Scholars Journal of Agriculture and Veterinary Sciences

OPEN ACCESS

Abbreviated Key Title: Sch J Agric Vet Sci
ISSN 2348–8883 (Print) | ISSN 2348–1854 (Online)
Journal homepage: https://saspublishers.com

Green Kitchen Waste: A Feed Resource for Urban and Peri-Urban Livestock

Fanta Coulibaly[1], Alassane Ba[2], Sory Sissoko[1], Mounéri Maïga[1], Abdoul Kader Koné[2], Doubangolo Coulibaly[3], Mamadou Oumar Diawara[1*], Hawa Salif Diakité[4]

[1]Département de Biologie, Faculté des Sciences et Techniques (FST), Université des Sciences, des Techniques et des Technologies de Bamako (USTT-B), Colline de Badalabougou, B.P. 3206 Bamako, Mali
[2]Institut d'Economie Rurale (IER), Centre Régional de Recherche Agronomique de Sikasso (CRRA), Programme Bovin, BP. 16 Sikasso, Mali
[3]Institut d'Economie Rurale, Centre Régional de Recherche Agronomique de Sotuba, Programme Bovin/Camelin, BP: 262, Bamako, Mali
[4]Institut d'Economie Rurale (IER), Centre Régional de Recherche Agronomique de Sotuba (CRRA), Laboratoire Sol – Eau – Plante, Unité Système d'Information Géographique et Télédétection, B.P. 262 Bamako, Mali

DOI: 10.36347/sjavs.2022.v09i09.002 | **Received:** 11.08.2022 | **Accepted:** 04.09.2022 | **Published:** 10.09.2022

***Corresponding author:** Mamadou Oumar Diawara
Département de Biologie, Faculté des Sciences et Techniques (FST), Université des Sciences, des Techniques et des Technologies de Bamako (USTT-B), Colline de Badalabougou, B.P. 3206 Bamako, Mali

Abstract **Original Research Article**

In Sub-Saharan Africa, the amount of household waste is expected to increase due to population growth and rapid urbanization. In addition to their impact on human and animal health, it has been proven that these wastes strongly contribute to global warming. Their management is nowadays a major concern in cities and countryside. The study was carried out to evaluate the prospects for the valorization of green kitchen waste in animal feed. A system for separating green kitchen waste from other household waste was set up in about thirty households in the commune V of Bamako. After the installation of the trash cans, weekly visits were made to the households to characterize the contents of the trash cans before weighing them. The results show a strong variability in the production of green kitchen waste according to the socio-professional category of the household head. The weekly production of this waste is between 0.46 and 1.90 kg for households of 2 to 16 people. The bromatological analysis carried out on a mixed sample shows that they constitute a potential feed resource for urban and peri-urban livestock with feed values that are between those of forage and oilcake. The valorization of these sub-products in livestock feed could contribute to the sanitation of our neighborhoods but also to the reduction of methane emissions in municipal dump sites.

Keywords: household waste, valorization, animal feed, urban livestock farms, Mali.

INTRODUCTION

Household waste generation has increased rapidly in recent decades in Sub-Saharan Africa due to population growth (Tabutin & Schoumaker, 2020), rapid urbanization (Jaglin *et al.*, 2018), and economic activity (OECD, 2020). According to the World Bank, 80% of future economic growth will take place in cities and urban agglomerations. Over the past three decades, the population of Bamako has grown from 746,000 in 1990 to 2,618,000 in 2020 (DNSI, 2021). This growth has resulted in a significant increase in the level of household solid waste generation. Estimated at 310,650 tons in 2004 for the city of Bamako, household solid waste production increased to 377,775 tons in 2011 (Mairie du District de Bamako, 2012).

In addition to their impacts on human (Bagalwa *et al*., 2013) and animal health, this waste has been shown to be a major contributor to global warming through methane production (Hogg & Ballinger, 2015). Their management is nowadays a major concern in cities and towns with a particular focus on cities due to a deficit of storage, transport and recycling infrastructure (Gourdon *et al.*, 2012).

Urban and peri-urban livestock farms face many challenges, including feed constraints due to high pressure on rangeland and difficulties in accessing feed supplements (Ali *et al.*, 2003). This breeding should also face the ever-increasing demand for animal products which, according to the FAO (2006), should double in the southern countries. The valorization of (green kitchen waste) fruit and vegetable peelings in animal feed could contribute to improve the zootechnical performance of these and reduce the cost of bio-waste treatment (Truong *et al.*, 2019; Dou *et al.*, 2018; CIRAD, 2009).

In Mali, horticultural production is estimated at over 200,000 tons per year, representing a turnover of nearly 50 billion CFA. The major horticultural production areas are: the Sikasso region, the Office du Niger zone and the Bamako region (Thiam *et al.*, 2001).

Waste sorting and recycling of household waste in general and green kitchen waste in particular have been the subject of very few studies in Sub-Saharan Africa, despite the contribution of this type of waste in the constitution of domestic waste, which is 47% according to Edjabou *et al.*, (2016). This study aims to evaluate the potential of green kitchen waste valorization in animal feed.

METHODOLOGY

Study Area

The data used in this study were collected from 30 households in commune V of the city of Bamako. Located on the right bank of the Niger River (Fig. 1), the population of the commune is estimated at 415,000 inhabitants (DNSI, 2009) for a total area of 41 km². The Commune, like the whole city of Bamako, is characterized by dry season from November to April and a rainy season from May to October. Its average annual rainfall is 1100mm. The average annual temperature is 27.7°C with extremes of 34.7°C and 21°C.

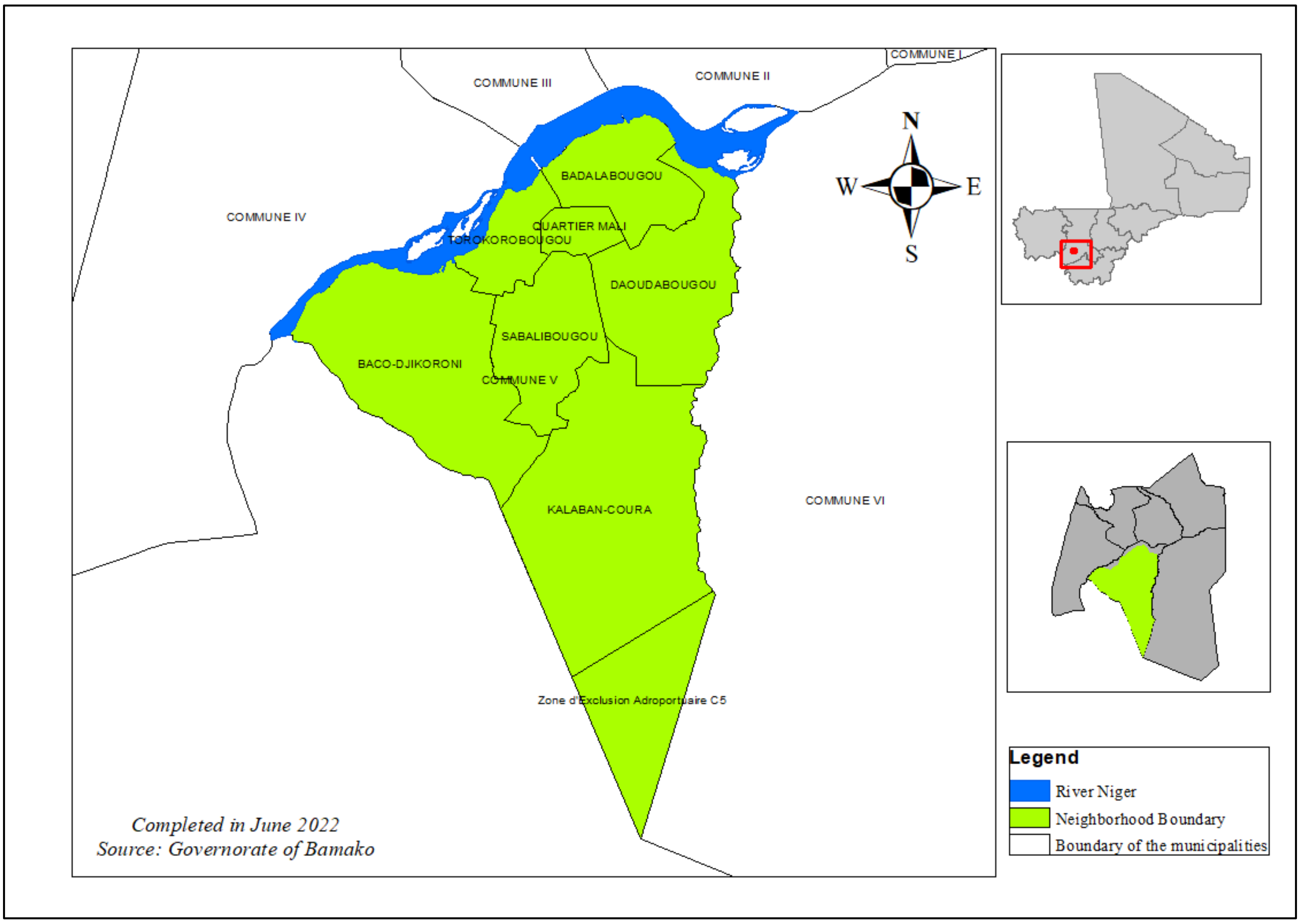

Figure 1: Location of the study area

Quantification of green kitchen waste

The system for quantifying green kitchen waste is based on the installation of about 30 green trash cans in a sample of households in commune V of the city of Bamako. These households were chosen to take into account the socio-professional diversity of their heads. The installation of the trash cans was preceded by an interview with the head of the household and his wife. The purpose of these interviews was first to explain the objective of the study and the requirement to separate green kitchen waste from other household waste, and secondly to determine them of the rate of recovery of green kitchen waste in their household before the beginning of the study. After the installation of the trash cans, weekly visits were made from February 21 to March 28, 2021 to the 30 households to characterize the contents of the trash cans (the fruits and vegetables in it) after weighing.

Characterization of the trash cans contents

After the first weighing to determine the fresh weight of the household's weekly green kitchen waste production, the contents of each trash can are spread out on a tarp before proceeding to identify the different fruits and vegetables in it (Fig 2).

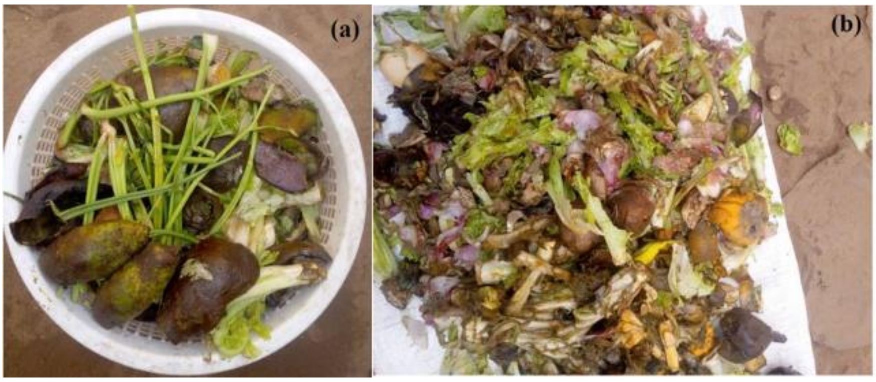

Figure 2: Illustration of the contents of a 'green trash can' before (a) and after weighing (b)

These fractions are then classified into three main categories: skins, peelings and leaves. The dry weight of each category is then determined after a few days of sun drying.

Bromatological analysis

After each observation, the contents of the green trash can are dispose into the 'big trash can'. To assess the potential of these fruit and vegetable peelings in animal feed, the contents of some randomly selected green trash cans were sun-dried for 10 days before being sent to the laboratory for bromatological analysis. These analyses were carried out at the animal nutrition laboratory of the Institute of Rural Economy (IER) in Sotuba (http://www.ier.ml/). The main biochemical methods of analysis of the sample reported in Sidibé *et al.*, (2020) consisted in the determination of:

Dry matter

The principle consists in eliminating the moisture contained in the sample (2g) by heating in an oven at 105°C for 2 hours. The results obtained were expressed as a percentage of dry matter.

Ashes

The sample was incinerated at 550°C for 6 hours in a muffle furnace. The residue was weighed and the difference in weight gives the ash content.

Raw Cellulose

The sample is treated successively by boiling solutions of sulfuric acid and sodium hydroxide of determined concentrations. The residue is then separated by filtration on washed sand, dried and calcined at 700°C. The weight loss resulting from calcination corresponds to the raw cellulose of the test sample.

Protein

The determination of nitrogen, required a mineralization, which consists of transforming the organic substances into mineral substances (0,3g). This mineralization is done in the presence of sulfuric acid and hydrogen peroxide. Dosing is performed with the Micro Kjedahl. The nitrogen contained in the sample was recovered in a boric acid solution, then titrated with a potassium bi iodate solution. The nitrogen content is obtained by multiplying the nitrogen content by 6.25.

Lipids

The lipid is extracted with a volatile solvent (petroleum ether, acetone, etc.) using the Soxhlet apparatus, then recovered in a flask whose weight is previously known. The difference in weight gives the lipid content.

Raw energy

The determination of the raw energy contained in the sample was done by calorimetry. The process consists of exploding the sample placed in a crucible (0.100 to 0.180 g) in the bomb calorimeter. This was done in the presence of oxygen and support to a wire and an ignition wick that are attached to the electrodes. The heat produced is converted into energy, which corresponds to the calorific value of the sample.

Minerals

Calcium, phosphorus, sodium and potassium are determined by flame photometry. As for phosphorus, it is determined by spectrophotometry. The process consists of mineralizing the samples first and preparing daughter solutions of different concentrations from the mother solutions of the minerals to be determined. The samples are then read for calcium, phosphorus, sodium and potassium.

Data Analysis

The moisture content of the samples was determined after 10 days of sun drying. Its calculation is based on this empirical formula:

$$w = \frac{(m_h - m_s)}{m_s} * 100$$

Where w: expression of the water content in %; m_h: mass of the wet sample and m_s: mass of the dry sample. To establish a relationship between household size and the amount of green kitchen waste generated per week, a linear regression was performed using R (RCRAN https://cran.r-project.org/Card).

RESULTS AND DISCUSSION

Valorization rate of green kitchen waste in surveyed households

Household surveys show that in 60% of these, green kitchen waste is not separated from other solid waste and is forwarded to municipal landfills. At the contrary, 40% of respondents said they separate fruit and vegetable peelings from other household waste. In 27% of households, they are given to herders. In the other households, respondents report drying them in the sun for a few days before distributing them as feed to sheep (10% of households) and cows (3% of households). The low valorization of green kitchen waste in the study sample households is not exceptional in sub-Saharan Africa (Gbinlo, 2010).

Weekly production of green kitchen waste

Weekly production of green kitchen waste varies with the education level of the household head (Fig 3). The Kruskal-Wallis test shows a significant difference at the 5% threshold between the weekly production of green kitchen waste (p-value = 0.005).

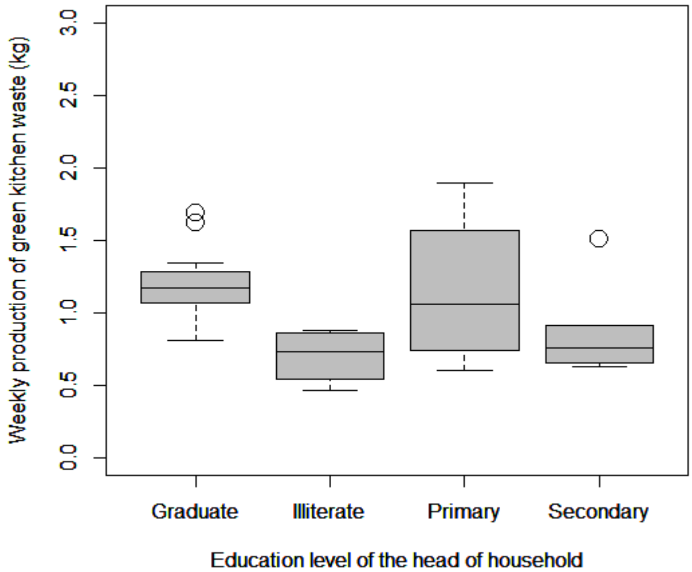

Figure 3: Variation in weekly production of green kitchen waste according to the level of education of the head of household

The amount of green kitchen waste produced was higher and very heterogeneous in households whose heads have completed primary education and to a lesser extent in households in whose heads have tertiary education. In households where the heads had no formal education the weekly amount of green waste produced was comparatively low. Households whose heads have reached secondary school level had low weekly production of green kitchen waste with very strong disparities between households. These results are consistent with those of Decq *et al*. (1991) who noted a significant difference between the production and composition of household waste in neighborhoods of different standards of living in Dakar but also in Ouagadougou.

Composition of green kitchen waste

The total composition of green kitchen waste is 14 vegetables and 7 fruits (Table 1).

Table 1: Frequency of observation of the different categories constituting green kitchen waste (GKW)

N°	Category	Type	Frequency of observation in % (n=180)
1	Onion peelings	V	100
2	Garlic peelings	V	100
3	Potato peelings	V	79,44
4	Tomato peels	V	62,22
5	Plantain peels	V	31,11

N°	Category	Type	Frequency of observation in % (n=180)
6	Lettuce leaves	V	39,44
7	Cucumber peelings	V	21,11
8	Carrot peelings	V	22,78
9	Avocado peels	F	45,56
10	Cabbage leaves	V	55,00
11	Banana peels	F	23,33
12	Orange peels	F	39,44
13	Mango skins	F	40,00
14	Eggplant peelings	V	5,56
15	Pumpkin peelings	V	10,00
16	Celery stalks	V	77,78
17	Papaya peelings	F	4,44
18	Potato peelings	V	7,78
19	Yam peelings	V	1,11
20	Pineapple peelings	F	1,11
21	Melon peelings	F	1,11

Legend: V= Vegetable; F= Fruit

It varies greatly from one household to another (52% during the observation period). Overall, the most observed categories for vegetables are onion peels (100%), garlic peels (100%) and potato peels (79.44%). Conversely, yam peelings and eggplant peelings are not very present in the trash can of the study sample, respectively 1.11 and 5.56%. For fruits, the most frequent categories are avocado (45.56%), orange (39.44%) and banana (23.33%) peels. These results are in agreement with those of Smale *et al*., (2019) who found that the weekly average of fruit and vegetable consumption by urban households in Mali was 5 and 3 days respectively. Expressed as a percentage of dry matter, the three main categories retained in this study represent 33, 50 and 17% for skins, peelings and leaves respectively (Fig 4). In a characterization study of household solid waste in another neighborhood of Bamako, Bah *et al*., (2021) estimated the contribution of fruit and vegetable waste to 0.80 percent of total household waste weight.

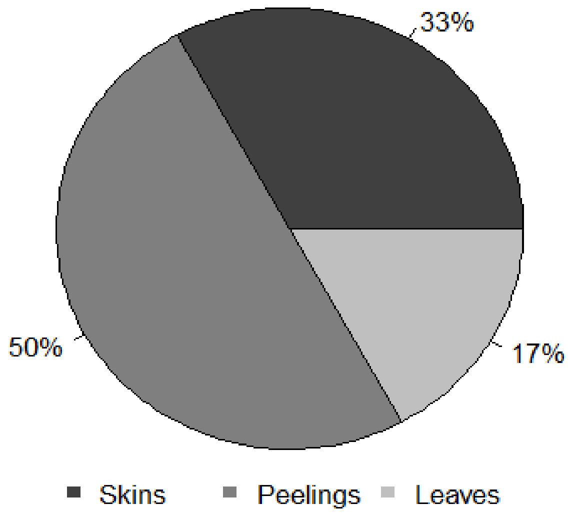

Figure 4: Proportion expressed in % of the dry mass of the 3 main categories

Relationship between weekly green kitchen waste generation and household size

The number of people in the study sample households ranged from 2 to 16 with a weekly production of green kitchen waste ranging from 0.46 to 1.90kg of dry matter. Regression between the two variables shows that household size explains 19% of the variation in weekly green kitchen waste generation (Fig 5).

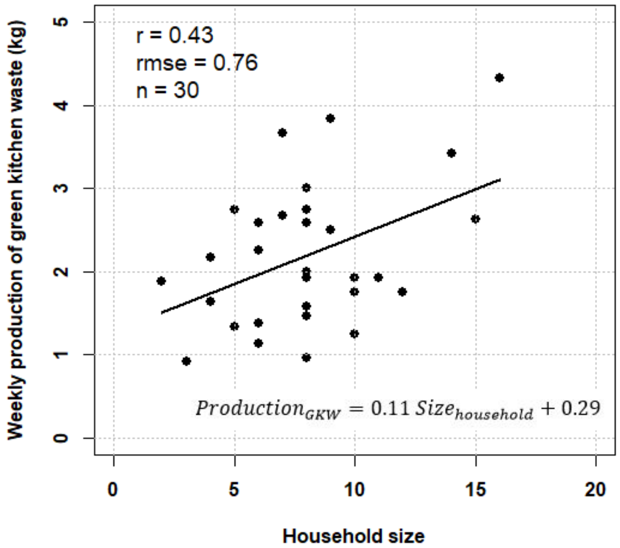

Figure 5: Relationship between weekly green kitchen waste generation and household size

A detailed analysis of the dispersion of the observations with respect to the regression line shows that the relationship is better for smaller families. The correlation coefficient r=0.43 shows that the relationship between these two variables is not direct. It could be affected by the income level of the head of the household, the dietary habits which in Mali are strongly sociological (Roy, 2010), but also by the relatively small number of households surveyed. The fact that the survey does not cover a calendar year may also contribute to a bias in this result especially since both fruit and vegetable production are seasonal (Smale *et al*., 2019).

Variation in the water content of green kitchen waste

The temporal variation in water content of green kitchen waste is presented in Fig. 6.

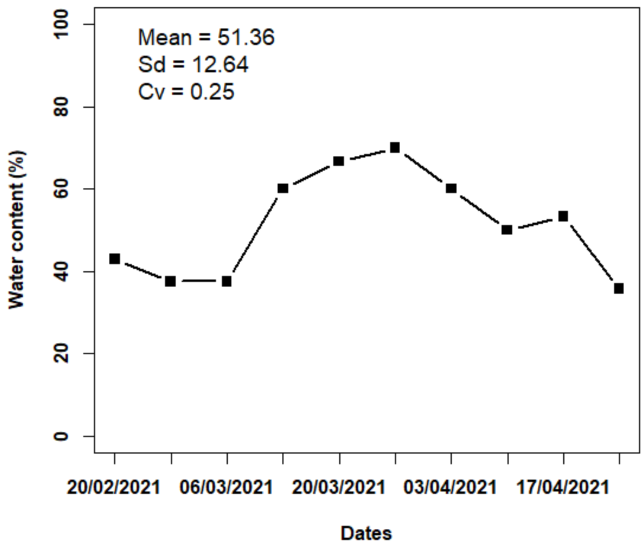

Figure 6: Temporal variation of water content in green kitchen waste

The analysis shows that green kitchen waste is rich in water, 51.36% on average over the period considered (February 20 and April 24, 2021) with a weekly variation of 25%. This moisture content can be explained by the fact that this waste consists mainly of peelings and skins. The maximum water content occurs between the end of March and mid-April, a period that corresponds to the abundance of certain fruits and vegetables (mangoes, avocados, etc.) on the shelves in Bamako.

Chemical composition of green kitchen waste compared to other food types

The chemical composition of a green kitchen waste sample compared to three other feed types is presented in Fig 7.

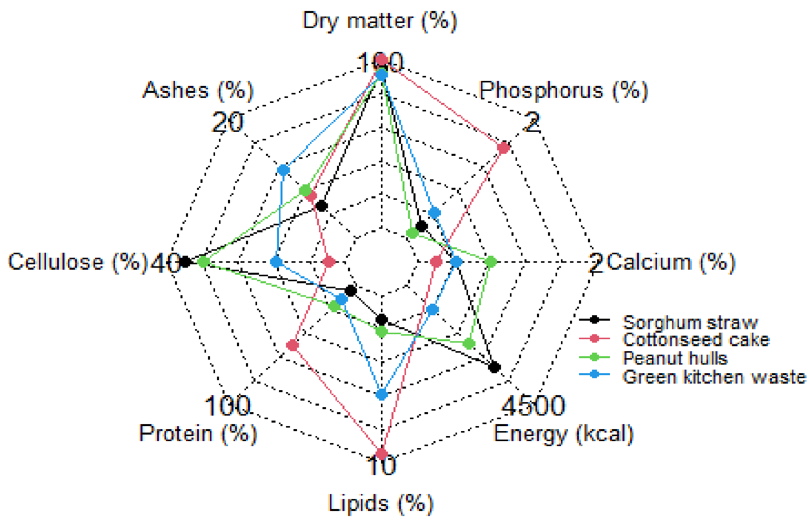

Figure 7: Chemical composition of green kitchen waste compared to other feed

At 91.3%, green kitchen waste has a lower dry matter content than cottonseed cake, 100% according to Branckaert *et al*., (1968) and close to that of peanut hulls and sorghum straw respectively 92.5% (Nantoumé *et al.*, 2018) and 95.35% (Sidibé *et al.*, 2020). The protein content of the sample (11.69%) is also lower than that of cottonseed cake (50%) reported by Branckaert *et al*., (1968) and groundnut haulm (17.09%) reported by Nantoumé *et al*., (2018), but far higher than that found by Sidibé *et al*., (2020) for sorghum straw (4.38%). Conversely, calcium levels are higher than or equal to those of sorghum straw and cottonseed cake. Green kitchen waste is also richer in phosphorus than peanut hulls and sorghum straw. However, the ash content of our sample (11.48%) is higher than that of the other three feeds (6.91% on average). This may be due to inorganic contaminants (sand or other dirt). However, it is not exceptional for forages. Nantoumé *et al*., (2018) report an ash content of 16.5% for a woody forage (*Ficus gnaphalocarpa*). Much higher ash contents (18.9%) were reported by Shenkute *et al*., (2012) for the same species.

CONCLUSION AND RECOMMENDATIONS

The objective of the study was to evaluate the potential of green kitchen waste valorization in animal feed. The chemical composition of these wastes shows that they can constitute an additional source of feed that could contribute to the securing of urban and peri-urban livestock farms, particularly those of ruminants. Additional tests are however necessary to estimate the disgestibility and determine the type of distribution, the preservation method but also the effects of the incorporation of this type of feed on the zootechical performances of the animals. Analyses of the bacteriological and fungal quality of the feed are also necessary to evaluate the risks of toxicity. Green kitchen waste is an significant portion of household waste, and its recycling will help reduce the cost of municipal waste management and clean up neighborhoods in West African metropolises.

REFERENCES

- Ali, L., Van Den Bossche, P., & Thys, E. (2003). Enjeux et contraintes de l'élevage urbain et périurbain des petits ruminants à Maradi au Niger: quel avenir?. *Rev Elev Med Vet Pays Trop*, 56, 73. https://doi.org/10.19182/remvt.9879
- Bagalwa, M., Karume, K., Mushagalusa, N., Ndegeyi, K., Birali, M., Zirirane, N., ... & Bayongwa, C. (2013). Risques potentiels des déchets domestiques sur la santédes populations en milieu rural: cas d'Irhambi Katana (Sud-Kivu, République Démocratique du Congo). *VertigO: la revue électronique en sciences de l'environnement*, *13*(2).
- Bah, O., Sanogo, B., & Traoré, M. (2021). Caractérisation des déchets solides ménagers de Faladié. *European Scientific Journal, ESJ*, 17(39), 77. https://doi.org/10.19044/esj.2021.v17n39p77
- Branckaert, R., Favier, J. C., & Vallerand, F. (1968). Utilisation du tourteau de coton dans l'alimentation animale. *Zootechnia*, 17(1), 42–50. https://core.ac.uk/download/pdf/39889494.pdf
- CIRAD. (2009). Drêche ensilée, tourteau de palmiste et coques de cacao Digestibilité comparée des rations contenant de la drêche ensilée des brasseries, du tourteau de palmiste ou des coques de cacao chez le porc en croissance finition au Cameroun déterminer la digestibilité des rations contenant des taux croissants de la drêche ensilée des brasseries, du tourteau de palmiste et des coques de cacao chez le porc en croissance finition. http://pigtrop.cirad.fr
- Decq, P., Hiot, B., & Oberdoref, M. (1991). Étude des impacts de la décharge de M'Beubeuss sur l'environnement. Plan d'assainissement et de gestion écologique du site, Pathe Balde, Dakar, 155 p.

- DNSI. (2021). Rapport sur les mouvements de populations. Direction Nationale de la Statistique et de l'Informatique.
- DNSI. (2009). Recensement général de la population et de l'habitat. Direction Nationale de la Statistique et de l'Informatique. Rapport général. 35p. https://nada.web.ined.fr/index.php
- Dou, Z., Toth, J. D., & Westendorf, M. L. (2018). Food waste for livestock feeding: Feasibility, safety, and sustainability implications. *Global Food Security* 17, 154–161. https://doi.org/10.1016/j.gfs.2017.12.003
- FAO. (2006). World Agriculture: towards 2030/2°50 Interim report Porspects for food, nutrition, agriculture and major commodity groups. Global perspectives Studies. Unit Food and Agriculture Organisation of the United Nations Rome, 78p.
- Gourdon, R., Djeutcheu, K. B., Naquin, P., Zahrani, F., & Ngnikam, E. (2012). Evaluation des impacts environnementaux d'un centre de stockage de déchets ménagers en activité sur la base de la caractérisation des flux de matière entrants et sortants : Application au site de Nkolfoulou, Yaoundé, Cameroun. Environnement, Ingénierie & Développement.
- Hogg, D., & Ballinger, A. (2015). La contribution potentielle de la gestion des déchets à une économie bas carbone. Rapport principal, unomia.
- Jaglin, S., Didier, S., & Dubresson, A. (2018). Métropolisations en Afrique subsaharienne : au menu ou à la carte ? *Metropoles*.
- Nantoumé, H., Cissé, S., Sow, P. S., Sidibé, S., Kouriba, A., Olivier, A., Bonneville, J., & Cinq-Mars, D. (2018). Impact de ration comportant des fourrages de Pterocarpus lucens, Pterocarpus erinaceus et Ficus gnaphalocarpa sur l'embouche ovine au Mali. *Tropicultura,* 36, 673-683.
- OCDE. (2020). Dynamiques de l'urbanisation africaine: Africapolis, une nouvelle géographie urbaine.
- Roy, B. (2010). Enquête du sens politique du diabète de type 2 au Mali. Sciences sociales et santé 2010/4 (Vol. 28), pages 77 à 87. https://www.cairn.info/load_pdf.php?ID_ARTICLE=SSS_284_0077&download=1
- Shenkute, B., Hassen, A., Assafa, T., Amen, N., & Ebro, A. (2012). Identification and nutritive value of potential fodder trees and shrubs in the mid rift valley of Ethiopia. *J. Anim. Plant Scie*, 22, 1126-1132.
- Sidibé, S., Tangara, M., Cissé, S.M., Dembélé, B., Traoré, S., Diankha, R., Maïga, A. M., & Nantoumé, H. (2020). Détermination de la valeur alimentaire de la paille de sorgho à double usage à partir de sa composition chimique. Symposium Malien sur les Sciences Appliquées (MSAS), 11ème Conférence, 21-23 Décembre 2020.
- Smale, M., Thériault, V., & Vroegindewey, R. (2019). Régimes alimentaires au Mali: implications pour la politique nutritionnelle. Document de recherche 148f.
- Tabutin, D., & Schoumaker, B. (2020). La démographie de l'Afrique subsaharienne au XXIe siècle. *Population,* 75, 169–295.
- Thiam, A. M., Fofana, M., & Sidibé, A. (2001). Etude de la capitalisation de l'information sur la filière fruits et légumes. Rapport technique, 39p. http://hubrural.org/IMG/pdf/mali_rapport_capitalisation_hoticulture.pdf
- Truong, L., Morash, D., Liu, Y., & King, A. (2019). Food waste in animal feed with a focus on use for broilers. *Int J Recycl Org Waste Agricult,* 8, 417–429.