



Research Article

Volume 29 Issue 1 - February 2025

DOI: 10.19080/ARTOAJ.2024.29.556435

Agri Res & Tech: Open Access J

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Banana Peels as an Alternative Livestock Nutritional Source: Chemical Composition and Meta-analysis

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Submission: January 16, 2025; **Published:** February 05, 2025

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Simple Summary

The awareness that much attention from research in the field of animal nutrition is directed to the identification of alternative protein sources, the need to find solutions to the growing demands of the circular economy and the idea of providing data suitable for implementing the meta-analytic calculation basis by artificial intelligence, have led the author to analyze the chemical composition of banana peels, an industrial and domestic waste. The chemical composition is such as to consider possible use in the zootechnical field, especially for the protein component whose amino acid content does not show absences in terms of essential components. It is desirable that the content of other chemical compounds, such as vitamins, minerals and any antinutritional factors, is explored with further research and that through “in vivo” tests it is possible to better define strengths and critical points for the different livestock species.

Abstract

In the context of the search for alternative protein sources, especially in the field of animal nutrition, several studies have been conducted on the use of banana peels, highlighting their chemical-bromatological characteristics, the multiple versatility of use and the correspondence to the request for compliance with the principles of the circular economy to be applied to the most varied production sectors. With the aim of providing further data to add to what is currently provided by the specific literature for the implementation of the meta-analytic calculation base, in this note, the “raw” chemical composition of banana peels is analyzed with the aim of providing further data and confirmations to add to what the specific literature provides us to date. The results obtained indicate a moisture content of 10%, protein of 6%, fat of 3.5%, carbohydrates of 54%, ash of 9%, fiber of 13% (on dry matter basis). The amino acid analysis highlights the presence of all essential amino acids with a prevalence of lysine (7.28%), isoleucine (6.90%), leucine (5.94%) and threonine (5.87%). The data obtained are on average similar to what has already been found in literature. In light of the results, banana peels show a protein content that is not high but of good quality in terms of essential amino acids; the carbohydrate content is high and the amount of crude fiber is useful for the nutrition of monogastric animals with a dietary function.

Keywords: Banana peels; Chemical composition; Protein and aminoacids; Circular economy, Meta-analysis

Introduction

In the field of human nutrition and livestock, the need to address the lack of protein ingredients linked to both territoriality and growing demand, pushes research to focus attention on alternative protein sources, both vegetal and animal. In fact, much research has been devoted to understanding the chemical-bromatological characteristics of agro-industrial by-products and food waste. Furthermore, for many years now, there has been an increasing need to organize production processes in compliance with the principles of the circular economy, attentive to the

reduction of waste of natural resources and consisting of sharing, reusing, repairing and recycling of waste materials and products.

Banana peels (*Musa spp*) deserve the attention of researchers because, given their chemical-bromatological characteristics, they are well suited to be used in various ways in the human and livestock fields and to satisfy the statements of the circular economy [1,2]. The production of banana peels by the food industry is considerable, as is the related disposal of waste material, which has become a cause for concern. However, recent studies have shown that banana peel is a rich food source of biologically active

compounds that can be transformed into valuable products [1-3].

It is difficult to know exactly how much bananas are produced in the world, since they are grown in about 150 different countries. According to 2012 data, approximately 106,710,000 tons of bananas were harvested [4], equal to 18.2% of the total fruit production worldwide [5]. India is the world's largest producer with 17.3% of total production [6]. The production of bananas produced in the European Union and marketed in the respective production area, from January to December 2023, was 53,931 tons for Spain, 6,613 tons for France and 1,035 tons for Greece. The total production forecast for 2023 was 661,487 tons [7]. The banana plant is used primarily for its fruit, which are widely consumed and used in various food processing applications, including the production of jam, chips, dried pulp, and alcoholic beverages such as beer or wine [8].

Both this widespread use of bananas in food industries and household consumption lead to a significant amount of waste in the form of banana peels, leaves, pseudostems and stems. Banana peels alone constitute 30-40% [6,9,10] of a fresh banana fruit, which poses a major challenge for safe solid waste disposal [9]. To facilitate its disposal, banana peel can be used for various industrial productions including the production of biofuels, biosorbents, pulp and paper, cosmetics, energy-related activities, organic fertilizers, environmental cleaning and biotechnology-related processes [11].

About 30-40% of the total banana production is discarded because it does not meet quality standards and is potentially available for livestock feed [12]. Banana peel is a valuable nutritional source for animal feed; banana peels are known to contain a significant amount of proteins, lipids, carbohydrates, fibers and a number of essential minerals such as potassium, sodium, calcium, iron and manganese [13]. They are rich in polyunsaturated fatty acids such as linoleic acid (Omega-6) and α -linolenic acid (Omega-3), which represent over 40% of total fatty acids [14,15].

The essential amino acids leucine and lysine are abundant in banana peels. Dietary consumption of leucine appears to have clear long-term health benefits, including a reduction in diet-induced weight gain, hyperglycemia, and hypercholesterolemia [16]. This characteristic appears to confer to particular lysine conjugates an anticarcinogenic power [17].

Heavy metals and antinutrients, such as tannins, are present in concentrations that fall within acceptable ranges. Tannins are the main antinutritional factors in bananas and are mainly contained in the peels. Ripening causes these tannins to migrate into the pulp or to be degraded by polyphenol oxidase and peroxidase [18]. Through microbial fermentation it is possible to improve the nutritional value of banana waste with an increase in protein and sugar content [19]. The nutritional value of banana peels fed to ruminants is estimated to be similar to that of cassava or citrus peels [20,18].

Wadhwa et al. (2015) suggest can replace up to 100% of corn with banana peels for small growing ruminants and in grass-fed Zebus, addition of 15-30% banana peels in the diet increased weight gain significantly without causing health problems or affecting palatability [6]. Dairy cows fed up to 21 kg of fresh ripe banana peels had increased milk production [21].

Replacing sorghum silage with banana peel up to 60% in the diet of lactating cows reduces the time spent feeding and improves the efficiency of feeding and dry matter rumination, maintaining the milk production of the cows [22]. In goats, dried peels of mature banana can completely replace corn kernels without adverse effects on animal growth and performance, and are an economical source of carbohydrates [23].

Like other banana products, banana peels can be an important staple food for pigs owned by smallholders in banana producing areas [24]. Dried ripe banana peels have been fed to growing pigs up to 20% of the dry matter (DM) diet without depressing growth, but higher inclusion rates caused poor growth [6,25]. Maximum inclusion rates of 7.5% and 10% dried banana peels have been suggested for broiler diets. In one experiment, dried banana peels as a replacement for corn kernels led to a significant decrease in weekly weight gain when included at more than 7.5% in the diet [26]. In another experiment, live weight gain and feed conversion efficiency were significantly higher in chickens fed up to 10% banana peel meal in the diet. Feed intake increased linearly with increasing peel levels up to 10%, after which growth decreased [27]. Wadhwa et al. (2015) suggest for broilers a replacement of 15% of the corn in the diet with [6].

According to Blandon et al. (2015) [28] the inclusion of banana peels in the diet of broiler chickens did not cause significant changes in performance but the increased replacement level of banana peels resulted in a reduction in the feed costs of the diets.

Dried banana peels could be replaced up to 18% as an alternative feed for laying hens, without detrimental effects on performance and egg quality characteristics [29].

Inclusion of 25% banana peel powder in corn-based feed ration ensures optimum weight gain and egg production in chickens [30].

Dried banana peels can be included at 20-30% DM in rabbit diets, particularly as a partial or total replacement for corn kernels [6,31]. Maturation may slightly improve their nutritional value [32]. Sun-dried mature banana peels could replace up to 75% of corn (27% DM diet) or 100% (36% DM diet) in weaned rabbit diets with positive economic returns, although total replacement depressed performance (digestibility, weight gain, feed conversion ratio, carcass quality) [31,33].

Inclusion rates above 30% may have detrimental effects on final weight gain, daily weight gain and feed conversion efficiency [32].

Aim of this work is to provide data on the simple chemical composition of banana peels useful for meta-analytical processing that can provide answers to the demand for alternative nutritional sources in the field of animal nutrition.

Materials and methods

Banana peels were analyzed in a suitably equipped analytical laboratory.

The chemical composition of the samples was determined using the standard analytical methods of the Association of Official Analytical Chemists [34]. The moisture content of the samples was determined by the method of drying in an oven at 105 °C to a constant weight. The crude protein of the samples was determined using the micro-Kjeldahl method. Crude lipids were determined by the Soxhlet extraction method using petroleum ether as the extraction solvent. The ash content was determined using a muffle furnace set at 5500 °C for 4 h to a constant weight. The crude

fiber was determined with Weende method. The carbohydrate content was obtained by difference using the following formula: Carbohydrate % = 100- (moisture % + protein % + ash % + fat % + crude fiber %).

Metabolizable energy (ME) was calculated according to the following mathematical formula (for poultry) of Lodhi et al. [35]:

$$\text{ME (kcal/kg)} = 370.29 + (24.47 \times \% \text{ crude protein}) + (65.77 \times \% \text{ ether extract}) + (44.07 \times \% \text{ available carbohydrate}) - (8.15 \times \% \text{ crude fiber}).$$

Amino acids were determined by the HPLC method.

Results and Discussion

Table 1 shows the results obtained from this investigation and the data available in the literature on the chemical composition of banana peels expressed as a percentage of dry matter.

Table 1: Chemical composition of Banana peel (% DM, $\pm$ SD*).

Parameters	Authors								Present data
	[36]	[37,15]	[38]	[39]	[40]	[41]	[42]	[6]	
Moisture	7.5			13.49	9.5				10.06 $\pm$ 0.3
Ash	6.7	9 11	12.45	9.83	8.9	11.1	12.1	11.1	9.05 $\pm$ 0.2
Ether Extract	1.81	2.24 11.6	8.4	23.93	0.9	6.2	7.8	6.2	3.5 $\pm$ 0.7
Crude Protein	3.22	5.5 7.87	10.44	5.53	2.3	8.1	6.8	8.1	6.02 $\pm$ 0.15
Nitrogen				0.8847					
Crude Fiber	29.52		11.81	14.83	10.4		16.8		13.45 $\pm$ 0.42
Dietary Fiber		47 53							
Carbohydrates	51.25	59.5 76.6	43.40	32.39	68.0	40.0	56.5		53.62 $\pm$ 2.3
Starch		3.5 6.3							
Resistant Starch		2.3 2.5							
Energy	234 ⁺						2634.8 ⁺⁺		2358.3 $\pm$ 60.8 ⁺⁺

The analysis of the samples showed a moisture content of 10.06%, ash of 9.05%, ether extract of 3.5%, crude protein of 6.02%, crude fiber of 13.45% and carbohydrates of 53.62%.

Results completely in line with the average values reported in the literature. In fact, the data showed an average moisture content of 10.16% (min 7.5%-max 13.49%), ash of 10.24% (min 6.7%-max 12.45%), ethereal extract of 7.67% (min 0.9%-max 23.93%), crude protein of 6.42% (min 2.3%-max 10.44%), crude fiber of 16.67% (min 10.4%-max 29.52%) and carbohydrates of 53.44 (min 32.39%-max 76.6%).

The ash content is medium high and provides useful contributions of macroelements mainly sodium, magnesium and potassium, followed by iron and manganese [13].

The crude fat content is low and may not be a good source of fat-soluble vitamins nor can it contribute significantly to the energy content of feed, but it increases shelf life and reduces the risk of rancidity.

The protein content is not particularly high but such as to make banana peels a valid substitute like other vegetable protein sources [1-3].

The fiber content is comparable to that of many other by-products of vegetable origin used profitably both for the feeding of ruminants and non-ruminants, in which fiber is known to have a dietary function. Carbohydrates are the most present constituents in percentage and represent the main energy source.

In Table 2, the amino acid content of banana peel protein determined by this investigation was compared with that found by Tsado et al. (2021) [43]. Both the total content and that of individual amino acids are comparable to that indicated by the authors. Among all amino acids, glycine (0.15%), glutamic acid (8.95%) and aspartic acid (8.93%) were the most abundant; among the essential ones, lysine (7.28%), isoleucine (6.90%), leucine (5.94%) and threonine (5.87%) prevail. All the essential amino acids are present which, being in quantities similar to those found in egg yolk [44], give the protein a good biological value.

Table 2: Amino Acids in Banana Peel (g/100 g protein, $\pm$ SD).

Amino Acid	[43]*	Present data
Leucine	3.885	5.94 $\pm$ 0.01
Lysine	7.305	7.28 $\pm$ 0.06
Isoleucine	6.65	6.90 $\pm$ 0.03
Phenylalanine	4.885	4.82 $\pm$ 0.02
Norleucine	2.625	3.05 $\pm$ 0.03
Tryptophan	0.295	0.25 $\pm$ 0.00
Valine	3.095	3.21 $\pm$ 0.03
Methionine	3.695	3.79 $\pm$ 0.05
Proline	2.48	2.32 $\pm$ 0.02
Arginine	4.12	3.85 $\pm$ 0.05
Tyrosine	4.73	4.96 $\pm$ 0.03
Histidine	3.035	3.20 $\pm$ 0.04
Cystine	1.545	1.83 $\pm$ 0.01
Alanine	3.535	4.15 $\pm$ 0.03
Glutamic acid	9.015	8.95 $\pm$ 0.06
Glycine	8.48	10.15 $\pm$ 0.72
Threonine	5.74	5.87 $\pm$ 0.04
Serine	4.32	4.42 $\pm$ 0.03
Aspartic acid	8.87	8.93 $\pm$ 0.04
Total	88.305	93.87 $\pm$ 4.14

*Modified by author. Average Plantain/Banana data

The data confirm as stated in literature, mainly a high content of carbohydrates and crude fiber and a protein of good biological value.

Conclusion

The need to provide adequate answers to requests from the most diverse sectors by implementing the database for meta-analytic processing by artificial intelligence, to find solutions for

the use of waste and by-products from various production sectors in compliance with the criteria of the circular economy and to highlight possible alternative protein sources, especially in the animal sector, has pushed the author to determine the chemical composition of banana peels, a food and agro-industrial waste that, judging from what emerges from the existing bibliography, can be used for multiple purposes.

The data obtained concerned the crude chemical composition and the amino acid composition of the protein and confirmed what was already present in previous scientific works, namely a high presence of carbohydrates and dietary fiber, a fair content of protein of good nutritional value, a high content of ash and a low content of crude fats which confirm its possible use in the nutritional field in the form of feed for both monogastrics and ruminants as a replacement for other by-products of plant origin.

There is no doubt that it would be desirable to conduct further investigations to investigate other aspects such as, among many others, the fatty acid composition, the presence of antinutritional factors and bioactive compounds, the mineral and vitamin content, the level of inclusion in diets for polygastrics and monogastrics through "in vivo" tests.

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44. CREA-Alimenti nutrizione.



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DOI: [10.19080/ARTOAJ.2025.29.556435](https://doi.org/10.19080/ARTOAJ.2025.29.556435)

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