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## RESEARCH ARTICLE

# LEVEL OF KNOWLEDGE OF STAKEHOLDERS ON WASTE MANAGEMENT IN THE POULTRY SECTOR IN THE MARITIME REGION OF TOGO

DOGBEVI Afi Bienvenue<sup>1\*</sup>; MELILA Mamatchi<sup>2</sup>; TCHEGUENI Sanonka<sup>1</sup>; DEGBE Koffi Agbegnigan<sup>1</sup>; BAFAI Diyakadola Dihéénane<sup>1</sup>; GANI Safouat<sup>2</sup> and TCHANGBEDJI Gado<sup>1</sup>

<sup>1</sup>Laboratoire de Gestion, Traitement et Valorisation des Déchets (GTVD), Faculté des Sciences, University of Lomé – Togo; <sup>2</sup>Laboratoire de Génie des Procédés et des Ressources Naturelles (LAGEPREN), Faculté des Sciences, University of Lomé – Togo

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\*Corresponding Author:  
DOGBEVI Afi Bienvenue

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## INTRODUCTION

Industrial waste dumped into the environment constitutes a risk for the population. Among this waste, that of the agri-food processing industry including the poultry sector is not negligible (Vineis *et al.*, 2019; Azabi, 2020). Second meat after pork, poultry production in the world is estimated at 70 million tonnes (Huart, 2004) with 24 billion chickens bled per year and 8.5 billion tonnes of waste produced (Purandaradas *et al.*, 2018) including feathers. It is noted that in landfills this waste undergoes transformations developing polluting gases such as hydrogen sulphide, nitrous oxide and ammonia which poses a threat to public health (Li, 2019). Globally, poultry processing industries produce millions of tons of feather waste (Azabi, 2020), a real headache for players. The incineration of this waste also brings serious changes to the environment. However, since the preservation of the environment has become a matter of collective interest since the beginning of the 1990s, poultry sectors should take into account production that respects the environment.

### ABSTRACT

Poultry is one of the main sources of animal protein that is mainly consumed in the world. At the same time its contribution has resulted in the creation of a substantial number of waste feathers. That end up in landfills creating environmental problems due to the ignorance of the actors about their socio-economic importance. Yet, they are renewable resources rich in keratin, a type of rigid and fibrous protein with multiple applications. This study which is an assessment of the level of knowledge of the actors of the poultry sector of the Maritime Region in Togo on the management of poultry feathers and their recovery, is a contribution to an efficient management and recovery of this waste. In total 36 structures were prospected using survey sheets, with the participation of one actor per structure. The survey carried out by semi-structured interview then made it possible to note that the actors experience a difficulty in the management of feathers, concomitantly with their slow biodegradability. Their storage without use then becomes a problem in poultry farming systems where these feathers are either thrown on dumps or simply incinerated. This difficulty in the management of poultry feathers explains their low storage observed through the present study, 27.78% against 88.89% for droppings. Even the valorization in composting remains very weak with only one structure on all the localities prospected and this, in spite of the high level of study of the actors. Overall, the actors in the poultry sector surveyed thus have little knowledge in the management and the use of these feathers. The valorization of poultry feathers in Togo therefore remains a challenge to be met.

Waste management therefore remains a constant concern in time and space. Moreover, the problem of poultry waste management, although universal is not the same acuteness in all regions of the world (Chatellier *et al.*, 2015). In Togo poultry farming occupies a prominent place in the national economy. It offers job opportunities to young people and helps meet the needs of the population in animal protein. Indeed, many young entrepreneurs are turning to this poultry sector which has undergone major reforms over the past ten years driven by a political will to promote local consumption. Reforms have also contributed to boosting production. From 8 million in 2010, it has more than 26 million heads of poultry in 2020 (Guézodjè & Amen, 2020). However, as in other parts of the world poultry farming in Togo is a source of production of a substantial quantity of feathers which represent the greatest concern in terms of waste management. Indeed, waste from the poultry sector such as droppings, food scraps and viscera are not only rapidly biodegradable but also recoverable in the fertilization of agricultural soils, while the biodegradability of feathers is slow (5 to 10 years). These feathers then constitute waste on landfills in the open air or incinerated. However, considering the development of the poultry sector and the fact that feathers

representing approximately 5% of the mass of the bird constitute an interesting source of keratin, their valorization in this protein becomes a great added value to this sector (Fagbemi *et al.*, 2020). Recent studies on the recovery of poultry waste and particularly that of poultry feathers have thus proposed measures for effective management (Azabi, 2020). This recovery requires raising the awareness of stakeholders who are still unaware of the socio-economic importance of this waste. To achieve this, it is important first of all to identify the characteristics of the actors and their level of knowledge in terms of managing the waste produced, including feathers. This is what justifies the present study which is a contribution to the efficient management and recovery of waste from the poultry sector and particularly that of feathers.

## MATERIAL AND METHODS

**Study framework:** The survey was carried out in 36 poultry structures in the Maritime Region and involved one actor per structure, i.e. 36 actors in total.

**Survey materials:** The material used for the survey consists of survey sheets. These sheets were pre-tested with fifteen students at the University of Lomé and readjusted before the actual survey. This preliminary survey made it possible to obtain the final survey form used.

### Methodology

**Choice of localities surveyed and selection of respondents:** The localities surveyed were chosen according to two main criteria. The first criterion is the existence of at least one production, processing or production and processing unit. The second criterion is that the structure belongs to the Maritime region. The selection of respondents was made randomly but above all, based on the availability of the respondent and/or on the proposal of the manager or owner of the structure to be surveyed. In total 07 prefectures were prospected namely the prefectures of Agoé, Avé, Golfe, Lacs, Zio, Vo and Yoto with 36 structures of the poultry sector surveyed (Figure 1), also corresponding to the number of actors who participated in the survey.

**Survey methodology:** The survey was carried out through a survey sheet designed for the occasion. The survey sheet was first tested with about fifteen students at the University of Lomé assimilated to the actors of the poultry sector. The survey difficulties identified then made it possible to readjust this sheet and make it more reliable during the survey itself. In the field, the survey was carried out by semi-structured interviews from June to August 2022 with actors in farms and poultry product processing structures. Direct observations were also made to inform certain parameters of the survey.

## RESULTS

**Sociodemographic characteristics of respondents:** All (100%) of the actors in the poultry sector surveyed were male with 52.78% employees and 47.22% owners. The age group of 30 to 39 years was the most represented with a proportion of 88.89% of actors having a higher level of study. Although poultry farming is a secondary activity for some, the majority, i.e. 38.89%, exercised poultry farming as their main function. The level of professional experience was between 1 and 4 years for 66.67% of respondents with 83.33% having training in poultry farming (Table 1).

**Characteristics of surveyed structures and poultry practices:** The tasks within the structures surveyed can be summarized in three, namely slaughtering only (5.56%), breeding only (61.11%) and breeding coupled with slaughtering (33.33%). Guinea fowls and hens were the poultry raised with mainly modern chickens at a proportion of 61.11%. The majority of farms had less than 1,000 head of poultry (50.00%) with slaughter rates of less than 500 poultry per month for the majority of farms (57.14%) and 28.57% of farms that slaughtered between 500 and 1000 poultry per month.

**Table 1. Sociodemographic characteristics of respondents**

| Sociodemographic parameters | Number of respondents (n) | Proportion (%) |
|-----------------------------|---------------------------|----------------|
| Sex                         |                           |                |
| Men                         | 36                        | 100.00         |
| Women                       | 0                         | 0.00           |
| Total                       | 36                        | 100.00         |
| Age                         |                           |                |
| [20-30[                     | 12                        | 33.33          |
| [30-40[                     | 18                        | 50.00          |
| [40-50[                     | 4                         | 11.11          |
| 50≤                         | 2                         | 5.56           |
| Total                       | 36                        | 100.00         |
| Education level             |                           |                |
| Primary                     | 2                         | 5.56           |
| Secondary                   | 2                         | 5.56           |
| University level            | 32                        | 88.89          |
| Total                       | 36                        | 100.00         |
| Occupation                  |                           |                |
| Poultry farmer              | 14                        | 38.89          |
| Searcher                    | 2                         | 5.56           |
| Accounting                  | 2                         | 5.56           |
| Poultry entrepreneur        | 4                         | 11.11          |
| Student                     | 2                         | 5.56           |
| Agronomist                  | 8                         | 22.22          |
| Farm hand                   | 2                         | 5.56           |
| Retirement                  | 2                         | 5.56           |
| Total                       | 36                        | 100.00         |
| Poultry training            |                           |                |
| No                          | 6                         | 16.67          |
| Yes                         | 30                        | 83.33          |
| Total                       | 36                        | 100.00         |
| Year of experience          |                           |                |
| [1;5[                       | 24                        | 66.67          |
| [5;10[                      | 8                         | 22.22          |
| [10;15[                     | 2                         | 5.56           |
| ≥15                         | 2                         | 5.56           |
| Total                       | 36                        | 100.00         |
| Actor's role                |                           |                |
| Employee                    | 19                        | 52.78          |
| Owner                       | 17                        | 47.22          |
| Total                       | 36                        | 100.00         |

Manual techniques were the most adopted both for slaughter (71.43%) and plucking (57.14%) with plucking water temperatures ranging from 60 to 100°C in 42.86% of the farms (Table 2).

**Type and quantity of waste produced by poultry structures:** According to the types of waste produced, 88.89% of structures produced droppings as waste, 16.67% blood, 27.78% feathers, 27.78% viscera and 44.44% food remains. The quantities of waste that could be assessed on a monthly basis are food scraps and droppings. Monthly, about 100 kg of food remains were recorded for 62.50% of structures and 63.89% ended up with just under 100 kg of droppings (Table 3).

### Becoming of poultry waste produced

**Become droppings:** The droppings from the surveyed poultry structures were either sold to market gardeners (56.25%) or stored (43.75%). The droppings did not undergo any type of treatment before being stored in the composting sites (85.71%) and in the open air (14.29%) (Table 4).

**Become viscera:** All of the slaughter structures surveyed did not retain the viscera resulting from their activities. They were transported either by wheelbarrows (64.29%) or manually (35.71%) for incineration (50.00%) to landfills (35.71%) or in garbage cans (14.29%). The effects of viscera elimination on the environment identified by the respondents were limited to odors (78.57%) and respiratory problems (21.43%). No health complaints from personnel treating viscera on the environment and humans were recorded (Table 5).

**Become feathers:** The presence of feathers as waste was observed in 27.78% of respondents and only one structure, i.e. 10.00% of them, kept the feathers to transport it by wheelbarrow to the composting site (Photo 1).

**Table 2. Characteristics of surveyed poultry structures and poultry practices**

| Parameters considered                            | Number of structures (n) | Proportion (%) |
|--|--------------------------|----------------|
| <b>Specific tasks of the company</b>             |                          |                |
| Slaughter only                                   | 2                        | 5.56           |
| Breeding and slaughter                           | 12                       | 33.33          |
| Breeding only                                    | 22                       | 61.11          |
| Total  | 36                       | 100.00         |
| <b>Types of poultry raised</b>                   |                          |                |
| Guinea fowls                                     | 2                        | 5.56           |
| Modern chickens                                  | 22                       | 61.11          |
| Traditional chickens                             | 4                        | 11.11          |
| Traditional and modern chickens                  | 4                        | 11.11          |
| Traditional and modern chickens and Guinea fowls | 4                        | 11.11          |
| Total  | 36                       | 100.00         |
| <b>Number of poultry reared</b>                  |                          |                |
| <1000 heads                                      | 18                       | 50.00          |
| [1000 - 5000]heads                               | 14                       | 38.89          |
| ≥ 5000heads                                      | 4                        | 11.11          |
| Total  | 36                       | 100.00         |
| <b>Number of poultry slaughtered per month</b>   |                          |                |
| < 500heads                                       | 8                        | 57.14          |
| [500 - 1000]heads                                | 4                        | 28.57          |
| ≥ 1000heads                                      | 2                        | 14.29          |
| Total  | 14                       | 100.00         |
| <b>Slaughter technique</b>                       |                          |                |
| Manual   | 10                       | 71.43          |
| Manual /Automated                                | 4                        | 28.57          |
| Total  | 14                       | 100.00         |
| <b>Plucking technique</b>                        |                          |                |
| Automated  | 2                        | 14.29          |
| Manual   | 8                        | 57.14          |
| Manual/Automated                                 | 4                        | 28.57          |
| Total  | 14                       | 100.00         |
| <b>Plucking water temperature (°C)</b>           |                          |                |
| 100  | 4                        | 28.57          |
| 60-100°C   | 6                        | 42.86          |
| 70   | 4                        | 28.57          |
| Total  | 14                       | 100.00         |

**Table 3. Type and quantity of waste produced by poultry structures**

| Type of waste                        | Number of structures (n) | Proportion (%) |
|--------------------------------------|--------------------------|----------------|
| <b>Droppings</b>                     |                          |                |
| Yes                                  | 32                       | 88.89          |
| No                                   | 4                        | 11.11          |
| Total                                | 36                       | 100.00         |
| <b>Blood</b>                         |                          |                |
| Yes                                  | 6                        | 16.67          |
| No                                   | 30                       | 83.33          |
| Total                                | 36                       | 100.00         |
| <b>Feathers</b>                      |                          |                |
| Yes                                  | 10                       | 27.78          |
| No                                   | 26                       | 72.22          |
| Total                                | 36                       | 100.00         |
| <b>Viscera</b>                       |                          |                |
| Yes                                  | 10                       | 27.78          |
| No                                   | 26                       | 72.22          |
| Total                                | 36                       | 100.00         |
| <b>Food leftovers</b>                |                          |                |
| Yes                                  | 16                       | 44.44          |
| No                                   | 20                       | 55.56          |
| Total                                | 36                       | 100.00         |
| <b>Amount of remaining food (kg)</b> |                          |                |
| < 100                                | 5                        | 62.50          |
| [100 - 500]                          | 2                        | 25.00          |
| ≥ 500                                | 1                        | 12.50          |
| Total                                | 8                        | 100.00         |
| <b>Droppings produced/month (kg)</b> |                          |                |
| < 100                                | 23                       | 63.89          |
| [100 - 500]                          | 9                        | 25.00          |
| ≥ 500                                | 4                        | 11.11          |
| Total                                | 36                       | 100.00         |

**Table 4. Become droppings**

| Parameters considered  | Number of structures (n) | Proportion (%) |
|--|--------------------------|----------------|
| <b>Manure production</b>                                     |                          |                |
| Yes  | 32                       | 88.89          |
| No   | 4                        | 11.11          |
| Total  | 36                       | 100.00         |
| <b>Become droppings</b>                                      |                          |                |
| Sales to market gardeners                                    | 18                       | 56.25          |
| Storage  | 14                       | 43.75          |
| Total  | 32                       | 100.00         |
| <b>Manure storage</b>  |                          |                |
| Outdoors   | 2                        | 14.29          |
| Composting site  | 12                       | 85.71          |
| Total  | 14                       | 100.00         |
| <b>Type of treatment carried out on the stored droppings</b> |                          |                |
| None   | 14                       | 100.00         |
| Total  | 14                       | 100.00         |
| <b>Mode of transport to storage location</b>                 |                          |                |
| Wheelbarrow  | 10                       | 71.42          |
| Trucks   | 2                        | 14.29          |
| Manual   | 2                        | 14.29          |
| Total  | 14                       | 100.00         |

**Photo 1. Poultry feathers and eggshells observed on a composting platform****Photo 2. Poultry feathers released into the open air by poultry production and slaughter units**

The rest, i.e. 90.00% of feather producers disposed of them in the open air (33.33%), (Photo 2), by incineration (33.33%), in garbage cans (22.22%) or by burial (11.11%) (Table 6).

**Training and knowledge of actors on the management of poultry waste:** Of all the structures surveyed, none received complaints related to poor management of livestock waste, even though only 22.22% had training in poultry waste management. Among those who had training, 50.00% had certified training and 50.00% did not receive it. Regarding the importance of good livestock waste management, 55.55% ignore it, while 38.89% mention the good health of poultry and 5.56% think of the quality of the environment (Table 7).

**Distribution of actors according to the acquisition of training and the type of poultry practices:** The distribution of the structures surveyed according to the acquisition of training in poultry farming reveals a high proportion of trained at the level of breeders only (55.55%) followed by breeders and slaughterers (22.22%) (Table 8).

Table 5. Fate of viscera in poultry slaughter structures

| Parameters considered                                 | Number of structures (n) | Proportion (%) |
|---|--------------------------|----------------|
| <b>Production of viscera</b>                          |                          |                |
| Yes   | 14                       | 38.89          |
| No  | 22                       | 61.11          |
| Total   | 36                       | 100.00         |
| <b>Preservation of viscera</b>                        |                          |                |
| Yes   | 0                        | 0.00           |
| No  | 14                       | 100.00         |
| Total   | 14                       | 100.00         |
| <b>Become viscera</b>                                 |                          |                |
| Trash cans  | 2                        | 14.29          |
| Incineration  | 7                        | 50.00          |
| Dump  | 5                        | 35.71          |
| Total   | 14                       | 100.00         |
| <b>Mode of transport to storage location</b>          |                          |                |
| Manual  | 5                        | 35.71          |
| Wheelbarrow   | 9                        | 64.29          |
| Total   | 14                       | 100.00         |
| <b>Effects of viscera disposal on the environment</b> |                          |                |
| Odour   | 11                       | 78.57          |
| Respiratory problems                                  | 3                        | 21.43          |
| Total   | 14                       | 100.00         |
| <b>Salmonellosis</b>                                  |                          |                |
| No idea   | 9                        | 64.29          |
| No  | 5                        | 35.71          |
| Total   | 14                       | 100.00         |

Table 6. Become feathers

| Parameters considered                        | Number of structures (n) | Proportion (%) |
|--|--------------------------|----------------|
| <b>Feathers</b>                              |                          |                |
| Yes  | 10                       | 27.78          |
| No   | 26                       | 72.22          |
| Total  | 36                       | 100.00         |
| <b>Conservation of feathers</b>              |                          |                |
| Yes  | 1                        | 10.00          |
| No   | 9                        | 90.00          |
| Total  | 10                       | 100.00         |
| <b>Feather storage</b>                       |                          |                |
| Composter                                    | 1                        | 10.00          |
| No storage                                   | 9                        | 90.00          |
| Total  | 10                       | 100.00         |
| <b>Intended for feathers not stored</b>      |                          |                |
| Open air discharge                           | 3                        | 33.33          |
| Trash cans                                   | 2                        | 22.22          |
| Landfill                                     | 1                        | 11.11          |
| Incineration                                 | 3                        | 33.33          |
| Total  | 9                        | 100.00         |
| <b>Mode of transport to storage location</b> |                          |                |
| Wheelbarrow                                  | 1                        | 100.00         |
| Total  | 1                        | 100.00         |

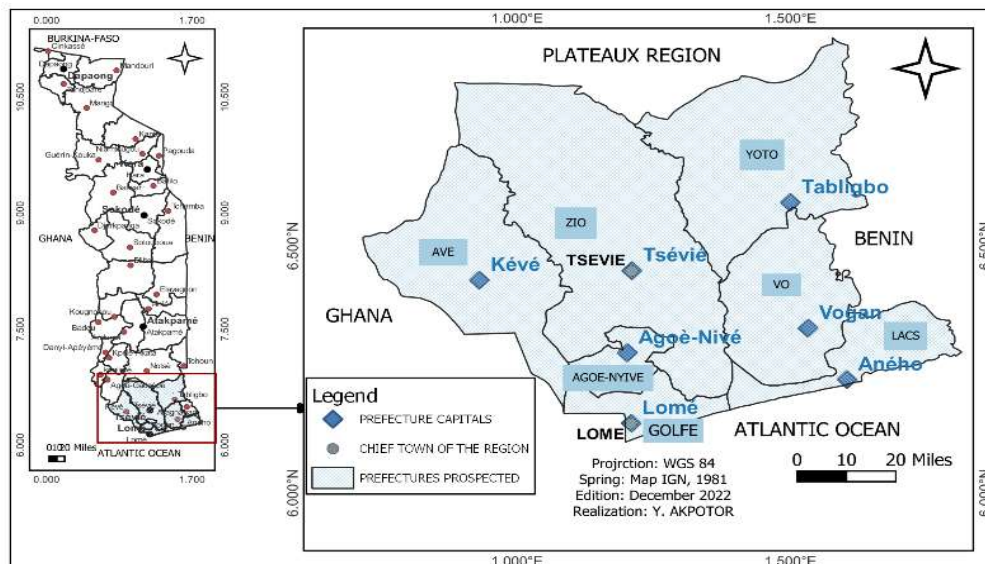


Figure 1. Location of surveyed prefectures

**Table 7. Training and knowledge of actors on the management of poultry waste**

| Parameters considered                  | Number of actors(n) | Proportion (%) |
|--|---------------------|----------------|
| Complaints related to waste management |                     |                |
| Yes                                    | 0                   | 0.00           |
| No                                     | 36                  | 100.00         |
| Total                                  | 36                  | 100.00         |
| Waste management training              |                     |                |
| No                                     | 28                  | 77.78          |
| Yes                                    | 8                   | 22.22          |
| Total                                  | 36                  | 100.00         |
| Certified training                     |                     |                |
| No                                     | 4                   | 50.00          |
| Yes                                    | 4                   | 50.00          |
| Total                                  | 8                   | 100.00         |
| Purpose of good waste management       |                     |                |
| Environmental quality                  | 1                   | 5.56           |
| Good poultry health                    | 7                   | 38.89          |
| No answer                              | 10                  | 55.55          |
| Total                                  | 18                  | 100.00         |

**Table 8. Distribution of actors according to the acquisition of training and the type of poultry practices**

| Parameters considered                      | Specific tasks of actors |      |                        |       |               |       | Total |        |
|--|--------------------------|------|------------------------|-------|---------------|-------|-------|--------|
|  | Slaughter only           |      | Breeding and slaughter |       | Breeding only |       | N     | %      |
|  | n                        | %    | n                      | %     | n             | %     |       |        |
| <b>Poultry training</b>                    |                          |      |                        |       |               |       |       |        |
| Yes  | 2                        | 5.56 | 8                      | 22.22 | 20            | 55.55 | 30    | 83.33  |
| No   | 0                        | 0.00 | 4                      | 11.11 | 2             | 5.56  | 6     | 16.67  |
| Total                                      | 2                        | 5.56 | 12                     | 33.33 | 22            | 61.11 | 36    | 100.00 |
| <b>Livestock waste management training</b> |                          |      |                        |       |               |       |       |        |
| Yes  | 0                        | 0.00 | 6                      | 16.67 | 2             | 5.56  | 8     | 22.22  |
| No   | 2                        | 5.56 | 6                      | 16.67 | 20            | 55.55 | 28    | 77.78  |
| Total                                      | 2                        | 5.56 | 12                     | 33.33 | 22            | 61.11 | 36    | 100.00 |
| <b>Registration of complaints</b>          |                          |      |                        |       |               |       |       |        |
| Yes  | 0                        | 0.00 | 0                      | 0.00  | 0             | 0.00  | 0     | 0.00   |
| No   | 2                        | 5.56 | 12                     | 33.33 | 22            | 61.11 | 36    | 100.00 |
| Total                                      | 2                        | 5.56 | 12                     | 33.33 | 22            | 61.11 | 36    | 100.00 |

NB: n = number of actors in relation to the practice considered; N = number of actors compared to the total number of actors considered.

Poultry processing industries generate a significant amount of feathers as residues estimated at millions of tons per year and having a powerful impact on the environment (Anitha & Palanivelu, 2012). Problems related to the management of poultry feathers in living environments pose a major concern for the environment. This situation is due to the lack of awareness, the insufficiency of financial resources, the bad policy of the managers of the structures of the poultry sector who do not take into account environmental concerns in their budgets. The efficient management of poultry waste, as in the case of other types of waste, is thus a major problem and the industrial recovery of this waste remains insufficient. Poultry feathers, rich in proteins, the main one being keratin, are not the rest, although they could be a source of this protein, the applications of which are multiple (Coward-Kelly *et al.*, 2006; Rai *et al.*, 2009; Bose *et al.*, 2014; Tamreihao *et al.*, 2019). It is therefore necessary to identify the actors for a contribution to the valorization of these feathers which represent approximately five percent of the body weight of chickens (Fagbemi *et al.*, 2020). The survey conducted in this study showed a predominance (100%) of male actors with 52.8% employees and 47.2% owners. This male predominance shows that men are more interested in the poultry sector than women (Guézodjè & Amen, 2020) concomitantly with mores in developing countries which assign most professional responsibilities to men. The age group of 30 to 39 years was the most represented with a significant proportion of 88.9% for holders of university degrees. This confirms that the activities of the poultry sector are the prerogative of working people. In addition, the higher level of education and the fact that 83.3% of the actors have training in poultry farming, constitute an asset in a perspective of awareness raising/training on the management and valorization of poultry feathers. Although poultry farming is a secondary activity for many, the majority, i.e. 38.9%, declared that they practice poultry farming as their main function, with a professional experience of

The choice of modern chickens is explained by the mastery of this type of breeding through training. Food, accessibility on the market being controlled, with a significant share of GDP (Chatellier *et al.*, 2015). The temperature between 60 – 100°C heats the water and facilitates plucking during slaughter without removing the meat from the poultry. This practice observed in the prospected slaughter units remains an advantage in the perspective of recovery of this type of waste. According to the types of waste produced and stored, 88.9% of structures store droppings, 16.7% blood, 27.8% feathers, 27.8% viscera and 44.4% leftover food. The high proportion of storage of droppings and food remains is justified by their use in plant speculations for soil amendment and by their incorporation in composting. However, their storage is a source of foul odors that degrade air quality (Lekefack, 2015). Blood and viscera representing a significant proportion of the body weight of the bird (FAO, 1996), even if they constitute waste from the poultry industry with risks of pollution and infestation of flies and other disease vectors (Ajogi *et al.*, 2005), still remain easily biodegradable waste. This is not the case with feathers, whose biodegradability is slow (5 to 10 years), justifying their difficult management for the poultry sector (Tsfaye *et al.*, 2018). Their storage without use then becomes a problem in poultry farming systems where these feathers are either thrown on dumps or simply incinerated. This difficulty in the management of poultry feathers explains the low storage observed through this study. Even the valorization in composting remains very weak with only one structure on all the localities prospected and this, in spite of the high level of study of the actors. Chicken meat is one of the major sources of animal protein mostly consumed around the world. At the same time, its contribution has resulted in the creation of a substantial number of feather waste by-products (Tsfaye *et al.*, 2017; Tsfaye *et al.*, 2018) that end up in landfills, creating environmental issues (Chinta *et al.*, 2013).

However, they are renewable resources that are very rich in keratin, a type of rigid and fibrous protein (Gupta *et al.*, 2011; Sharma & Gupta, 2016) with multiple applications. This study has shown that all the actors in the poultry industry surveyed have little knowledge of the management and use of these feathers. The efficient management and valorization of poultry feathers in Togo therefore remains a challenge to be met. This recovery requires a characterization of this waste in order to guide the actions to be taken.

## CONCLUSION

Poultry farming has experienced a very remarkable development in recent years, producing millions of tons of feathers as waste. The latter are mainly composed of very stable and resistant proteins, the main one being keratin. This keratin is important because of its multi-sectoral applications. Poultry feathers, which are an important source of this molecule, could be used in this way, while they still constitute a problem for players in the poultry sector. This study, which is a first in Togo, was intended to contribute to the enhancement of these feathers through their biochemical characterization and the study of their dissolution. The survey carried out in some structures of the poultry industry in the Maritime region showed that the actors have little knowledge of the management of the waste produced and poultry feathers constitute waste that cannot yet be recycled. A contribution to the efficient management and recovery of these feathers therefore remains a necessity in the interest of environmentally friendly production. A production of keratin based on poultry feathers would also be useful for the food, pharmaceutical and cosmetic industries.

### Author Contributions

Conceived and designed the experiments: TS, DAB and MM. Performed the investigation: DAB, TS, DKA, BDD, GS and MM. Analyzed the data: DAB, TS, DKA and MM. Contributed materials/analysis tools: TS and TG. Wrote the paper: DAB, TS, DKA, BDD and MM.

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## REFERENCES

- Ajogi I., Okolocha EC., Luga II., Dzikwi AA., Egege SC., Umoh JU., Adesiyun AA., Aganga AO., Du-Sai DHM., Ezeifeka GO., Kwaga JKP., Lombin LH., Mosimabale FO. and Oni OO. 2005. A Manual for Clinics in Veterinary Public Health and Preventive Medicine. Prepared by the Department of Veterinary Public Health and Preventive Medicine, Ahmadu Bello University, Zaria S. Asekome & Co Zaria, 15-20.
- Anitha TS., Palanivelu P. 2012. Production and characterization of keratinolytic protease (s) from the fungus, *Aspergillus parasiticus*. *International Journal of Research in Biological Sciences*, 2(2): 87-93.
- Azabi M. 2020. Extraction et caractérisation de la kératine des plumes de volailles. Mémoire de Master de Chimie, Université de Saad Dahlab Blida 1 (Algérie); 105p.
- Bose A., Pathan S., Pathak K., Keharia H. 2014. Keratinolytic protease production by *Bacillus amyloliquefaciens* 6B using feather meal as substrate and application of feather hydrolysate as organic nitrogen input for agricultural soil. *Waste and biomass valorization*, 5(4): 595-605.
- Chatellier V., Magdelaine P., Trégaro Y. 2015. La compétitivité de la filière volaille de chair française : entre doutes et espoirs. *INRA Prod. Anim.*, 2015, 28 (5), 411-428.
- Chinta, S., Landage, S., Yadav, K. 2013. Application of chicken feathers in technical textiles. *International Journal of Innovative Research in Science, Engineering and Technology*, 2 : 1158–1165.
- Coward-Kelly G., Chang VS., Agbogbo FK., Holtzapple MT. 2006. Lime treatment of keratinous materials for the generation of highly digestible animal feed: Chicken feathers. *Bioresource technology*, 97(11): 1337-1343.
- Fagbemi OD., Sithole B., Tesfaye T. 2020. Optimization of keratin protein extraction from waste chicken feathers using hybrid pre-treatment techniques. *Sustainable Chemistry and Pharmacy*, 17 (2020) 100267.
- FAO. 1996. Bloodmeal: a review of its nutritional qualities for pigs, poultry and ruminant animals. AGRIS, Crawshaw R. (National Renderers Association Inc (NRA)). Available online at : <https://agris.fao.org/agris-search>. Consulted on November 10, 2022.
- Guézodjè R., Amen E. 2020. Togo : une nouvelle formule pour booster le secteur avicole/Accès à l'eau potable gage de développement économique en Afrique. Togo, Economie et Développement (Magazine), Economie. Available online at : <https://corporate.dw.com/fr/togo>. Consulted on July03, 2022.
- Gupta A., Kumar P., Bin MYR., Binti KN. 2011. Extraction of keratin protein from chicken feather. In: *Chemeca 2011: Engineering a Better World*. Sydney Hilton Hotel, NSW, Australia, p. 2200, 18-21 ; September 2011.
- Huart A. 2004. La production de la volaille dans le monde et en Afrique. *ECO-CONGO Agriculture*, F-EP-A5-16 : 1-3.
- Lekefack JP. 2015. Evaluation de la gestion des fientes de poules pondeuses: cas de la grande ferme du GIC AECAM de MENDONG. Mémoire de Master Professionnel en Sciences de l'Environnement, Option : Assainissement et restauration de l'environnement ; Université de Yaoundé 1 (Cameroun), 65p.
- Li Q. 2019. Progress in Microbial Degradation of Feather Waste. *Frontiers in Microbiology*, 10: 1-15.
- Purandaradas A., Silambarasan T., Murugan K., Babujanathanam R., Arumugam DG., Kayal VD., Anbumani D., Kavitha P. 2018. Development and quantification of biodiesel production from chicken feather meal as a cost-effective feedstock by using green technology. *Biochemistry and Biophysics Reports*, 14: 133-139.
- Rai SK., Konwarh R., Mukherjee AK. 2009. Purification, characterization and biotechnological application of an alkaline  $\beta$ -keratinase produced by *Bacillus subtilis* RM-01 in solid-state fermentation using chicken-feather as substrate. *Biochemical Engineering Journal*, 45(3): 218-225.
- Sharma S., Gupta A. 2016. Sustainable management of keratin waste biomass: applications and future perspectives. *Braz. Arch. Biol. Technol.* 59.
- Tamreihao K., Mukherjee S., Khunjamayum R., Devi LJ., Asem RS., Ningthoujam DS. 2019. Feather degradation by keratinolytic bacteria and biofertilizing potential for sustainable agricultural production ». *Journal of basic microbiology*, 59(1): 4-13.
- Tesfaye T., Sithole B., Ramjugernath D. 2017. Valorisation of chicken feathers: a review on recycling and recovery route—current status and future prospects. *Clean Technologies and Environmental Policy*. 19(10): 2363-2378.
- Tesfaye T., Sithole B., Ramjugernath D. 2018. Valorisation of waste chicken feathers: Optimisation of decontamination and pre-treatment with bleaching agents using response surface methodology. *Sustainable Chemistry and Pharmacy*, 8: 21-37.
- Vineis C., Varesano A., Varchi G. and Aluigi A. 2019. Extraction and characterization of keratin from different biomasses ; In : *Keratin as a protein biopolymer*, Springer Series on Polymer and Composite Materials, Sharma S. and Kumar A. (eds), Springer Nature Switzerland AG, pp 35 – 76.

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