



Former food in animal feed

Ksenija Nešić^{1*} 

¹ Scientific Institute of Veterinary Medicine of Serbia, Smolucska 11, 11077 Belgrade, Serbia

ARTICLE INFO

Keywords:
Feed alternatives
Former food
Food waste

ABSTRACT

With the global population on the rise and growing demand for animal products, competition between food sources for humans and animals is intensifying. As a result, the livestock industry is actively seeking cost-effective feed alternatives that are not suitable for human consumption. One promising option is the use of former food products (FFPs), which are derived from leftovers and residues from food processing. Available FFPs offer a potential substitute for traditional cereals and concentrates in animal diets. This review examines the relevant regulatory framework alongside recent findings on the application of FFPs in animal nutrition, focusing on their capacity to replace energy-rich feeds while addressing the associated risks and benefits. Overall, existing research supports the use of FFPs as a sustainable practice in animal feeding, contributing to global efforts to reduce food waste.

1. Introduction

The United Nation's 2024 report projects world population to be about 10.2 billion in 2100 (UN, 2024). In addition, according to recent data from the Food and Agriculture Organization (FAO, 2024), with only six years left until 2030, current trends in hunger and food insecurity are not on track to meet the goal of ending hunger by the target date. Similarly, progress indicators for global nutrition targets show the world is falling behind in efforts to eliminate all forms of malnutrition. Billions of people still lack access to adequate, safe, and nutritious food. The escalating nutritional demands of a growing global population, along with climate challenges, are exerting significant pressure on both animal husbandry and the animal feed production sector. This situation underscores critical concerns regarding the availability and sustainable use of essential

resources, such as land and water, which are fundamental to food production systems. Consequently, competition between human and animal food requirements is intensifying. In response, there is a sustained effort within the scientific and agricultural communities to identify and implement innovative strategies that can mitigate these challenges.

Among several alternatives, the idea of using so-called former food in the diet of domestic animals stands out, which practically represents recycling within the food chain. As defined within the EU Catalogue of Feed Materials (European Union, 2017), "former foodstuffs" mean foodstuffs, other than catering reflux, which were manufactured for human consumption in full compliance with the EU food law but which are no longer intended for human consumption for practical or logistical reasons or due to problems of manufacturing or packaging defects or other defects and which do not present

*Corresponding author: Ksenija Nešić, ksenija.nesic@nivs.rs

Paper received July 1st 2025. Paper accepted July 17th 2025.

The paper was presented at the 63rd International Meat Industry Conference "Food for Thought: Innovations in Food and Nutrition" – Zlatibor, October 05th-08th 2025.

Published by Institute of Meat Hygiene and Technology – Belgrade, Serbia.

This is an open access article CC BY licence (<http://creativecommons.org/licenses/by/4.0>)

any health risks when used as feed”. *Luciano et al.* (2020) indicate that examples of former food products (FFPs) include a range of food industry leftovers such as pasta, bread, cereals, savoury snacks, biscuits, sweets, and chocolate bars. These foods are high in sugar, starch, oil, or fat, so they have a high energy content.

The European Feed Manufacturers’ Federation (*FEFAC*, 2023) reported that processed former foodstuffs represent a nutrient-rich alternative ingredient to cereal grains and vegetable oils in a compound feed formulation and that this approach also supports the circular economy and reduces environmental impact by requiring fewer natural resources than traditional crop-based feed. The importance of this practice is evidenced by the fact that the European Former Foodstuff Processors Association (*EFFPA*, 2025) was founded in 2014 as a non-profit EU trade network with the aim of connecting food manufacturing with the animal feed production sector. One of the main goals is to make an important contribution to relevant sustainability targets in terms of resource efficiency.

2. Regulatory framework

Former foodstuffs incorporated into animal feed are subject to specific legislative requirements, whereby both former foodstuff processors and food business operators are classified as feed business operators. They are responsible for maintaining feed safety, ensuring the quality and integrity of both sourced and processed materials, and preserving the feed status throughout the supply chain. These materials must only be sourced from the manufacturing, distribution, and retail sectors of the food and beverage industry, explicitly excluding catering establishments. Additionally, sourced former foodstuffs must be free of any prohibited animal by-products (*FEFAC*, 2023).

Feed safety is the foremost priority in the use of former foodstuffs as feed ingredients. To maintain trust in the sector, both suppliers and customers must be assured that former foodstuff processors operate responsibly and uphold stringent standards of safety and traceability. Therefore, these processors are required to comply with a range of key EU Regulations and Directives governing feed safety, hygiene, and traceability within the feed supply chain (*EFFPA*, 2025).

Arranged in chronological order, the following EU regulations apply:

- Regulation (EC) No 178/2002 laying down the General Principles and Requirements of Food Law (*European Union*, 2002a). Producers of feed for food-producing animals are an integral part of the food chain and are subject to the principles outlined in the General Food Law. Crucially, feed must be safe and must not pose any risk to animal or human health, as stipulated in Article 15. Furthermore, Article 18 requires that feed be fully traceable and identifiable at all stages of the supply chain. In cases where non-compliant products are identified, Article 20 mandates that appropriate measures be taken to withdraw such products from the market, ensuring the continued integrity and safety of the food and feed system.
- Directive 2002/32/EC on Undesirable Substances in Animal Feed (*European Union*, 2002b). To ensure the delivery of safe feed to the market, former foodstuff processors must fully comply with the legislation that sets maximum allowable limits for undesirable substances in animal feed.
- Regulation (EC) No 882/2004 on Official Controls performed to ensure the Verification of Compliance with Feed and Food Law (*European Union*, 2004). This regulation establishes the framework for official feed controls, to which former foodstuff processors, as feed business operators, are fully subject.
- Regulation (EC) No 1831/2003 laying down Requirements for Feed Hygiene (*European Union*, 2003). These regulatory requirements fully apply to former foodstuff processors, as they do to all operators within the animal feed sector. Consequently, former foodstuff processors are obligated to implement Hazard Analysis and Critical Control Points (HACCP) principles as part of their feed safety management systems.
- Directive 2008/98/EC on Waste (*European Union*, 2008). To emphasize that former foodstuffs are not legally considered waste, former foodstuff processors refer to Article 5 of this Directive, which outlines the criteria for by-products.
- Regulation (EC) No 767/2009 on placing on the Market and Use of Feed (*European Union*, 2009a). Former foodstuff processors, as entities placing feed on the market, are required to fully comply with all aspects of this regulation. This includes, among other provisions, adherence to specific feed labelling requirements.

- Regulation (EC) No 1069/2009 laying down Health Rules as regards Animal By-Products and Derived Products not intended for Human Consumption (*European Union*, 2009b). Former foodstuffs that contain or are derived from animal by-products, such as milk, eggs, honey, or gelatine, are classified as Category 3 animal by-products, as defined in Article 10 of this Regulation. This category includes materials considered low risk and suitable for use in feed, subject to specific handling and processing requirements to ensure safety.
- Regulation (EU) No 2017/1017 on the Catalogue of Feed Materials (*European Union*, 2017). The Catalogue serves as a voluntary, co-regulated reference for feed materials used in livestock farming within the EU. As mentioned before, in Annex, Part A(3), it provides the official definition of former foodstuffs. Notably, the third update of the Catalogue, released in 2017, introduced *mechanical packaging removal* as a recognised process within the glossary, further clarifying the handling of former foodstuffs intended for feed use.
- Commission Notice — Guidelines for the Feed Use of Food no Longer Intended for Human Consumption (*European Union*, 2018). Although these Guidelines do not have legal status, they have been accepted by EU Member States and provide valuable clarifications regarding the eligibility of former foodstuffs, including those that have fallen on the floor and those past their food labelling expiration dates.

3. Implementation for food-producing animals

Depending on the target animal species, processed FFPs are typically included in compound feed formulations at inclusion rates ranging from 5% to 30%. They are generally available across most European feed markets at costs comparable to those of cooked cereal grains and oil-rich feed components (*FEFAC*, 2023). These materials can be broadly classified into two primary categories: residues from the food industry predominantly comprising bakery products (e.g., bread, pasta) and those principally consisting of confectionery products (e.g., chocolates, biscuits). Bakery products, including bread and savoury cakes or snacks, due to the prolonged baking process, constitute a macerated and readily digestible source of energy characterized by high starch content. Confectionery products, such as chocolate, dry cakes, biscuits, waffles, and muesli, are considered supplemental feeds, available throughout the year, and are rich in simple sugars, lipids, and energy. Given these compositional attributes, FFPs are primarily targeted at young animals, including piglets, chicks, and calves, owing to their elevated levels of digestible carbohydrates, particularly cooked starch (*Luciano et al.*, 2020).

Pinotti et al. (2021) summarized the available data and provided an overview of the nutritional composition of bakery and confectionery products analyzed as FFPs (Table 1). They concluded that these values are variable and affected by processing, and although they pose a challenge for feed

Table 1. Nutritional composition (g/Kg of dry matter or MJ/Kg of dry matter) of former food as reviewed by *Pinotti et al* (2021)

Component	Bakery products		Confectionery products	
	Range	Average	Range	Average
Crude protein	2.10 - 16.70	11.40	7.30 - 13.20	10.60
Ether extract	0.30 - 12.20	6.50	4.80 - 15.00	9.80
Crude fibre	0.50 -13.40	3.60	0.50 - 5.20	2.60
Neutral detergent fibre (NDF)	2.10 - 50.50	20.50	5.40 - 22.60	12.10
Acid detergent fibre (ADF)	0.40 - 22.10	7.90	1.20 - 6.80	3.20
Ash	0.70 - 8.60	4.90	1.40 - 8.20	3.40
Non-structural carbohydrate	60.10 - 78.90	65.70	50.60 - 79.30	64.70
Starch	24.00 - 86.30	44.70	41.90 - 73.40	50.90
Nitrogen free extractives	75.50 - 77.90	76.70	60.80 - 79.00	69.40
Metabolizable energy (MJ/Kg of dry matter)	11.40 - 19.00	14.60	14.50 - 18.20	16.40

formulation, they also provide valuable flexibility in adjusting ratios to meet the nutrient and energy needs of the target animals.

Srikanthithasan et al. (2024a) studied the inclusion of dietary FFPs in broiler diets, assessing growth performance, digestibility, haematobiochemical profiles, and liver gene abundance. They concluded that these foodstuffs could be incorporated into nutritionally balanced diets at up to 25% substitution levels for 33 days without negatively affecting growth performance in male broilers raised under commercial conditions. However, they emphasized the need for further research to confirm the haematological trait findings. *Luciano* (2021) suggested that a percentage of inclusion from 27% to 30% of FFPs in weaning pig diets does not affect growth performance or health of animals, proposing FFPs as a valuable alternative feed ingredient. *Termezidou et al.* (2023) later examined the inclusion of bakery meal at 15% and 20% (w.w.) in the diet of post-weaned piglets, reporting no significant negative effects on growth parameters, welfare, or behavioural indicators. According to existing *in vitro* and *in vivo* studies on the inclusion of FFPs in ruminant feeding, FFPs appear to support adequate rumen function and pH, while promoting favourable ruminant performance and health (*Tretola et al.*, 2025). The use of FFPs as alternative energy sources—replacing conventional ingredients, such as cereal grains, fats, oils, or molasses—could potentially alleviate the current feed-food competition, without negatively affecting animal productivity or welfare in lactating dairy cows or fattening cattle (*Tretola et al.*, 2025). However, achieving this objective requires careful regulation of the chemical composition and inclusion rates of FFPs, ensuring their integration with other feed components. The nutritional composition of the final diet is crucial, as it directly influences rumen microbial communities, which in turn impact animal performance, health, and related products. Despite the promising potential, the limited number of studies available and the variability in *in vitro* and *in vivo* findings highlight the need for further validation to ensure the safe and effective use of FFPs in ruminant diets from a nutritional perspective.

Disclosure Statement: No potential conflict of interest was reported by the authors.

Acknowledgement: The paper is published as part of the contract between the Scientific Institute of Veterinary Medicine of Serbia and the Ministry of Science, Technological Development and Innovation of the Republic of Serbia No 451-03-136/2025-03/200030.

4. Safety remarks

As highlighted by *Srikanthithasan et al.* (2024b), further research focusing on safety aspects across various animal species is essential. The critical need for farmers, nutritionists, industries, and governments is to prioritize animal feed production, as the quality and safety of feed are fundamental to ensuring human food safety. One key concern, as noted by *Luciano* (2021), is the potential presence of packaging material residues, which must adhere to regulatory standards governing feed constituents. Furthermore, *Tretola et al.* (2025) identified a significant gap in the existing literature regarding the potential effects of undesirable substances present in FFPs, including theobromine (a principal alkaloid of the cacao bean), packaging residues, and chemicals associated with packaging materials. Additionally, it is recognized that all other requirements pertaining to the safety of feed and feedstuffs must be fully satisfied.

5. Conclusion

The utilization of FFPs contributes to achieving international targets for food waste reduction and supports the broader objectives of developing a sustainable food system. Nevertheless, further multidisciplinary *in vivo* studies are essential to validate the potential inclusion of FFPs in the diets of various livestock species at different inclusion levels—particularly for those that have so far been largely overlooked, such as beef cattle, goats, lambs, laying hens, and ducks. These studies should aim to identify the optimal or maximum inclusion rates that meet the specific nutritional requirements of each species, while also thoroughly assessing all safety aspects. Overall, this is a promising strategy that warrants continued research and development in pursuit of effective solutions for the collective benefit. Consequently, it is essential to promote its recognition and encourage its implementation within animal nutrition practices through appropriate domestic regulatory frameworks.

References

- EFFPA, (2025).** <https://effpa.eu> Accessed June 16, 2025.
- European Union, (2002a).** Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. *Official Journal of the European Union*, L31, 1–24. <http://data.europa.eu/eli/reg/2002/178/oj>
- European Union, (2002b).** Directive 2002/32/EC of the European Parliament and of the Council of 7 May 2002 on undesirable substances in animal feed - Council statement. *Official Journal of the European Union*, L140, 10–22. <http://data.europa.eu/eli/dir/2002/32/oj>
- European Union, (2004).** Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules. *Official Journal of the European Union*, L165, 1–141. <http://data.europa.eu/eli/reg/2004/882/oj>
- European Union, (2005).** Regulation (EC) no 183/2005 of the European parliament and of the Council of 12 January 2005 laying down requirements for feed hygiene. *Official Journal of the European Union*, L35, 1–22. <http://data.europa.eu/eli/reg/2005/183/oj>
- European Union, (2008).** Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. *Official Journal of the European Union*, L312, 3–30. <http://data.europa.eu/eli/dir/2008/98/oj>
- European Union, (2009a).** Regulation (EC) No 767/2009 of the European Parliament and of the Council of 13 July 2009 on the placing on the market and use of feed, amending European Parliament and Council Regulation (EC) No 1831/2003 and repealing Council Directive 79/373/EEC, Commission Directive 80/511/EEC, Council Directives 82/471/EEC, 83/228/EEC, 93/74/EEC, 93/113/EC and 96/25/EC and Commission Decision 2004/217/EC. *Official Journal of the European Union*, L229, 1–28. <http://data.europa.eu/eli/reg/2009/767/oj>
- European Union, (2009b).** Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal by-products Regulation). *Official Journal of the European Union*, L300, 1–33. <http://data.europa.eu/eli/reg/2009/1069/oj>
- European Union, (2017).** Commission Regulation (EU) 2017/1017 of 15 June 2017 amending Regulation (EU) No 68/2013 on the Catalogue of feed materials. *Official Journal of the European Union*, L159, 48–119. <http://data.europa.eu/eli/reg/2017/1017/oj>
- European Union, (2018).** Commission Notice — Guidelines for the feed use of food no longer intended for human consumption. *Official Journal of the European Union*, L133, 2–18. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=oj:JOC_2018_133_R_0002
- FAO, (2024).** The State of Food Security and Nutrition in the World 2024 – Financing to end hunger, food insecurity and malnutrition in all its forms. Rome. <https://doi.org/10.4060/cd1254en>
- FEFAC, (2023).** Use of processed former foodstuffs (circularity). <https://fefac.eu/pages/sustainable-animal-feeding-strategies/all-farm-species/use-of-former-foodstuffs-circularity/> Accessed June 16, 2025.
- Luciano, A. (2021).** The use of former food in post-weaning pig diets: effects on growth performance, apparent total tract digestibility, gut health, feed safety and environmental impact. Doctoral Dissertation, Università degli studi di Milano, Italy, 1–257. https://air.unimi.it/retrieve/dfa8b9aa-4426-748b-e053-3a05fe0a3a96/phd_unimi_R12156.pdf
- Luciano, A., Tretola, M., Ottoboni, M., Baldi, A., Cattaneo, D., & Pinotti, L. (2020).** Potentials and Challenges of Former Food Products (Food Leftover) as Alternative Feed Ingredients. *Animals*, 10(1), 125. <https://doi.org/10.3390/ani10010125>
- Pinotti, L., Luciano, A., Ottoboni, M., Manoni, M., Ferrari, L., Marchis, D., & Tretola, M. (2021).** Recycling food leftovers in feed as opportunity to increase the sustainability of livestock production. *Journal of Cleaner Production*, 294, 126290. <https://doi.org/10.1016/j.jclepro.2021.126290>
- Srikanthithasan, K., Gariglio, M., Diaz Vicuna, E., Fiorilla, E., Miniscalco, B., Zambotto, V., Cappone, E.E., Stoppani, N., Soglia, D., Raspa, F., Nery, J., Giorgino, A., Sala, R., Luis, A., Marinz, M., Madrid Sanchez, J., Schiavone, A., & Forte, C. (2024a).** Dietary processed former foodstuffs for broilers: impacts on growth performance, digestibility, hematobiochemical profiles and liver gene abundance. *Journal of Animal Science and Biotechnology*, 15, 122. <https://doi.org/10.1186/s40104-024-01081-w>
- Srikanthithasan, K., Giorgino, A., Fiorilla, E., Ozella, L., Gariglio, M., Schiavone, A., Luis, A., Marín, M., Diaz Vicuna, E., & Forte, C. (2024b).** Former foodstuffs in feed: a minireview of recent findings. *Environmental Science and Pollution Research*, 31, 23322–23333. <https://doi.org/10.1007/s11356-024-32695-2>
- Termatzidou, S.-A., Dedousi, A., Kritsa, M.-Z., Banias, G. F., Patsios, S. I., & Sossidou, E. N. (2023).** Growth Performance, Welfare and Behavior Indicators in Post-Weaning Piglets Fed Diets Supplemented with Different Levels of Bakery Meal Derived from Food By-Products. *Sustainability*, 15(17), 12827. <https://doi.org/10.3390/su151712827>
- Tretola, M., Lin, P., Eichinger, J., Manoni, M., & Pinotti L. (2025).** Review: Nutritional, safety, and environmental aspects of former foodstuff products in ruminant feeding. *Animal*, 101512. <https://doi.org/10.1016/j.animal.2025.101512>
- UN (2024).** World Population Prospects 2024. <https://www.un.org/en/UN-projects-world-population-to-peak-within-this-century>

Authors info Ksenija Nešić, <https://orcid.org/0000-0001-9255-3187>