Valorization of poultry slaughterhouse waste into flour to prevent environmental pollution

Zalani Karima[1], Houssou Hind[2], Foufou Ammar[3], Gourgane Ikram[1], Boudmagh Ines[1]

1. Department of Agronomy. Faculty of Sciences. 20 August 1955 University-Skikda, Algeria.
2. Laboratory of Animal Productions, Biotechnology and Health, Institute of Agriculture and Veterinary Sciences, University of Souk Ahras, Algeria.
3. Laboratory for the Optimization of Agricultural Production in Sub-Humid Regions. 20 August 1955 University of Skikda, Algeria

Abstract

Slaughterhouse waste are mainly disposed of by incineration, which generates pollution and greenhouse gases. Conversely, these wastes could be recovered are a source of useful biological resources. This study was carried out in 2024 at the wilayas of Skikda. We carried out the treatment of each poultry by-product (legs, viscera, heads and feathers) by cooking at a temperature of 120°C; nevertheless; the cooking time was different for each by-product; In order to valorize the waste generated and identify its value, we carried out an analysis of the flour physicochemical for four type of by-products. The samples were processed for bacterial analysis such as total coliforms, faecal coliforms, *faecal streptococci* and, *Salmonella.* The findings revealed that the protein content analysis indicated that feathers contain the highest protein content (88.2%), followed by other waste components (51-52%).The analysis also revealed considerable concentrations of minerals (3.86%) for viscera, (13.02%) for legs, (12.37%) for heads and (1.24%) for feathers. The lack of microbiological risk associated with their use has been proven. Good efficiency resulting from the use of waste materials, as well as limiting the negative impact of poultry farms on the environment, make this solution an attractive alternative.

1. Introduction

Economic development entails waste as its side effect. It is estimated that 1.3 billion Mg of solid waste is collected all over the world each year. This number is expected to increase to 2.2 billion Mg in 2025 (Izydorczyk et al., 2022). In Algeria, poultry farms run under intensive production systems contribute significantly to food security, but they are dependent on very expensive imported raw materials and have a highly negative impact on the environment due to the slaughter by-products they generate, which are not recycled. Indeed, poultry slaughter by-products are not recycled in Algeria (Djeffal et al., 2025); their recycling could be a means of enabling the economic development of several sectors of activity, thus contributing to a more sustainable animal production system (Vincenza, 2020).

By-products from poultry slaughter are known to be rich in protein, so they could be used as animal meal, which would be used as a feed supplement for the production of farmed fish at lower costs, knowing that in Algeria, the production of farmed fish has become a strategic sector for food security. For this reason, the valorization of these poultry slaughterhouse by-products would help make poultry farms more profitable and also protect the environment from their negative effects (Kannappan and Baahrathi 2012; Mokrejs et al., 2017). According to Mahmoudi and Mahmoudi (2023), the valorization of poultry slaughterhouse by-products could significantly contribute to the protection of the environment and the health of the population, also, it could help create jobs, generate income for slaughterhouses and finally produce in a more sustainable way.

The objective of our research is to find a solution to reduce the negative impact of poultry slaughter by-products generated (feet, heads, viscera and feathers) on the environment and also to reduce the production costs of farmed fish, including feed costs, which constitute a significant part of the total cost. Thus, we have produced animal meal from poultry slaughter by-products that could be used as a supplement in feed for farmed fish on one hand. On another hand, the production of farmed fish feed from poultry slaughterhouse by-products could lead to the availability of fish feed at competitive prices, thus strengthening the profitability of fish farms. Also, the production of feed using local and sustainable ingredients would have a positive impact on the environment and reduce our dependence on imported and expensive raw materials

2. Materials and methods

2.1 Data collection and sampling conditions

For the research work, we brought by-products from the Hamadi Krouma poultry slaughterhouse in the wilaya of Skikda. The by-products brought back are: legs, heads, viscera and feathers. The establishment has a slaughter capacity of 2,000 chickens per hour, or approximately 12,000 chickens daily. Twenty (20) tons of poultry are slaughtered daily by the poultry slaughterhouse.

2.2 Production of flour

Once they arrive at the laboratory, the by-products are washed with distilled water to remove any residue, then left to drain and air dry. Each type of by-product was then weighed using a precision balance.

We processed each poultry by-product by cooking at a temperature of approximately 120°C; however, the cooking time varied for each by-product (6 hours for feathers, 8 hours for feet, 10 hours for viscera, and 12 hours for heads). Finally, we ground the four types of animal meal produced after cooling.

2.3. Physicochemical analysis of the flour produced (four types)

Afin de déterminer la composition physicochimique des quatre types de farines produites, nous avons entrepris le conditionnement des quatre types de farine dans des tubes stériles étiquetés.

2.3.1. Determination of Total Nitrogen Content in flour produced

The total nitrogen content was determined using the Kjeldahl method. The measurement of total Kjeldahl nitrogen (TKN) provides a useful parameter for measuring nitrogen content, as it includes bioavailable nitrogen forms (ammonium and urea) (Figure 1). Typically, TKN is measured using a method developed by Johan Kjeldahl and consists of three steps: digestion, distillation, and titration (Sáez-Plaza, et al. 2013; Hicks et al., 2022).

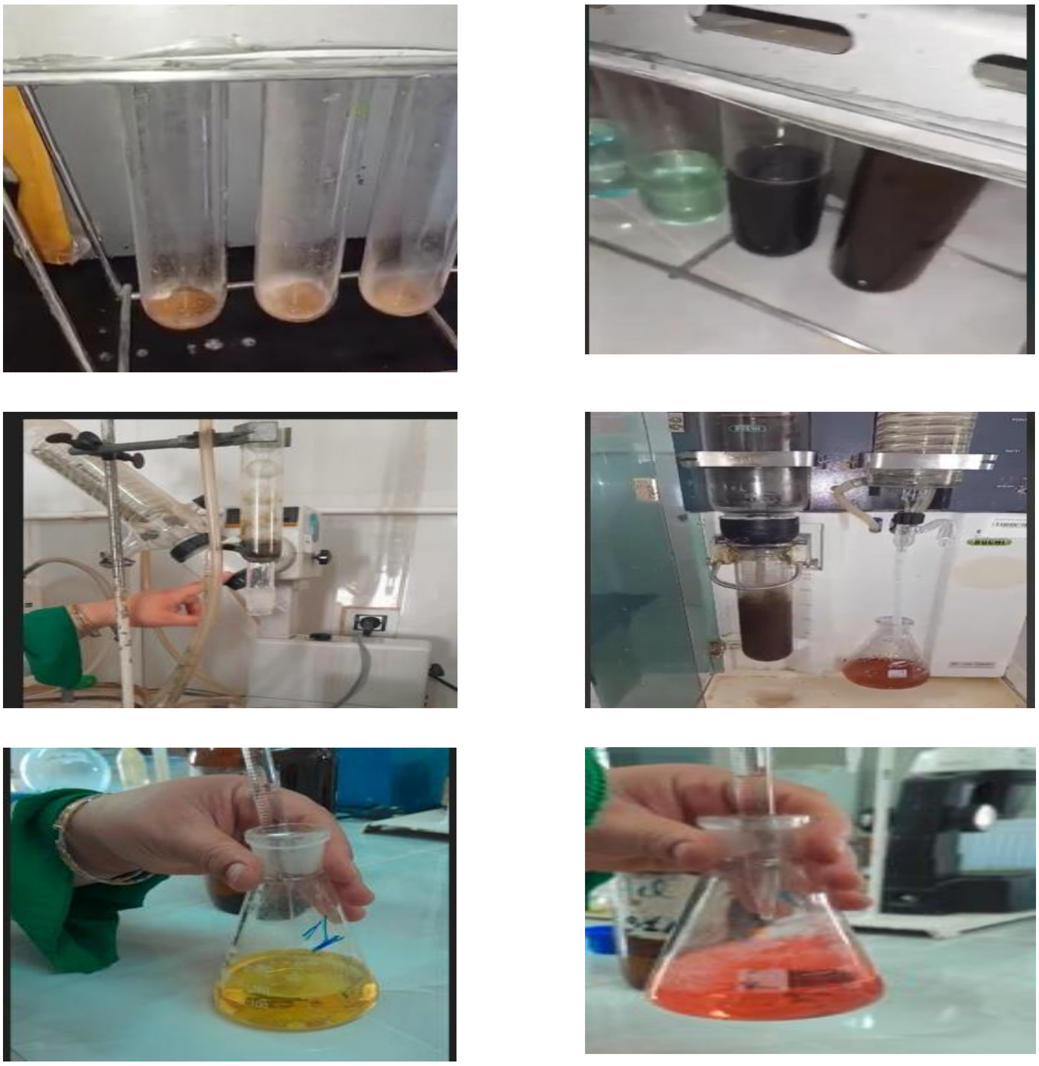

Figure 1. Determination of total nitrogen levels of the four types of animal **meal3.2 Determination of moisture content (H %) and dry matter content**

Dry matter % = 100- moisture content

Conventional method in moisture content determination include the oven drying method (Butts et al., 2014) The principle of the oven drying method is to calculate the moisture content by comparing the changes of sample weight before and after drying. Samples of the four types of animal meal were weighed (p0) using a precision balance, then dried at 105°C for 24 hours in an oven. Upon removal from the oven, the samples cooled in the desiccator were weighed (p1), and the moisture and dry matter content were calculated using the following formulas::

$$\text{Moisture } \% = \frac{P0 - \mathbf{p1}}{p\mathbf{0}} x100$$

2.3.2. Determination of the mineral matter content

The determination of mineral matter was carried out by the loss on ignition method (AOAC, 2000). Thus, a 5g sample was calcined at a temperature of 550 °C in a muffle furnace for a period of 6 hours. The calcined samples were weighed after cooling in a desiccator.

2.4. Bacteriological analysis

A total of 10 samples taken wastes were the subject of a bacteriological study aimed at counting total coliforms, faecal and streptococci as well as the search for Salmonella. Bacteriological analyses were performed according to the standards protocols

3. Results and Discussion

3.1 Results of the protein content of the four types of flour produced

The quantitative balance of this waste is assessed on the basis of the ratio of powder type by waste type, for a better management strategy. The rates are shown in figure 1.

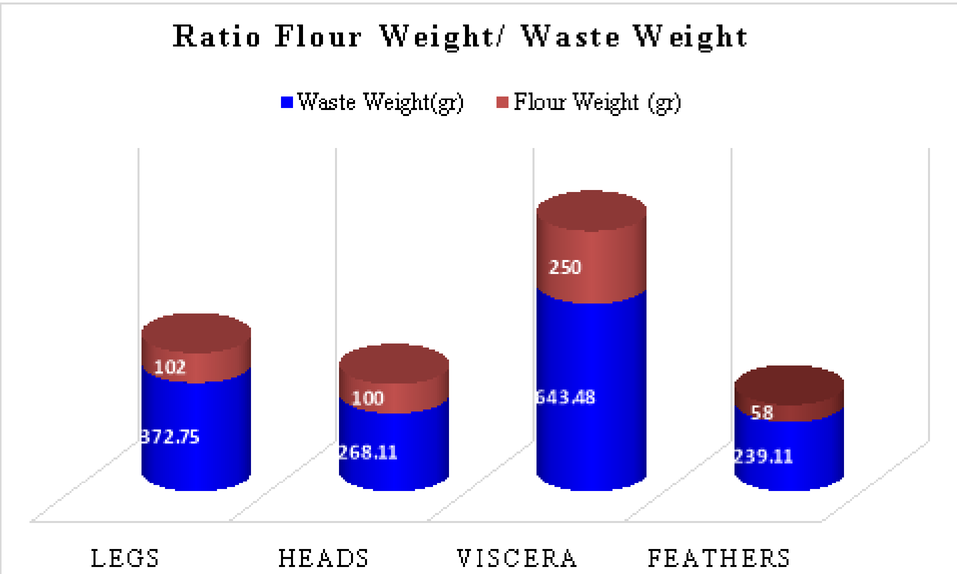

Figure 1: The ratio of weight of the flour obtained/ waste weight

The results of the protein content of the four types of flour produced (Figure 3), demonstrate a significant protein content of the poultry by-products, these contents are 52.41% for the viscera, 51.24% for the legs, 52.08% for the heads and finally the highest protein content (88.2%) for the feathers.

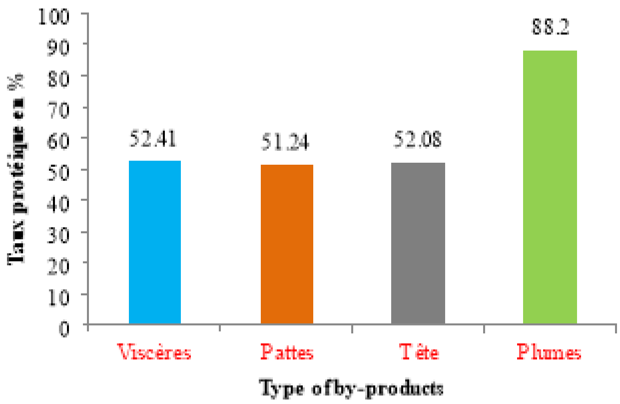

Figure 3. Protein content (%) of the flour products

3.2 Moisture and Dry Matter Content Results for the Four Types of flour

The moisture content results for the four types of beechnut are summarized in Table 1 and illustrated in Figure 4. Examination of these results shows that the minimum moisture content is 52.73% for viscera, while the maximum moisture content is 89.24% for feathers. However, the dry matter content results for the animal meals produced (Table 1 and Figure 4) show a minimum content of around 10.76% for feathers and a maximum content of around 47.27% for viscera.

Table 2. Moisture and Dry Matter Contents for the Four Types of flour products

Type of by products	**p°**	**p1**	**H° %**	**MS %**
Viscera	250.5	118,4	52,73	47,27
Legs	372,75	136,5	63,38	36,62
Heads	385,00	73,6	80,88	19,12
Feathers	237,00	61,5	89,24	10,76

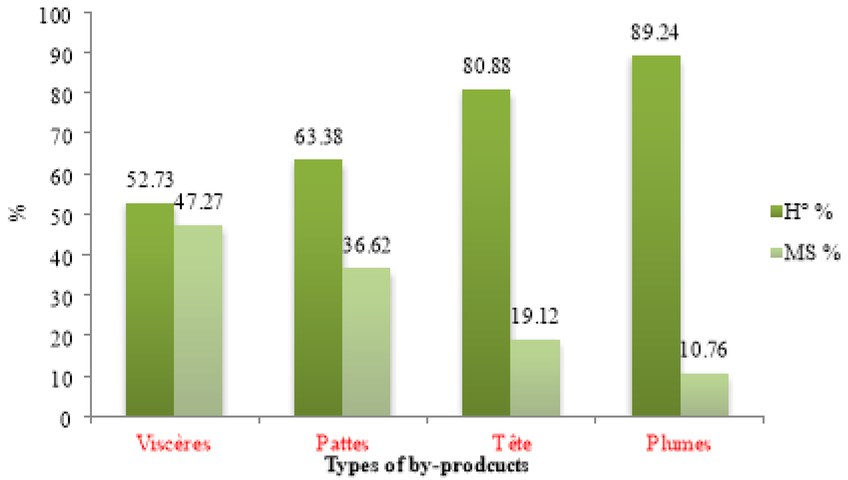

Figure 4. Moisture and dry matter content of the four types of flour produced

3.3 Results of the mineral and calcium content of the four types of flour produced

The rates of mineral content for the four types of flour produced (Table 3 and Figure 5) show that the minimum mineral content is (1.248%) for animal meal from feathers, while the maximum content is (13.02%) for animal meal from feet. Furthermore, the minimum organic matter content is (86.98%) for animal meal from feet, while the maximum content is (98.76%) for animal meal from feathers.

Also, the rates of calcium content for the four types of animal meal produced are summarized in the table and illustrated in Figure 5. The results show a maximum calcium content (4.3%) for animal meal for feet and a minimum content (0.2%) for feathers.

Table 3. Mineral and organic content and calcium levels (%) in the four types of flour produced

Type sous produits	Teneur minérale (%)	Taux en calcium (%)	Teneur en Matière organique (%)
Viscères	3,86	0,8	96,14
Pattes	13,02	4,3	86,98
Tête	12, 37	2,5	87,63
Plumes	1,24	0,2	98,76

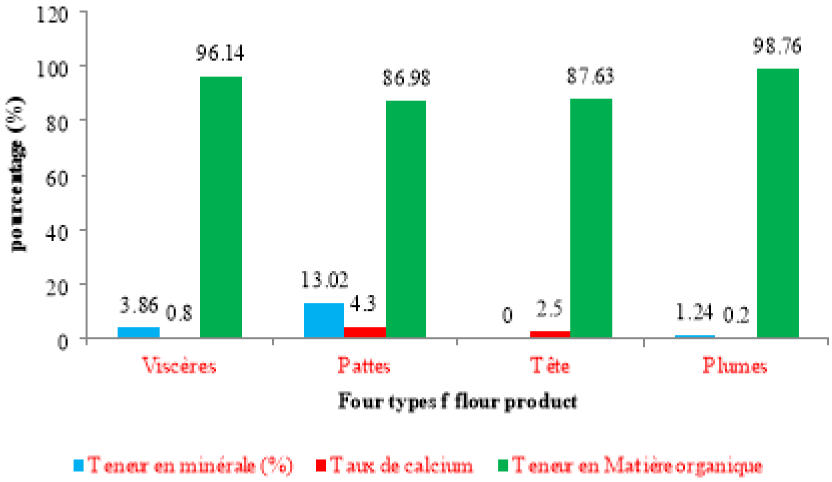

Figure 4 Organic matter content, calcium content and mineral content of the four types of flour

3.4. Discussion

The physicochemical characteristics of the four types of flour revealed high protein concentrations (52.41% for viscera, 51.24% for legs, 52.08 for heads and 88.2% for feathers).These animal wastes contain considerable amounts of insoluble and difficult-to-degrade structural proteins, such as collagen, elastin, and keratin, which are the main constituents of bones, organs, and hard tissues. These by-products can be extracted and hydrolyzed for use as animal feed or functional ingredients (Brandelli et al., 2015).

Mokrejs et al (2017) reported higher protein content (95%) for chicken feet. While Kannappan (2012) reported 91% protein content for feathers. The development of suitable processes to convert waste into digestible proteins and amino acids has been the main goal, and biotechnological approaches based on microbial enzymes have been extensively investigated in the last decade (Gupta et al., 2013; Kornillowicz-Kowalska and Bohacz, 2011). Overall, Elmoualdi et al., (2006) reported that, proteins are found at high levels (in poultry waste while the mineral composition is dominated by potassium . This relatively balanced composition leads to an ingredient that can be of interest, among other things, in soil fertilization. It should be noted that other recovery channels can be opened up to these wastes that can be considered noble from the point of view of nutritional value.

Physicochemical analyses also revealed high mineral contents of the order of 3.86% for the viscera, 13.02% for the legs, 12.37% for the heads and 1.24% for the feathers. These results demonstrate that poultry slaughter by-products can be an important source of protein and minerals for farmed fish production. Chennaoui et al (2012) determined that slaughterhouse by-products could represent a valuable source of nutrient-rich components of high nutritional value.

4. CONCLUSION

In conclusion, this study provided data on the protein and mineral compositions of four types of animal meal produced from poultry slaughter by-products (feet, viscera, heads, and feathers). The characteristics of the four types of animal meal revealed high concentrations of protein (52.41% for viscera, 51.24% for feet, 52.08% for heads, and 88.2% for feathers) and minerals (3.86% for viscera, 13.02% for feet, 12.37% for heads, and 1.24% for feathers). These four types of animal meal could therefore be used as a source of protein and minerals in farmed fish feed. This environmentally friendly method aims to reduce pollution caused by slaughterhouse waste and develop an integrated agricultural system. The aim of using poultry slaughter by-products would be to reduce our dependence on expensive imports of raw materials and also reduce their negative impact on the environment.

5. References

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