100 poultry shop owner from those markets randomly interviewed. There are 70 shops on an average in every market. In total 100 questionnaire survey was done.

3.4.5. Key Informant Interview

Key Informant Interview was done at the selected study area poultry markets. The main focus of the KII was to know about the use of poultry waste and the disposal method of poultry waste. Feed processing using poultry wastes, for instance feather waste processing idea for animal feed preparation was also learnt from through the KII.

3.4.6. Poultry shop survey

The primary information was mainly collected through direct interview of the respondent in each selected poultry shop with pretested questionnaire. The questionnaire survey was done in between June, 2020 to May, 2021.

The questionnaire survey was done in 20 markets and 100 data is collected. The markets are:

1. Banani Community Center Cum Kacha Market
2. Boro Mogbazar Kacha market
3. Khilgaon Taltola Kacha market
4. Mohakhali Kacha Market
5. Gulshan (North) Kacha Market
6. Gulshan-1 (South) Kacha Market
7. Mohammadpur Kacha Market
8. Mohammadpur Geneva Camp Toll Market
9. Rayerbazar City Corporation Market
10. Mohammadpur Ring Road Tinshed Paka Market
11. Mohammadpur New Kacha Market
12. Mohammodia Housing Society Toll Market
13. Mohammadpur Townhall Auditorium Market
14. Karwanbazar Chicken Shed Market
15. Mirpur-1 kacha Market
16. Duaripara kacha Market
17. Shawrapara kacha Market

- 18. Kazipara kacha Market
- 19. Molla Marktet Mirpur 12
- 20. Rupnagar kacha Market, Pallabi

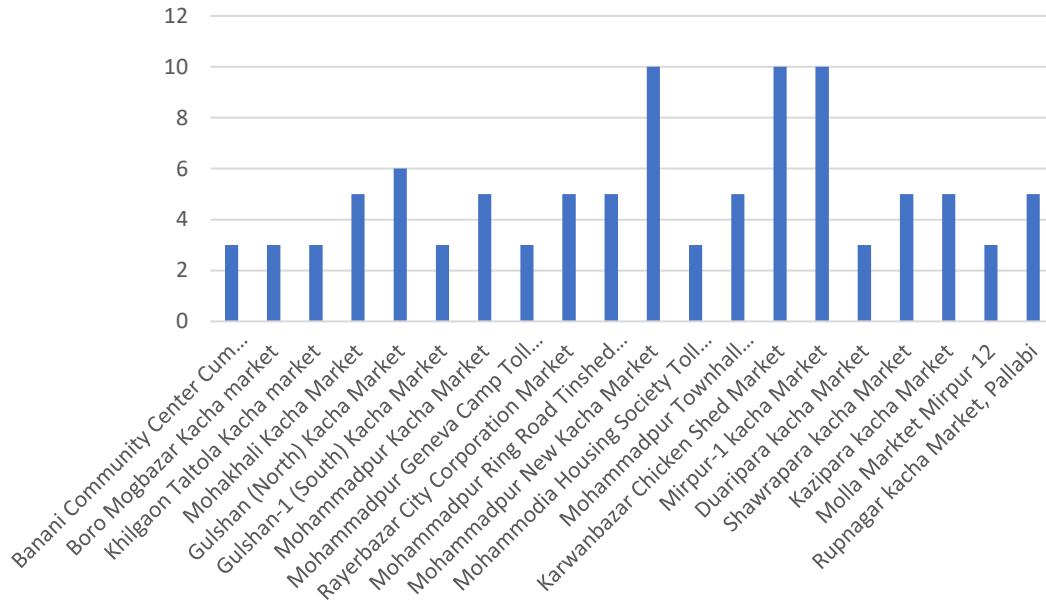


Figure 3.3: Number of Markets and Respondents Interviewed

The questionnaire was divided into two kind information collections parts; socioeconomic information and poultry waste related information. Socioeconomic condition of the respondents such as age, family size, income levels, educational conditions and occupation of the respondents and poultry sell amount and questions related poultry waste production and discharge were asked to the survey respondents.

3.4.7. Transact walk

Transect walking aided in the selection of a study area as well as data collection for research purposes. Almost every field visit included some form of transect walking. In the targeted locations of DNCC poultry markets, systematic walking was conducted by inquiring, listening, observing, and taking notes. The data collection from the research area location was facilitated by a thorough study of transect walking.

3.4.8. Lab sample collection

Raw poultry wastes samples were collected from different markets for nutrient and toxicity analysis. Collection of poultry waste from the poultry market was the first part of lab sample collection. Then the collected poultry waste was parted and then feather was separated from the waste.

3.4.9. Lab sample preparation

The collected poultry waste samples were parted and feather wastes were separated. Then the feathers were cleaned and thoroughly washed and were readied for processing. To process the feather for feather meal preparation several trials were run to identify the perfect procedure.

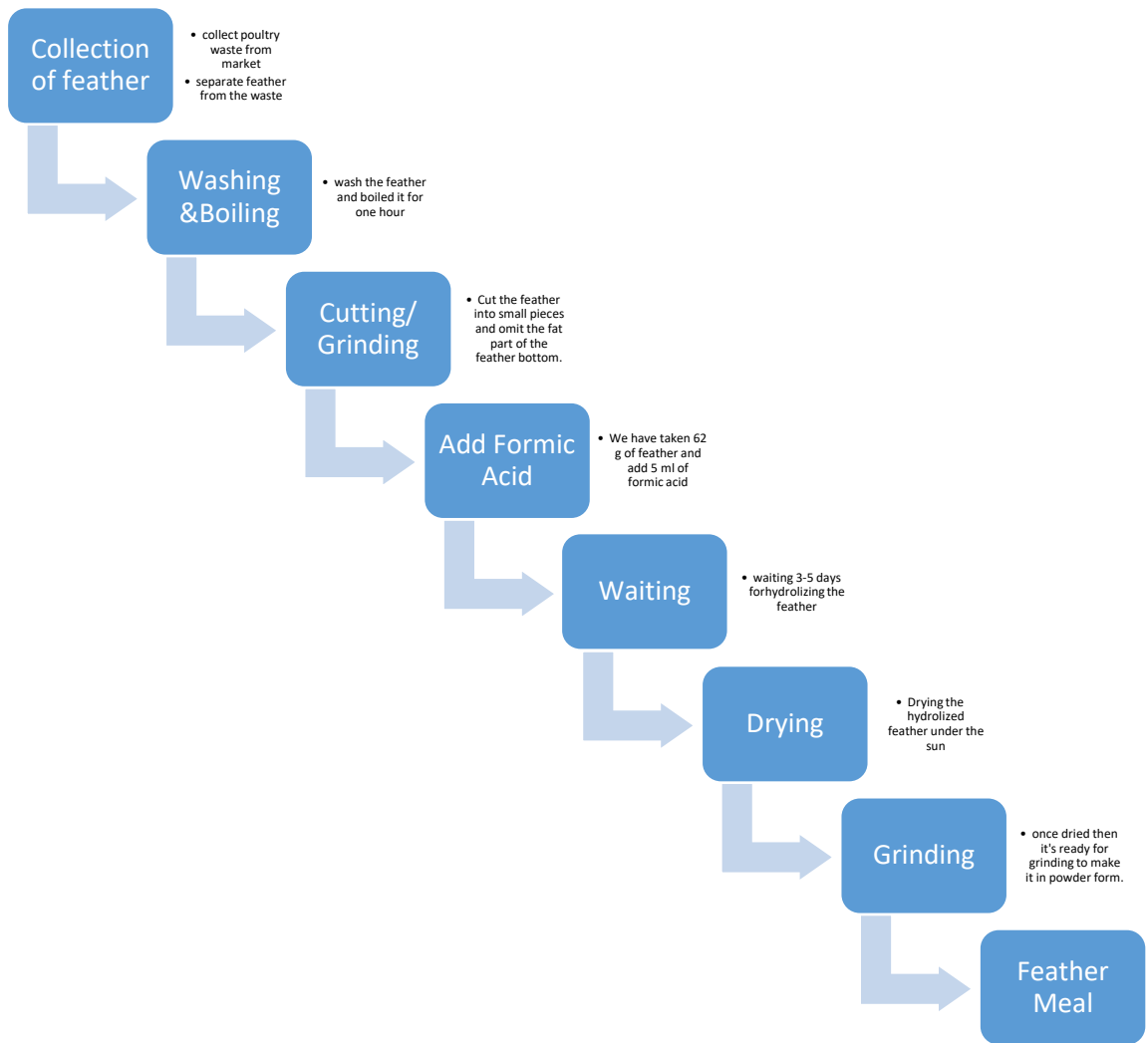


Figure 3.4: Flow Diagram of Feather Meal Preparation

The perfect steps so far, we found are showed in figure 3.3 as a flow diagram. As the figure 3.3 after separating the feather from other poultry waste, the feather was washed thoroughly for cleaning and was boiled for one hour. After that the feather was cut into small pieces and the fat part of the feather bottom was omitted. Hydrolysis of feather meal in laboratory condition was then done. For hydrolysing, Formic Acid was added into the feathers. For 62 g of feather, 5 ml of Formic Acid was added. After that we waited for 5 days for hydrolysing the feather. Then the hydrolysed feather was dried under the sun. Once dried then it's ready for grinding to make it in powder form, which is the final product (feather meal).



(a) Separating feather from poultry waste



(b) Cut, washed and boiled feather



(c) Adding acid to hydrolyze



(d) Hydrolyzing



e) Hydrolyzed feather meal



f) Grinded hydrolyzed feather meal

Figure 3.5: Photos of Analytical Stages of Feather Meal Preparation

3.5. Data Analysis

All the collected primary and secondary data were compiled and interpreted for processing and analysis. The data from questionnaires were grouped, categorized and interpreted according to the objectives as well as the indicators. Some data continued numeric and some contains narrative facts. For measurable and indicative answer data have been grouped in the Tabular forms. All the collected data were analyzed using computer by prominent program (MS Excel 2016).

CHAPTER FOUR

RESULTS AND DISCUSSION

The findings of the study and interpretation of results are presented in this chapter. These are conveniently presented according to the objectives of the study even sections of this chapter.

4.1. Socio economic status

The socio-economic characteristics of the business men, such as their age, family size, income levels, educational levels, and occupation, are of minor but significant importance in this research. These qualities have a significant role in determining an individual's behaviour.

4.1.1. Age

As stated in Table 4.1, the respondents were categorized into three groups. This categorization is consistent with Ahmed's (2003). The majority of respondents (59%), were of middle age (36 to 50 years), 31% were young, and 5% were old.

Table 4.1: Age Profile of the Respondents (Source: Field Survey, 2020)

Characteristics	Categories (Scores)	Number of respondents	Distribution of respondents (%)
Age	Young (Upto35 years)	31	31
	Medium (36 – 50 years)	59	59
	Old (> 50 years)	10	10
	Total	100	100

4.1.2. Family size

The respondents' families varied in size from two to six members. The responses were divided into three groups, as seen in pie chart 4.1 Around 82 percent of responders come from a medium-sized family, whereas 18 percent come from a small-sized family.

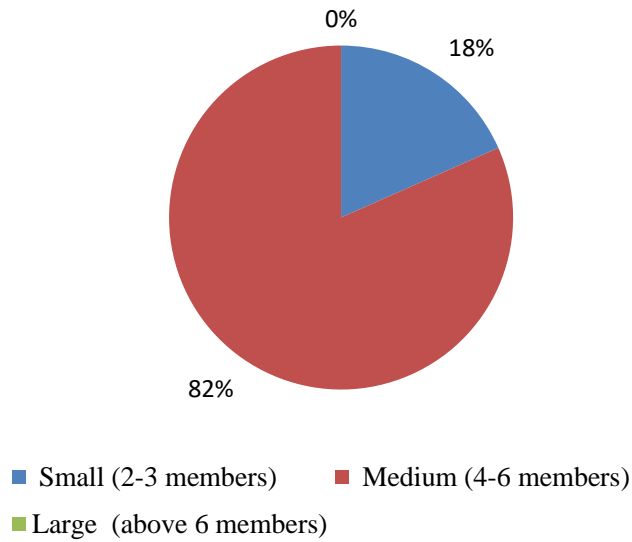


Figure 4.1: Distribution of The Respondents According to Their Family Size (Source: Field Survey, 2020)

4.1.3. Educational status

According to the field survey, respondents had a minimum level of education. As seen in the graph and table below, 51% of respondents were in primary school, but the majority did not finish primary education, 41% of respondents were enrolled in high school, and only 8% of respondents completed high school and were admitted to college.

Table 4.2: Educational Conditions of Respondents in the Study Area. (Source: Field Survey, 2020)

Educational levels	No. of respondents	Percentage
Primary level	51	51%
SSC level	41	41%
HSC level	8	8%

As a result of the investigation, the study found that, on average, 49% of them received a

high school education and that not all of them completed their high school studies. As a result of their educational standing, it can be concluded that they are under-educated to understand the risk associated with chicken waste and how these wastes may be transformed into an asset by producing animal feed.

4.1.4. Income levels

According to the results of the survey, all of the respondents were involved in the poultry business sector. They were completely reliant on the chicken industry for their livelihood. The study showed that the respondent's monthly income ranged between 20,000 and 60,000 Taka.

Table 4.3: Income Levels of Respondents in the Study Area (Source: Field Survey, 2020)

Income levels (Tk./Month)	No. of respondents	Percentage (%)
20,000-30,000	45	45%
30,000-40,000	41	41%
40,000-60,000	14	14%

According to Table 4.3, forty five percent of the respondents' monthly income is between 20 thousand to 30 thousand taka, forty one percent earns between 30 thousand to 40 thousand taka monthly, and the remaining respondents earn more than 40 thousand taka monthly, indicating a middle-class lifestyle.

4.2. Present status and condition of the poultry market waste produced in the North Dhaka city

In this research, the amount and varieties of poultry sold, the average daily sale (kg), the quantity of chicken body waste (kg), and the weight of feathers (kg) were all found in the study region.

It was estimated that, the average sale of chicken meat is 242 kg, and the average amount of poultry waste created by each shop is 97 kg, with feather waste accounting for an additional kg on average. From the study is also found that among the waste produce from poultry

waste 2% of it are feather waste. According to the figure 4.4, it was observed that, edible poultry meat is 71% and 28% is poultry waste, mainly internal organs and 1% is the feather. This 29% is discarded without any use. (Field Survey)

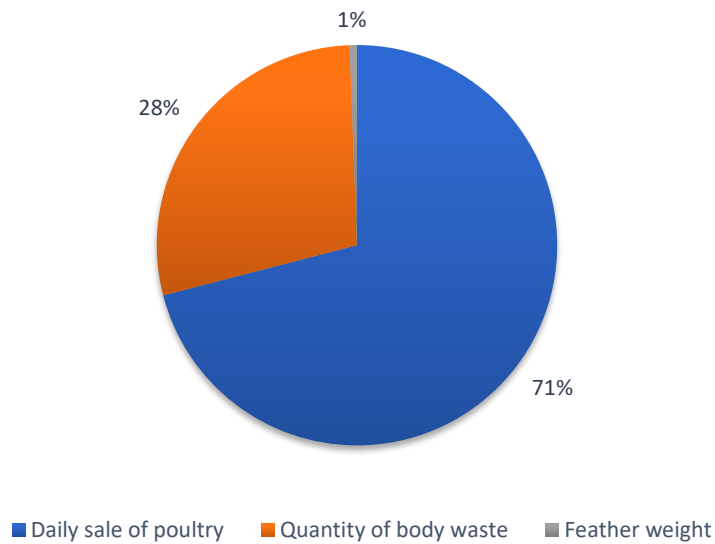


Figure 4.2: Average estimated Proportion of Waste Material on Daily Sales of Poultry
(Source: Field Survey, 2020)

4.2.1. Types of poultry sale

In Dhaka North City, four kinds of poultry breeds were available for purchase such as the broiler, the layer, the cock, and the Sonali breed. According to the study, 57 percent of poultry shops offer four varieties of poultry, 35 percent of poultry shops sell three types of poultry, and 8 percent of poultry shops sell two types of poultry.

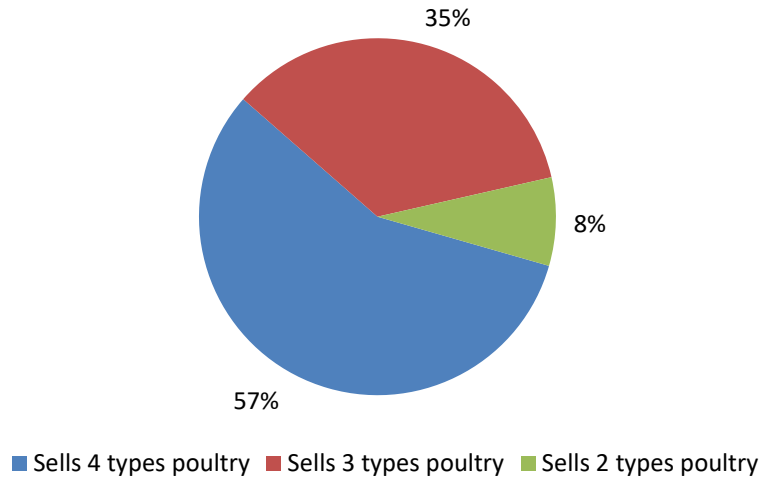


Figure 4.3: Poultry Types Sold in Shops (Source: Field Survey, 2020)

4.2.2. Poultry waste disposal and use

According to the results of the study, 95 percent of poultry shop throw the poultry waste away, 4 percent of poultry shop sell the poultry waste to fish farmers, mainly for catfishes and 1 percent of poultry shop sell the poultry waste to feed manufacturers. The 4% of wastes are sold to fish growers in and around Dhaka city were given straight to the fish as feed. One percent of the chicken wastes delivered to the feed manufacturer, were utilized as a feed ingredient, as a complete waste.

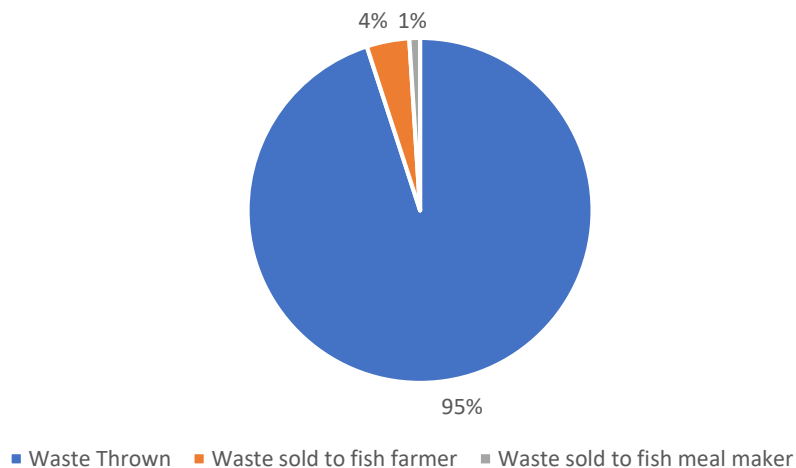


Figure 4.4: Poultry Waste Usage (Source: Field Survey, 2020)

4.3. Proximate composition of feather meal and the poultry waste as feed ingredients for animal feed

From the observations made, it has been found that there were around 35 low-cost raw ingredients accessible in Bangladesh that may be utilized to manufacture supplemental feed for animal. (Ali and Hoq, 2010).

It is possible that collecting feather debris for the purpose of manufacturing animal feed is the most cost-effective option to using any other animal feed materials. In addition, it is a win-win scenario for both the economy and the environment as well. The availability of safe, widely accessible, and cost-effective feed components is soon becoming one of the most urgent concerns confronting the aquaculture industry as it attempts to become more sustainable. This is quickly becoming one of the most pressing issues facing the aquaculture sector. The most difficult challenges facing the sector are cutting feed prices while also limiting environmental consequences without losing product quality and worth. On the other hand, because of the demand for high-quality goods at cheap prices, corporations are forced to reduce feed costs by using lower-cost components and less rigorous feeding standards (Halteren, et al., 2009).

Table 4.4: Comparison of feather meal ingredient with other feed ingredients (Source: Feed Industries Association Bangladesh, 2021).

Ingredient	Crude Protein %	Crude Lipid %	Carbohydrate rate%	Price/kg	Source	Export quantity (Thousand tons)
Fishmeal	55-56	10-12	1-2	132	Own country	
Maize	8-10	3-4	65-70	32	Own + other country	2400
Meat and Bone Meal	45-55	10-15	1-2	84	Other country	
Mixed dried fish	30-40	5-8	2-4	40	Own country	
Mustard oilcake	28-35	8-14	30-40	37	Own country	
Rice bran	10-4	10-15	55-60	32	Own country	
Sesame oilcake	30-35	10-15	30-35			
Soyabean meal	40-45	10-15	30-35	54	Own + Other country	350
Wheat bran	12-16	3-6	70-80			6700
Wheat flour	12-18	2-3	75-80	37		
Feather meal	86-87	5-6	-----			

Major feed ingredients such as maize, soybean meal, meat and bone meal, and fishmeal are generally imported from other countries, and these commodities are subject to significant duty taxes, such as maize at 13% and soybean at 7%.

In addition, 60 percent of the maize and soybeans used in the feed sector are imported from foreign nations. i.e., India, China, and the United States of America (Feed feeds Bangladesh – Policy Insights, 2021).

The proximate composition of feather meal, Table 4.6, that is made in lab and tested from BLRI. From the result we compared the nutritional value of feather meal as a feed ingredient in Table 4.4 .

Table 4.5: Physical Examination of Hydrolyzed Feather Meal (Source: Laboratory report of Sample)

Sample	Hydrolyzed Feather Meal
Physical Examination	
Color	Normal
Odor (Smell)	Normal
Sample type	Hydrolyzed Feather Meal
Insect Infection	No

Table 4.6: Proximate Composition of Hydrolyzed Feather Meal (Source: Laboratory report of Sample)

Chemical Examination (% on DM basis)	
Moistur	11.25
Dry Matter	88.75
Crude Protein	86.53
Total Ash	07.31
Acid Insoluble Ash	0.42
Crude fiber	0.73
Crude Fat	5.03

4.4. Scope and possibility of business opportunity of poultry market waste and the feed

According to the Bangladesh Bureau of Statistics' 2019-20 report, the agriculture industry contributes to 13.35 percent of our GDP, with poultry and fisheries accounting for 4.95 percent of it. Feed mills play a critical part in meeting our country's high protein demand by creating high-quality feeds. The total commercial feed market in Bangladesh is expected to be 5.03 MMT (million metric tons), with a market turnover of US\$ 2.5 billion. From the research we found that, its convenient to produce feather meal for fish from the poultry waste. So, if feather meal can be used as a protein source, we can manufacture a significant amount of feather meal right here in Bangladesh.

In this study, we have found that poultry waste produced from each market around 500 kg/day and feather waste generated approximately 10 kg/day. Since we have mentioned earlier that there were almost 5000 poultry shops in Dhaka North City, it was estimated that about 8700 kg feather waste produced daily from Dhaka North City.

Table 4.7: Actual and Estimated Poultry and Feather Waste Produced Daily in Dhaka North City. (Source: Field Survey, 2020)

Variables	Unit	Actual	Variables	Estimated
Shopkeeper Surveyed	No.	100	Number of shopkeeper	5000
Average number of poultry sold	No.	3	Number of poultry sold	3
Quantity of poultry sold	tons	23.7	Quantity of poultry sold	1187
Quantity of body waste produced	tons	9.4	Quantity of body waste produced	473.7
Quantity of feather produced	tons	1.74	Quantity of feather produced	8.7

There is a business opportunity possible when product produced from these wastes in the lab. We have found that almost 500 gm product can be produced from the 1 kg feather waste which open up a good business opportunity compare to other markets. Total cost required to produce the fish feed from feather waste was found 28 BDT per kg. If a margin is estimated

4 BDT/kg, total estimated price would be 32 BDT/kg which is far less than the current market price. In addition, this produced product has high nutritional value with zero environmental impact. For example, the market price of fishmeal sell by ACI is 132 BDT/kg (Sarkar et al. 2014) which is 4 times higher than this study's produced product.

Table 4.8: Estimated Cost, Profit and Business Opportunity of Feather Meal. (Source: Field Survey, 2020)

Cost Components	Value (BDT/Kg)
Collection	2
Transportation	10
Processing	16
Total in this study	28
Expected Profit	4 BDT/Kg
Price	32
National Market (e.g. ACI fish meal)	132
Bone meal	84

4.5. Discussion

The enormous production in different agricultural sectors have made the country one of top food producing countries in the world. Bangladesh achieved world ranking in the production of different agricultural production i.e. 3rd in freshwater fish production, 4th in rice production 6th in potato production. The economy of the country is growing up and is now going to established mechanized and intensive agricultural farming. New trends and processing technologies are being taken into account for this purpose. In this regard, the meat and poultry processing industries are booming; especially poultry production and processing, as the growth rate of it is very high.

Feather meal produced through the hydrolysis process is a natural source of protein and minerals those are much cheaper than other animal protein sources that can be used as important feed ingredient for fish, cattle and poultry.

Whereas the other protein enriched ingredient for manufacturing animal feed cost is higher in the market i.e. fishmeal 132 BDT/kg, meat and bone meal 84 BDT/kg, soybean meal 54 BDT/kg. Feather meal can reduce feed cost; its production could be economically advantageous to the country.

Feathers are nearly hard to disintegrate in the digestive tract because they are mostly made of the protein (β -) keratin, which is normally indigestible until treated with physical and chemical alterations, such as autoclaving. When feathers are treated in this manner, they can be transformed into feather meal (FM). Protamine (BCF Life Sciences, Inc.) is a unique substance that is created by an extensive process of acid hydrolysis of feathers; it is really an Extensively Hydrolyzed Poultry Feather (EHPF). Study shows that feather meal prepared by acid hydrolysis having higher nitrogen digestibility (99.6%) and amino acid digestibility (97%) than traditionally prepared Hydrolyzed Feather Meal (83.5% & 72.1%) and Poultry By Products Meal (89.7% & 88.3%) (Eugenio et al., 2020).

In the lab we made feather meal by acid hydrolyzation process. After separating the feather from other collected poultry waste, the feather was washed thoroughly for cleaning and was boiled for one hour. After that the feather was cut into small pieces and the fat part of the feather bottom was omitted. Hydrolysis of feather meal in laboratory condition was then

done. For hydrolyzing, Formic Acid was added into the feathers. For 62 g of feather, 5 ml of Formic Acid was added. After that, we waited for 5 days for hydrolyzing the feather. Then the hydrolyzed feather was dried under the sun. Once dried then it's ready for grinding to make it in powder form, which is the final product (feather meal). The feather meal is then tested in BLRI for proximate composition.

The proximate composition of the hydrolyzed feather revealed that the HFM had a greater DM and CP content. These values are consistent with the findings of other studies (El-Boushy et al., 1996; Kim and Patterson, 2000; Ayanwale, 2006). Our final product's crude protein level of HFM was 86 percent, which is within the range of previous publications on the crude protein level of HFM. Cotanch et al., (2007) reported an 84.1 to 90.5 percent range, Morel et al., (2003) reported an 82.2 to 84.6 percent range, and Wang and Parsons, (1997) reported an average of 88.7 percent.

Earlier studies indicated a percentage fat range of 6.1 – 14.8 and the average value for HFM observed in this study is 5.03. These studies demonstrate the variance in HFMs that exists across plants and between hydrolysis methods, such as temperature and pressure combinations and chemical treatments.

Authors mentioned that not all HFM have the same nutritional makeup, and their digestibility may be influenced by the processing processes used in their manufacturing (Payne, 1972; El-Boushy et al., 1990; Wang and Parsons, 1997; Aderibigbe and Church, 1983a).

Protein denaturation reduces digestibility; HFM is created at either a high temperature and pressure for a short length of time or at a lower temperature and pressure for a longer period of time, using different acid treatments. Some amino acids may be lost when the processing temperature is elevated or chemicals are used to remove the fat (Aderibigbe and Church, 1983a).

The FI, BWG, and FCR all followed the same pattern, decreasing as the degree of HFM inclusion increased. It would have been assumed that because Apparent CP Digestibility improved with increasing HFM levels, animal performance would follow suit. This might be due to the HFM's low nutritional content, which is not as readily available as the protein

source in the control diet. The low usage of the protein in HFM might be because of its deficiency in lysine and methionine which can be prosccribing amino acids for broilers (MacAlpine and Payne, 1977; Apple et al., 2003).

It became determined that Apparent CP digestibility (ACPD) extended with boom in HFM inclusion stage with inside the diet. This fashion became additionally determined via way of means of Chiba et al., (1996) and Apple et al., (2003). ACPD became appreciably exclusive in any respect degrees of FM inclusion. The sizable boom ($\alpha 0.05$) determined in crude protein digestibility indicates that the HFM can also additionally had been an increasing number of damaged down into its constituent amino acids however because of the bad first-rate of the protein, it isn't utilized in tissue biosynthesis (Moran et al., 1966; Baker et al., 1981). Feather Meal usage has been proven to have progressed with supplementation with the prosccribing amino acids (Combs et al., 1958; Chiba et al., 1995).

However, we did not examine the digestibility of our product but many studies showed the digestibility rate of HFM is better than other feed ingredients.

Several scientists studied the economic aspects of feather meal feeding. According to Ahaotu and Ekenyem, (2009) and Mandubuike et al., (2009), there is a significant variation in the cost of feed production with or without the use of feather meal. According to Caires et al., (2010), using 5% feather meal in broiler feed is economically effective. According to Nakhash, (2008), adding feather meal reduces the relative cost per unit weight growth. It is vital to note that feed costs account for over 70% of total broiler production costs.

Yu (2008) advised that for African catfish, the substitution of feather meal into fish meals be limited to less than 40%. There were no statistically significant changes in the growth responses of Carp Fry fed control or 25% hydrolyzed feather meal. (Hasan et al., 1997). These researches shown that using feather meal in fish aquaculture is also economically viable.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. Key Findings

The respondent group of poultry market are mostly middle aged with a medium size family. The study found that, on average, 49% of respondent received a high school education and that not all of them completed their high school studies. As a result of their educational standing, it can be concluded that they are under-educated to understand the risk associated with chicken waste and how these wastes may be transformed into an asset by producing animal feed.

The poultry shops in Dhaka North City Corporation produce 473.7 tons poultry waste daily. Among them 95 percent of poultry shop wastes are thrown away, 4 percent of poultry shop wastes are sold to fish farmers, and 1 percent of poultry shop wastes are sold to feed manufacturers.

Among the poultry waste 8.7 tons is poultry feather has been wasted every day and more than 3132 tons of unutilized feather discarded yearly, this is a major concern of environmental pollution. It is observed that 35 raw ingredients accessible in Bangladesh that may be utilized to manufacture supplemental feed for animal. Poultry feather waste for the purpose of manufacturing HFM that is rich in protein could be used as a feed ingredient is the most cost-effective option to use any other feed ingredient.

By following the Acid Hydrolyzation method developed in the lab, it was observed, from per kilogram of feather of poultry produce half kilogram of feather meal. If we could process all the feather from the Dhaka North City corporation, we can produce more than 1500 tons of feather meal per year, that has international market value more than 1 million US\$. The feather meal could contribute significantly to satisfy the protein requirement for feed by reducing the feed cost for fish and poultry. As the price of fishmeal is increasing and heavily dependent on wild catch fish, we need to utilize the feather meal as an alternative of fishmeal.

The feather meal produced in the laboratory, is tested in BLRI for proximate analysis. The result shows that it contains very high amount of crude protein (86.53%) and very low

amount of crude fiber (0.73%). That indicates that protein rich feather meal could be used as an important ingredient for feed formulation.

The total commercial feed market in Bangladesh is expected to be 5.03 MMT (million metric tons) with a market turnover of US\$ 2.5 billion. According to a Market Research, the global feather meal market would be worth US\$ 359.5 million in 2020. According to the analysis, the market is estimated to reach US\$ 820 million by 2030, growing at an annual rate of 8.6%. From the present research, it was observed that there is huge possibility to produce feather meal as a feed ingredient for animal feed from the poultry feather waste in our country which could be economically beneficial that accounted more than 14 million US\$.

According to a research conducted by Larive International B.V. and LightCastle Partners Ltd. (2020), Bangladesh consumes 525 MN broiler each year. According to the Daily Star (2017), the country produces 570 million tons of poultry meat each year.

Based on our current research, we estimate that more than 40 thousand tons of chicken feather waste produced each year. It is possible to produce more than 20 thousand tons of feather meal from this resource.

The international market price of feather meal is about 60 BDT/kg, and the value of 20 thousand tons of feather meal is about 14 million US dollars.

5.2. Conclusion

It was observed from the study that there is a great possibility to use feather meal as an alternative to other meal and marketing them would be a good investment for economic gain. Feather meal could also be great solution for the environmental pollution created by poultry waste discharge. It can be concluded that, production and use of feather meal could be a great way to reduce the cost of traditional animal feed and could contribute for the economic growth of the country as well as creating employment opportunities for large number of unemployed youth, on the contrary will play a great role for protecting environment.

5.3. Recommendations

Based on the study's findings, it was concluded that poultry feather waste could be a great resource, which can generate income and create job opportunities and can play a vital role in country's economy. However, various impediments and constraints hampered the attainment of the aforementioned goals. As a result, policymakers should take the necessary steps. The following policy recommendations are offered based on the study's findings:

- According to the study, most of the respondent did not complete their high school studies. Based on their educational standing, it can be concluded that they are under-educated to understand the risk associated i.e. environmental hazard, with poultry waste and how these wastes may be transformed into an asset by producing animal feed. Hence, the policymakers should take necessary steps to strengthen the technical knowledge of shopkeepers and adjuvant leaps to concern them about the waste, produced on their own shop.
- Appropriate waste disposal methods should be practiced by the City Corporation, as the waste are not disposed properly and causing environmental hazard.
- The study reveals that, among the feed manufacturers, poultry feather is not acquainted properly as feed ingredient. They are also unaware of the business opportunity associated with HFM. Concerned authorities should take adjuvant moves to inspire the feed manufacturers to use it, ascertain the precise training program and grab the economic benefit.

In the course of this work a number of challenges were encountered which when surmounted would improve and impact on research in the production of HFM from feather wastes for animal feeding. These challenges are:

- a) Lack of data on amount feed ingredients uses in animal feed manufacture.
- b) Lack of data on organic market waste quantity and disposal method.
- c) Lack of study on the impact of the poultry market waste on environment.

Further in-depth study is required to investigate the overall poultry feather waste producing all over the country and also assess the use of poultry skin, intestine and kitchen waste as a resource, which is now considering as waste and causing environmental pollution.

References

- Aderibigbe, A. O. and Church, D. C. (1983). Feather and Hair meals for Ruminants. I. effect of processing on utilization of feather meal. *Journal of Animal Science*, 56: 1198 - 1207.
- Agboola, JO., Yossa, R and Verreth J. (2019). Assessment of existing and potential feed resources for improving aquaculture production in selected Asian and African countries. CGIAR Research Program on Fish Agri-Food Systems. Program Report: FISH-2019-03, Jul. 2019. Penang, Malaysia.
- Ahmed, M. B. (2003). Impact of shrimp farming on socio-economic, agriculture and environmental condition in Paikgacha upazila of Khulna district. PhD. Thesis. Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh.
- Ahaotu, O.E., and B.U. Ekenyem. (2009). Replacement value of feather meal for fish meal on performance of finisher broiler chicks. *International Journal of Tropical Agriculture and Food System*, 3(3): 117-126
- Alam, M., Hossain, M., and Elahi, K. (2020). Solid Waste Management System of Dhaka North City Corporation and Process Development for Healthy Environment: A Case Study. *International Journal of Scientific Research and Reviews*, 9(4), pp: 28-36.
- Apple, J. K., Boger, C. B., Brown, D. C., Maxwell, C. V., Friesen, K. G., Roberts, W. J. and Johnson, Z. B. (2003). Effect of feather meal on live animal performance and carcass quality and composition of growing-finishing swine. *Journal of Animal Science*, 81:172-181.
- Ayanwale, B. A. (2006). An evaluation of Hydrolysed Feather Meal as a protein source in rabbit diets. *Research Journal of Biological Sciences*, 1(1-4):32-35.
- Baker, D. H., Blitenthal, R. C., Boebel, K. P., Czarnecki, G. L., Southern, L. L. and Willis, G. M. (1981). Protein-amino acid evaluation of steam-processed feather meal. *Poultry Science*, 60: 1865-1872.

- Bdnews24.com. (2021). HC to hear plea against DCC appointments Thursday. [online] Available at: <<https://bdnews24.com/bangladesh/2011/12/12/hc-to-hear-plea-against-dcc-appointments-thursday>> Accessed 10 December 2021.
- Beketov, S., Kozlov, A., Nikiforov-Nikishin, D., and Platonov, A. (2020). Qualitative characteristics of blood meal and feather meal in connection with the possibility of its use in fish feed. *BIO Web of Conferences*, 17, 00155. doi: 10.1051/bioconf/20201700155
- Berensen, M. L., and Levine, D. M. (1992). *Basic business statistics: Concepts and application*. Pentin Hall. *Inc., USA*.
- Bureau, D.P. (2010). Feather meal. Improving its nutrient value characterization for fish. *Render*, 39(4): 14-16.
- Calo and Parise. (2009). Waste management and problems of groundwater pollution in karst environments in the context of a post-conflict scenario: The case of Mostar (Bosnia Herzegovina). *Habitat International*, 33(1): 63-72.
- Calvin, M. (1972). Effect of processing methods on utilization of feather meal by broiler chicks. PhD. Thesis. Iowa State University.
- Cao, L., Naylor, R., Henriksson, P., Leadbitter, Metian, Troell and Zhang. (2015). China's aquaculture and the world's wild fisheries. *Science*, 347 (6218): 133–135.
- Caires, C. M. I., E. A. Fernandes, N. S. Fagundes, A. P. Carvalho, M. P. Maciel and Oliveira. (2010). The Use of Animal By-products in Broiler Feeds. Use of Animal Co-products in broilers Diets. *Revista Brasileira de Ciencia Avicola*.12(1).
- Chiba, L. I., Ivey, H. W., Cummins, K. A. and Gamble, B. E. (1995). Effects of hydrolyzed feather meal as source of extra dietary Nitrogen on growth performance and carcass traits of finisher pigs. *Animal Feed Science Technology*, 53:1-16.
- Chiba, L. I., Ivey, H. W., Cummins, K. A. and Gamble, B. E. (1996). Hydrolyzed feather meal as source of amino acids for finisher pigs. *Animal Feed Science Technology*, 57:15-24.

- Combs, G. E., Alsmeyer, W. L. and Wallace, H. D. (1958). Feather meal as a source of protein for growing-finishing swine. *Journal of Animal Science*, 17: 468-472.
- Cotanch, K. W., Grant, R. J., Dann, H. M. and Darrah, J. W. (2007). Analysis of nutrient composition of feather meal and feather meal with blood. <http://www.midwestpoultry.comwww.uspoultry.org/ppfc/docs/FeatherMealCornell.pdf>. Accessed 12/03/2010.
- Collins, K. E., Kiepper, B. H., Ritz, C. W., McLendon, B. L., Wilson, J. L. (2014). Growth, livability, feed consumption, and carcass composition of the Athens Canadian Random Bred 1955 meat-type chicken versus the 2012 high-yielding Cobb 500 broiler. *Poultry Science*, 93(12): 2953-2962.
- Ekta Tiwary, Rani Gupta. (2012). Rapid conversion of chicken feather to feather meal using dimeric keratinase from *Bacillus licheniformis* ER-15, *Journal Bioprocess Biotechniq*, 2012; 2:4.
- El-Boushy, A. R., van der Poel, A. F. B. and Walraven, O. E. D. (1990). Feather meal- A biological waste: Its processing and utilization as a feedstuff for poultry. *Biological Waste*, 32(1): 39-74.
- Elsaidy, N., Abouelenien, F., and Kirrella, G. (2015). Impact of using raw or fermented manure as fish feed on microbial quality of water and fish. *The Egyptian Journal of Aquatic Research*, 41(1), 93-100.
- Fagbenro, O. (2004). Soybean meal replacement by roquette (*Eruca sativa Miller*) seed meal as protein feedstuff in diets for African Catfish, *Clarias gariepinus* (Burchell 1822), fingerlings. *Aquaculture Research*, 35(10): 917-923.
- Falch Ø. (2014). Strong growth predicted for aquaculture: Shrimp and tilapia expected to more than double by 2030. Inocap: Oslo. <https://admin.mekke.no/data/downloads/284/Fish2030-prospectsforaquaculture.pdf>
- FAO. (2014). *The State of World Fisheries and Aquaculture*. FAO, Rome, Italy.

- Feather Meal Market. (2021). Industry Share, Size, Growth - Mordor Intelligence. (2021). Retrieved 2 December 2021, from <https://www.mordorintelligence.com/industry-reports/feather-meal-market>
- Ghose, B. (2014). Fisheries and Aquaculture in Bangladesh: Challenges and Opportunities. *Annals of Aquaculture and Research*, 1(1): 1001.
- Global Industry Report, 2030. (2021). Feather Meal Markets. Retrieved 7 December 2021, from <https://www.transparencymarketresearch.com/feather-meal-market.html>
- GoB. (2010). Government of Bangladesh, Report of the task forces on Bangladesh development strategies of the 2010's. Univ. Press Ltd., Dhaka, Bangladesh, 2-4.
- Hasan, M.R., M.S. Haq, R.M. Das and G. Mowlah. (1997). Evaluation of poultry feather meal as a dietary protein source for Indian major carp, *Labeo rohita* fry. *Aquaculture*, 151: 47-54.
- Hossen, M., Hoque, Z., and Nahar, B. (2015). Assessment of poultry waste management in Trishal upazila, Mymensingh. *Research In Agriculture Livestock and Fisheries*, 2(2), 293-300. doi: 10.3329/ralf.v2i2.25013
- Kabir, M. R. (2015). Municipal solid waste management system: a study on Dhaka North and South City corporations. *Journal of Bangladesh Institute of Planners*, 8:35-48.
- Kim, W. K. and Patterson, P. H. (2000). Nutritional value of enzyme or sodium hydroxide treated feathers from dead hens. *Poultry Science*, 79:528-534.
- MacAlpine, R. and Payne, C. C. (1977). Hydrolysed feather protein as a source of amino acids for broilers. *British Poultry Science*, 18:265-273.
- Mandubuike, F.N., B.U. Ekenyem and E.O. Ahaotu. (2009). Effect of dietary substitution of feather meal for fish meal on the performance of starter broilers. *Animal Production Research Advances*, 5(1): 93- 97.
- Miah, M.T.H. (1990). Economics of Commercial poultry Farming in Bangladesh. Report No. 21, Bureau of Socio-economic Research and Training, Bangladesh Agricultural University, Mymensingh.

- Miller, J. (2009). Cambridge Advanced Learners Dictionary, Third Edition. Cambridge University Press, pp. 100.
- Ministry of Foreign Affairs. (2020). Poultry sector study Bangladesh Commissioned by the Netherlands Enterprise Agency. Retrieved from: <https://www.rvo.nl/sites/default/files/2020/12/Poultry%20sector%20study%20Bangladesh.pdf>
- Morel, P. C. H., Melai, J., Jame, E. A. C. and Reynolds, G. W. (2003). Nutritive value of feather meal. Project report for New Zealand Pork. Institute of Food, Nutrition and Human health; Massey University, Palmerston North.
- Moran, E. T., Summers, J. D. and Slinger, S. J. (1966). Keratin as a source of protein for the growing chick. I. Amino acid imbalance as the cause for inferior performance of feather meal and the implication of disulphide bonding in raw feathers as the reason for poor digestibility. *Poultry Science*, 45: 1257-1266.
- Nakhash R.M.S. (2008). The effects of partial replacement of soybean meal in the grower diet with sun dried blood and boiled feather meals on the performance of broiler chicks. MS thesis, Faculty of Graduate Studies, An-Najah National University, Nablus, Palestine.
- Payne, P. R. (1972). Protein quality of diets, chemical scores and amino acid function. Bigwood, Ed. Pergamen press; New York. pp. 259-306
- Poultry World. (2017). Feather meal and its nutritional impact. [online] Available at: <https://www.poultryworld.net/Nutrition/Articles/2017/2/Feather-meal-and-its-nutritional-impact-95745E/> [Accessed 12 December 2021].
- Policyinsightsonline.com. (2021). Feed feeds Bangladesh – Policy Insights. [online] Available at: <https://policyinsightsonline.com/2019/01/feed-feeds-bangladesh/> [Accessed 12 December 2021].
- Population and Housing Census. (2011). Bangladesh Bureau of Statistics. Archived from the original (PDF) on 8 December 2015. Retrieved 12 December 2021.

- Prabakaran, R., and Valavan, S. (2021). Wealth from poultry waste: an overview. *World's Poultry Science Journal*, 77(2): 389-401.
- Prodhan, A. S. U., & Kaeserb, A. (2021). Municipal Solid Waste Management in Dhaka City: Present Status, Problems, and Probable Solutions–A Review. In book: *Environmental Thoughts, Part-I, 2019, Edition: March-2019*
- Sarker, S. K., Hasan, M. T., Das, S. K., and Mazumder, S. K. (2014). Fish Culture Practice and Socio Economic Status in Northern Middle Part of Bangladesh. *Malaysian journal of medical and biological research*, 1(1): 42-51.
- Soni, A., Chand, S., Talukder, S. (2017). Feather meal and its nutritional impact. *Poultry World*, Misset Uitgeverij B.V. <https://www.poultryworld.net/Nutritions/Articles/2017/2/Feather-meal-and-its-nutritional-impact-95745E/>
- Swapan, M. S. H., Zaman, A. U., Ahsan, T., & Ahmed, F. (2017). Transforming urban dichotomies and challenges of South Asian megacities: Rethinking sustainable growth of Dhaka, Bangladesh. *Urban Science*, 1(4), 31.
- The Daily Star. (2017). Tk 30,000cr needed to beef up poultry sector. *The Daily Star*. <https://www.thedailystar.net/business/tk-30000cr-needed-beef-poultry-sector-1370230>
- Usman, S., Ogbe, K., Oguiche, J., Momoh, T., and Omale, S. (2019). Utilization of poultry waste as feed and supplementary feed for fish growth. *Journal of Applied Sciences And Environmental Management*, 23(4), 627.
- Wang, X. and Parsons, C. M. (1997). Effect of processing systems on protein quality of feather meals and hog hair meals. *Poultry Science*, 76(3):491 - 496.
- WASTE CONCERN. (2005). CDM Project Potential In the Poultry Waste Management Sector In Bangladesh. Dhaka, Bangladesh. Retrieved from <http://wasteconcern.org/wp-content/uploads/2016/04/Poultry-Final.pdf>

Web.archive.org. (2021). Bangladesh Sangbad Sangstha (BSS). [online] Available at: <<https://web.archive.org/web/20120415124834/http://www1.bssnews.net/newsDetails.php?cat=0&id=211760&date=2011-12-01>> [Accessed 10 December 2021].

Yu, Y. (2008). Replacement of Fish Meal with Poultry By-Product Meal and Hydrolyzed Feather Meal in Feeds for Finfish. In: Alternative Protein Sources in Aquaculture Diets, Lim, C., C.D. Webster and C.S. Lee (Eds.). The Haworth Press, United States of America, New York, pp: 51-86

APPENDICES

APPENDIX: Questionnaire

"Assessment of Poultry Feather Waste as a Feed Ingredients for Animal Feed and Its Business Opportunity : A Study on North Dhaka City"

1. Respondent Personal Information

Name:

Market name:..... Ward:..... Thana:.....

Contact number:..... Sex: (M/F)

2. Socio-Economic Profile of the respondent

Age: years

Main Occupation: Secondary Occupation:

(1= Business, 2= Agriculture, 3=Job, 4= Daily Labor, 5= Rickshaw Puller, 6= Others)

Family size of the respondent

Name	Sex	Education level (Years of schooling)	Occupation
Total Number:			

(Note: 1= Agriculture, 2= Business, 3=Job, 4= Daily Labor, 5= Rickshaw Puller, 6= Housewife, 7= Students, 8= Others)

3. Sources of Income

Parameter	Amount (Taka)
Business	
Rickshaw Pullar	
Daily Labor	
Job	
Foreign Income	
Farming	
Livestock production	
Fisheries	
Other	
Total	

Monthly income:.....

Annual income:.....

4. Sources of Funding

Parameter	Put $\sqrt{\quad}$ marks
Own Savings	
Bank Loan	
NGO Loan	
Government Incentives	
Others	

5. Market situation

1. How many types of poultry do you sale?

Ans:

2. What quantity do you sale (in k.g.) everyday?

Ans: a)Broiler:..... b)Layer:.....

c)Sonali:..... d)Cock:..... *Total:.....

3. What quantity of body waste is produced (in k.g.) every day from the poultry?

Ans:

4. What do you do the body waste?

- a) Sell
- b) Throw away

If answer is, (a) skip the next two question and start from question no.7.

5. Where do you throw it away?

- a) Market dustbin (1)
- b) City Corporation garbage cart (2)
- c) Open place (3)

6. Who dispose it?

- a) Market community (1)
- b) City Corporation (2)
- c) Social community (3)
- d) Other (4)

7. What is the price of the waste (per k.g.)

Ans:

8. How do you sale it?

- a) Through middleman
- b) Direct to buyer

If answer is (a) ask the next question otherwise skip

9. How middleman collects it?

- a) Come to you & buy it
- b) You go to them & sale it

10. Do you think organized selling opportunity makes it more profitable?

Ans:

6. Participation of the respondent

1. How many years you have been involved in this business? Years

2. Are you member of any social/business organization? (Yes/No)

If yes, how many organizations?

3. Does DAM (DEPARTMENT OF AGRICULTURAL MARKETING) officer visit your business firm? (Yes/No)

If yes, how many times in a year?

4. Are DAM Workers Helpful to you? (Yes/No)

5. Did you attend any training regarding New technology for poultry waste management provided by near DAM office or any NGO?
..... (Yes/No)

7. Problems of the Adoption New technology

Do you face any problem to adopt new technology in your business environment?
..... (Yes/No)

If yes. Can you identify some problems?

.....
.....
.....
.....
.....
.....

8. Recommendation of respondent :

.....
.....
.....
.....
.....
.....

Date:

Correspondent Sign: