J. Sylhet Agril. Univ. 11(1): 31-36, 2024 *https://doi.org/10.3329/jsau.v11i1.82679*

ISSN: 2308-1597

Journal of the Sylhet Agricultural University

Journal home page: http://www.jsau.sau.ac.bd

Research Article

STUDY ON NUTRITIONAL IMPROVEMENT OF POULTRY FEED THROUGH WHEY FERMENTATION IN LABORATORY

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Article info

Article history

Received: 12.03.2024

Accepted: 15.05.2024

Published: 30.06.2024

Keywords

Poultry Feed, Fermentation, Whey, Proximate analysis

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Abstract

The study aimed to improve the nutritional quality of poultry feed through whey fermentation. Whey, a by-product of the cheese industry rich in high-quality proteins, was incorporated into feed ingredients such as maize, wheat bran, soybean meal and auto rice polish. Sweet whey fermented by lactic acid bacteria was used in five different treatments: Control T_0 (without whey), T_1 (20 ml whey/100g feed), T_2 (30 ml whey/100g feed), T_3 (40 ml whey/100g feed), and T_4 (50 ml whey/100g feed), incubated for 24, 48, and 72 hours in a 5x3 factorial design. Proximate analyses revealed significant nutritional improvements in the whey-fermented feeds. The results indicated that the optimal crude protein (CP) content was achieved in soybean meal at T_3 (45.41%) and wheat bran at T_1 (16.88%) after 72 hours. Crude fiber (CF) content decreased significantly, with T_4 showing the lowest CF values across various feed types, enhancing digestibility. Ether extract (EE) and total ash content varied, with notable EE increases at T_4 treatments. The study concluded that whey fermentation significantly enhances the protein content and digestibility in poultry feed with varying impacts on other nutritional components with 40 ml whey/100g feed for 72 hours incubation being the most effective treatment, suggesting a practical approach to improving poultry nutrition and production performance. This research provides a viable strategy for utilizing whey, contributing to the sustainable development of the poultry sector in Bangladesh.

Introduction

Bangladesh as an agriculturally based country, has integrated poultry farm that have generated employment opportunities, improved food safety, and increased supply of high-quality protein containing foods, boosting the country's economic growth and reducing poverty rates in both rural and urban areas (Hamid et al., 2017). So, for sustaining and poultry sector more development, we should provide rich nutrients in poultry feed for better production performance like; egg and meat.

Whey, a precious by-product (80-90%) of the cheese production, well known for its higher protein, used in human food chain which produced after coagulating and separating caseins from milk in various form (liquid, condensed, and dried) and have contained highly concentrated H_2O, lactose ($C_{12}H_{22}O_{11}$)and Na (Pescuma et al., 2015; Tsiouris et al., 2020; Panesar et al. 2007). While ruminants can thrive with up to 30% of their dry-matter intake as liquid whey, swine exhibit optimal performance with a maximum of 20% to avoid diarrhea. Additionally, whey-derived fermented protein sources impact both the productive performance and gut microbiota composition of broilers. The benefits of the selected protein on animal growth are related to their inclusion level, digestibility and amino acid profile (Beski *et al.*, 2015) whereas the WPC (30 % CP and 52.5 % lactose of dry matter) is considered as an excellent amino acid source in bird nutrition and is composed of biologically active proteins such as β-lactalbumin, α-lactalbumin and immunoglobulins (Szczurek, 2013).

Cite This Articale

Kamruzzaman M, Hossen MM, Momu JM, Haque ME, Mahfuz S and Uddin MJ. 2024. Study on Nutritional Improvement of Poultry Feed Through whey Fermentation in Laboratory. J. Sylhet Agril. Univ. 11(1): 31-36, 2024. https://doi.org/10.3329/jsau.v11i1.82679

Dried whey and its derivatives are essential components in food enterprise operations. (Whetstine et al., 2005). In addition to reducing abdominal fat and cholesterol, creatinine and urea levels in the blood, dietary supplementation with dry whey may enhance the ultimate productive performance of poultry, resulting in a healthier end product (Abd El-Hack et al., 2015). All vital and supportive amino acids are conveyed by whey proteins which also enhance the constitution of the body, regulate the defense system of the body and antimicrobial properties as well. Moreover, whey protein also acts as a chelating mediator and antiviral, antibacterial, hypolipidemic, antihypertensive, anticancer, and antioxidant agent. Additionally, it prevents cardiovascular disease and osteoporosis by increasing muscular strength (Bjorkmanet al., 2012). It also known as "fast protein" due to muscle development capacity during physical exercise. Rostami et al., 2013 reported that whey protein is used in baking products. Whey protein supplementation can increase the amount of lean muscle and enhance protein metabolism in comparison with an iso-nitrogenous casein protein (Cribb, 2006). Shariatmadari and Forbes, 2005 and Kanza et al., 2017 reported that whey and whey derived proteins were used in the formulation of poultry feed due to the presence of unidentified growth factors. The chicken develops lactose intolerant at higher levels of liquid whey, causing osmotic diarrhea and decreasing body weight (Al-sadi et al., 2008).

According to the report of Kermanshahi and Rostami, 2006, Whey supplementation correlated to a proportional enhancement of body weight gain and nitrogen retention, as well as a considerable improvement in FCR, protein and fat digestibility, and absorption of minerals, including Ca, P, Cu, Fe and Mg. Besides from its nutritional properties, whey has been utilized to avert gastrointestinal infections in broiler chicks caused by *Salmonella spp., Campylobacter spp.,* and *Clostridium perfringens* (Tsiouris et al., 2018). In this study, we focus on investigating the nutrient components of whey and whey fermented feed (Maize, Wheat bran, Soyabean meal and auto rice polish) ingredients at different incubation period.

Materials and Methods

Study Area and study period

The chemical analysis of collected samples (Maize, Wheat Bran, Rice Polish Auto Rice polish and Soyabean Meal) from local market, Sylhet, was conducted at the Animal Nutrition Laboratory, Department of Animal Nutrition, Sylhet Agricultural University, Sylhet from 1st June, 2020 to 30th June 2021.

Collection and fermentation of whey

Sour and sweet whey were collected from sweetmeat shop of Sylhet City corporation was stored at -20^{0}C temperature for further laboratory work and fermented by lactic acid bacteria. Only sweet whey was considered for fermentation. If sour case occurs, it was sweetened adding @ 5% cane sugar was added. The preserved whey was kept in room temperature up to 6 hours and then it was thoroughly mixed before incorporation in concentrated feed.

Study design

The five treatments in every feed like Control T_0 (without whey), T_1(20 ml whey/100g of feed) T_2(30 ml whey /100g of feed), T_3(40 ml whey /100g of feed) and T_4(50 ml whey /100g of feed) were considered with three (24h, 48h and 72h) level of incubation time considering 5X3 factorial design and subjected to laboratory analysis following the methods of AOAC (1980). Whey feed content petridishes of each treatment (T_0, T_1, T_2, T_3 and T_4) were placed into oven allowing 39^0 C temperature upto 24 hours, 48 hours and 72 hours. Before setting into the tray, mould inhibitor (Mould CID, Dr.Eckel, Germany) was added @1 gm/kg feed.

Proximate Analyssis

Dry Matter (%), Moisture (%), Ash (%), Nitrogen free extracts (%) and Crude fat (%) were determined by the following methods of AOAC (2011). Crude fibers were determined by using the acid base digestion method. Crude protein was determined using an auto analyzer after digestion in sulphuric acid by the Kjeldahl Method.

Data Analysis

All the data analyzed by using SPSS v.29.0.2 and MS Excel.

Results and Discussion

The study evident from table-1 that whey fermented maize of T_3 Group (40ml/100g DM feed) exhibited the highest crude protein (CP) content (13.22%) at 72 hours, surpassing T_0, T_1, T_2, and T_4. Concurrently, at 24h of incubation CF content ranges from 6 to 7% but with whey fermentation at different period and incorporation level, crude fiber (CF) content decreased by 28.57%, with T_4 showing the lowest CF value (5%) at 72 hours, possibly due to lactobacillus bacteria in whey. Ether extract (EE) was highest in T_4 (14.75%) at 24 hours, while total ash was lowest in T_3 (2.54%) at 24 hours and highest in T_4 (6.52%) at 72 hours. Nitrogen-free extract (NFE) was lowest in T_4 (64.56%) at 24 hours and highest in T_0 (75.91%) at 72 hours. (Kermanashahi and Rostami, 2006) revealed that 0.2 to 0.8 % whey powder fed broilers enhanced BWG at 49-day inwhere Al-asadi *et al.*, (2008) stated that 0.25 and 0.5% whey powder significantly increased BWG of broilers meanwhile. Ashour *et al.*, (2019) also showed significant improvement in FCR in all whey protein concentrate (WPC) groups. The findings align with Fallah (2016), who suggested that whey supplementation enhances body weight gain (BWG) in poultry. Similarly, Kermanashahi and Rostami (2006) found enhanced BWG with whey powder supplementation (0.2 to 0.8 %). Contradictory findings were noted by Kermanshahi and Rostami (2006), who observed increased feed intake with whey diet (0.1%) while Ashour et al. (2019) reported reduced feed intake but improved feed conversion ratio (FCR). These variations could be attributed to differences in experimental conditions and dosage.

Table 1. Variation of chemical composition in whey fermented crushed maize at different hours of fermentation.

C.C (%)	Treatment															*p*
	T_0			T_1			T_2			T_3			T_4			
	24h	48h	72h	24h	48h	72h	24h	48h	72h	24h	48h	72h	24h	48h	72h	
CP	8.74±0.04	8.92±0.03	9.04±0.04	9.73±0.03	10.04±0.03	10.16±0.04	8.54±0.02	10.22±0.03	10.03±0.03	8.59±0.03	10.52±0.03	13.22±0.03	8.55±0.06	10.90±0.03	10.46±0.03	<0.001
CF	6.99±0.04	6.5±0.02	6.03±0.03	6.54±0.04	5.99±0.04	5.73±0.03	7.03±0.03	6.32±0.03	5.81±0.02	7±0.03	6.23±0.03	5.81±0.02	6.05±0.05	5.23±0.03	5.00±0.03	<0.001
EE	4.33±0.03	4.04±0.04	3.05±0.05	9.93±0.03	8.95±0.03	7.9±0.04	11.72±0.02	10.5±0.03	9.24±0.05	12.25±0.05	10.8±0.03	10.05±0.05	14.75±0.01	11.93±0.03	11.05±0.05	<0.001
TA	5.6±0.53	5.97±0.02	5.97±0.03	2.95±0.05	3.6±0.02	3.7±0.02	3.84±0.03	3.9±0.02	3.88±0.02	2.54±0.04	2.66±0.02	2.76±0.02	6.09±0.01	6.2±0.01	6.52±0.41	<0.001
NFE	74.34±0.46	74.56±0.08	75.91±0.09	70.85±0.04	71.41±0.04	72.51±0.1	68.87±0.07	69.05±0.08	71.32±0.12	69.62±0.11	69.68±0.09	68.16±0.09	64.56±0.1	65.75±0.08	66.96±0.47	<0.001

C.C- Chemical Composition, T_0-Without whey, T_1-20ml/100g feed, T_2-30ml/100g feed, T_3-40ml/100g feed, T_4- 50ml/100g feed, CP-Crude protein,CF-Crude fiber,EE-Ether extract,TA-Total ash, NFE-Nitrogen free extract, h- Hours, *p*-Probability value

The results from table-2 represent that in whey-fermented wheat bran, CP peaked at 16.88% in T_1 at 72 hours, followed by T_3 at 16.63%. T_2 displayed 14.72% CP at 24 hours, while T_3 hit a low of 14.3% at 24 hours. CF reached 33.05% in T_4 at 24 hours, and EE peaked at 4.54% in T_4 at 24 hours. Total ash was highest in T_4 (9.82%). NFE was highest in T_2 (53.13%) at 72 hours. Addition of 20 ml sweet whey per 100g increased CP by 14%, but higher whey levels didn't raise CP adequately, likely due to decreased pH and reduced soluble carbohydrate content. Ibrahim et al., (2015) observed that adding whey protein concentrate (WPC) to broiler diets enhanced eventual LBW and BWG compared to the control group. Similarly, Fallah (2016), Al-asadi et al., (2008), and Ashour et al., (2019) administered whey to broilers either through drinking water or as WPC in feed, yielding favorable outcomes in growth rate, feed conversion efficiency, and gut health. The results of present study agree with the above statements indirectly as here feed ingredients were fermented with sweet whey and elevated the nutritional values (CP, NFE).

Table 4. Variation of chemical composition in whey fermented Auto Rice Polish at different hours of fermentation.

C.C (%)	Treatment															*p*
	T_0			T_1			T_2			T_3			T_4			
	24h	48h	72h	24h	48h	72h	24h	48h	72h	24h	48h	72h	24h	48h	72h	
CP	15.19f ±0.02	15.19f ±0.04	15.35e ±0.03	15.31e ±0.04	15.88d ±0.03	16.46 ±0.02	14.53 ±0.03	17.53c ±0.02	17.46b ±0.02	14.12 ±0.1	9.66± 0.03	14.9± 0.02	15.35 ±0.03	18.4b ±0.02	18.65a ±0.03	<0.001
CF	13.65 ±0.05	15.05 ±0.05	13.13 ±0.03	14.31 ±0.04	14.14± 0.04	13.04 ±0.04	14.01 ±0.07	13.94± 0.04	13.64± 0.04	13.7± 0.03	13.48 ±0.03	12.05 ±0.05	11.35 ±0.03	11.04 ±0.04	11.04± 0.04	<0.001
EE	10.84 ±0.03	9.84± 0.04	8.74± 0.04	11.81 ±0.02	11.08± 0.02	7.09± 5.17	12.23 ±0.02	11.19± 0.03	10.49± 0.03	13.8± 0.02	12.73 ±0.25	12.25 ±0.03	14.25 ±0.04	13.24 ±0.04	13.04± 0.04	<0.001
TA	15.53 ±0.03	15.65 ±0.03	15.76 ±0.03	14.32 ±0.03	14.40± 0.02	14.52 ±0.04	15.2± 0.02	15.3±0. 02	15.39± 0.01	15.54 ±0.04	15.58 ±0.02	15.78 ±0.02	15.68 ±0.03	15.70 ±0.02	15.72± 0.03	<0.001
NFE	49.07 ±0.09	43.67 ±0.15	47.03 ±0.12	44.25 ±0.06	44.5±0 .09	50.89 ±5.11	41.03 ±0.1	42.04± 0.11	46.01± 0.09	42.84 ±0.12	48.56 ±0.32	45.02 ±0.12	43.38 ±0.12	41.62 ±0.08	47.54± 0.13	<0.001

C.C – Chemical Composition, T_0-Without whey, T_1-20ml/100g feed, T_2-30ml/100g feed, T_3-40ml/100g feed, T_4- 50ml/100g feed, CP-Crude protein, CF-Crude fiber, EE-Ether extract, A-Total ash, NFE-Nitrogen free extract, h- Hours, *p*-Probability value

Incorporating whey into energy and protein-rich feeds such as maize, wheat bran, rice polish, and soybean meal significantly increased CP levels by 13% to 51.25% over 24 to 72 hours of incubation, while somewhat reducing CF levels. However, higher whey concentrations might increase acidity, potentially inhibiting microbial fermentation and causing a slight reduction in CP, though CF reduction was notably increased by up to 47% in some cases, suggesting whey fermentation's potential to improve nutrient levels and feed digestibility, warranting further biological trials for bird response assessment.

Conclusion

Incorporating whey into energy and protein-rich feeds significantly increased crude protein (CP) and nitrogen-free extract (NFE) levels while decreasing crude fiber (CF) content across varying incubation periods. Optimal CP enhancement (13% to 51.25%) occurred with 20 to 40 ml of whey per 100 g of feed. However, higher whey concentrations may elevate acidity, potentially inhibiting microbial fermentation and leading to slight CP reductions. Nonetheless, substantial CF reduction highlights whey fermentation's potential to improve feed digestibility. Further research is needed to assess its impact on poultry performance comprehensively.

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Figure 1. Whey Fermented Feed Ingredients