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Research Article

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Determination of Potential Feed Value and In Vitro True Digestibility of Biscuit Industries Residues

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Abstract This study aimed to determine the potential feeding value and in vitro true digestibility of biscuit industrial residues (BIR). In the study, by-products obtained from a private biscuit factory, which could not be evaluated and considered as residue, were used as feed material. A Daisy incubator was used to determine the in vitro true digestibility of the biscuit residue. According to the obtained results, it was observed that the BIR used in this study fell into the category of non-reusable residue regarding its moisture content (%12.32) and that utilizing it as animal feed would provide economic benefits. Biscuit industry residues were found to be rich in readily soluble carbohydrates (%80.85 DM) and sufficiently nutritious for sheep feeding even when used alone due to their high crude protein content (%8.67 DM) and also crude fat (%8.0 DM). In addition, considering its low content of cell wall structural components and high in vitro true digestibility (%91.49 DM), it can be concluded that Biscuit industry residues have significant potential for animal feeding. Therefore, it is recommended to conduct further in vivo studies on its use in animal nutrition.

Keywords Biscuit industrial residues, feed value, environment pollution, digestibility

1. Introduction

Generally, the biscuit industry generates a significant amount of residual products (ranging from 1% to 5% of production) depending on the specific product and processing methods. Biscuit industry residues can be classified into two categories based on moisture content. Residues with less than 10% moisture content can be ground and used again in the biscuit factory during production. However, residues with moisture exceeding 10% cannot be reused due to potential risks to product quality and consumer health. Therefore, some parts of these residues are utilized in producing biofuels (biodiesel), while other parts can be used in the animal feed industry for feeding livestock [1,2].

Oruc et al. [3] reported that expired biscuits can be used in juvenile fish (koi crucian carp=Cyprinus carpio) diets instead of 100% of cornmeal without causing any adverse effects. The researchers determined that the biscuits used in the study had 5.0% moisture, 7.0% crude protein, 8.0% crude oil, 4.0% crude ash, and 1.0% crude fiber content.

In the study conducted by Kapusuz [2], different moisture contents of biscuit industrial residues (BIR) were analyzed, and it was determined that the moisture, protein, fat, ash, and total carbohydrate contents varied between 7.15-20.68%, 7.63-9.04%, 18.03-18.46%, 1.32-1.93%, and 73.01-70.57%, respectively. The researcher also suggested that the remaining residues obtained after biodiesel-bioethanol production from these by-products could be utilized as a feed source. The protein, fat, ash, and total carbohydrate contents of these residues were reported to range from 12.75-15.81%, 2.24-4.67%, 6.15-10.79%, and 68.73-78.86%, respectively.

Shahryar et al. [4] conducted a study in broiler chickens, where they replaced corn in the diet with biscuit and wafer residues at a rate of 24% (containing 12.6% crude protein, 2.2% crude ash, 4.05% crude fat, 2.55% crude

fiber, and 8.0% moisture). They found that the inclusion of these residues had no adverse effects on the performance and carcass characteristics of broiler chickens. Furthermore, they reported that the utilization of biscuit industrial residues (BIR) allowed for a more economical formulation of broiler diets.

In studies conducted by Lounge [5] and Adeyemo et al. [6] on broiler chickens, it was reported that replacing corn with 50% inclusion of biscuit industrial residues (BIR) in the starter and finisher diets had a positive effect on performance, carcass characteristics, growth rate, and the economy of the ration. Additionally, Shittu et al. [7] reported that the utilization of BIR in animal feed could potentially play a significant role in reducing the competition for corn consumption between human and animal nutrition.

Eniolorunda [8] recommended the utilization of biscuit residue flour (with 3.15% moisture, 9.65% crude protein, 2.10% crude fiber, 5.25% crude fat, 6% crude ash, and 77.00% nitrogen-free extract on a dry matter basis) combine with alfalfa in the feeding of small ruminants. This combination was suggested due to its potential as a source of energy and protein, as well as its economic benefits.

Sayed et al. [9] reported that the replacement of 20% of corn with BIR (with 7.90% moisture, 1.10% crude fiber, 8.78% crude protein, 8.01% crude fat, 81.01% nitrogen-free extract, 1.10% crude ash content) in the diet of lactating goats improved milk yield and composition, as well as the feeding value and digestibility, without causing any adverse effects. Furthermore, it was stated that this practice was economically beneficial.

In the biscuit industry, various products are produced and a wide range of flavorings and additives are used. These include flour, water, oil, sugar, salt, baking powder, eggs, cream, chocolate, cocoa, sodium bicarbonate, ammonium bicarbonate, milk, milk powder, lecithin, color and flavoring agents, emulsifiers, antimicrobial preservatives, stabilizers, enzymes, some oily seeds such as sesame, fruit particles, nuts, various spices and more. As these ingredients can also be found in biscuit industry residues (BIR), it is believed that their use as animal feed may contribute to reducing methane production. Indeed, BIR is considered to have the potential to act as a methane inhibitor since they are rich in both protein and readily soluble carbohydrate content.

Currently, preventing the environmental damage caused by various forms of industrial residues and waste has become crucial. If these residues are not properly disposed of, it may lead to significant environmental problems. Utilizing these by-products as animal feed not only contributes to environmental sustainability but also reduces the cost of animal rations and livestock production. Therefore, it is important to determine the potential use of industrial residues as animal feed. This study aimed to determine the nutrient contents, feeding value, and in vitro true digestibility of the biscuit industrial residue (BIR) that cannot be reutilized after production in the biscuit industry. This study hypothesized that the digestibility of BIR will be high due to its excess amount of readily soluble carbohydrate content, especially sugar and starch-containing additives

2. Materials and Methods

Supply of Feed Material and Rumen Fluid

In the study, residues from products such as biscuits and wafers obtained from a private biscuit factory were used as feed material, and their nutrient content is provided in Table 1. Rumen fluid used for determining the in vitro true digestibility, was collected from the rumen of a healthy 2 years old Holstein breed steer with a live weight of 400 kg, which had completed rumen development. The rumen fluid was obtained by straining the rumen content into thermoses at 38-40°C temperature at a slaughterhouse in the Atakum district of Samsun province, Turkiye. A handful of solid rumen content was also added to the thermos for use in the in vitro digestibility, and it was transported to the laboratory, where the study was conducted within approximately 20 minutes. The pH value of the rumen fluid was determined using a Hanna model digital pH meter, and it was measured to be within the range of 5.82-5.95.

Nutrient Analysis

In the study, the biscuit industrial residues (BIR) were ground to pass through a 1 mm sieve. The analyses of dry matter (DM), crude protein (CP), and crude ash (CA) were conducted according to the methods described by AOAC [10]. The analyses of acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL) were carried out following the methods reported by Van Soest et al. [11]. The crude fat (CF) analysis was determined using the Ankom XT15 Extraction System device, as specified by AOCS [12]. The organic matter

(OM), cellulose, and hemicellulose values were calculated. All chemical analyses of samples in the study were performed in 3 replications.

Determining In Vitro True Digestibility

The in vitro true digestibility (IVTD) of the feeds was determined using the Ankom DaisyII Incubator D 220 [13]. The Daisy incubator consists of four independent jars, which served as artificial rumen chambers in the in vitro study. All feeds were tested in the Daisy incubator in five replicates. After incubation, NDF analyses were performed on the remaining samples in the bags, and the in vitro True Nutrient Digestibility (IVTD) of the feeds was calculated using the following formula.

$$\%IVTD = 100 - \frac{((W3 - (W1 \times C1)) \times 100}{W2}$$

Here, W1: Weight of F57 bags, W2: Amount of NDF in the dry sample, W3: Amount of NDF remaining in the bag after incubation, and C1: Weight of the blank F57 bag (weight of the empty bag after removal from the incubator and drying in the oven divided by the original bag weight).

Statistical Analysis

The means and standard deviations of the data obtained in the study were analysed, and similarities and differences between these results and those obtained in other studies were compared.

3. Results and Discussion

In the Study, the nutrient content of BIR was determined as shown in Table 1. The dry matter content of the BIR used in this study was determined to be 87.68%, with a moisture content of 12.32%. According to the classification reported by Kapusuz [2], the BIR used in the study contains moisture content above 10.0%, which makes it unsuitable for use again in biscuit production. Therefore, it is considered more appropriate to utilize the available residues as animal feed, both from an economic perspective and to prevent potential environmental pollution caused by these residues.

It is believed that the variation in the dry matter contents determined for BIR in different studies may be affected by many factors such as the product obtained, the processing method, and the materials used. However, it should be noted that the moisture content reported by Kapusuz [2] for BIR ranges from 7.15% to 20.68%, and the moisture content determined in this study remained within this range. Nevertheless, it is worth mentioning that the moisture content for these residues is higher than those reported by Eniolorunda [8], Oruç et al. [3], Sayed et al. [9], and Shahryar et al. [4] (3.15%, 5.0%, 7.90%, and 8.0% respectively), which may be attributed to the factors mentioned above.

Table 1: Nutrient contents and cell wall structural components of biscuit industrial residues (% DM)

	DM*	OM	Ash	CP	EE	NFE	NDF	ADF	ADL	HCEL	CEL
Mean	87.68	97.52	2.48	8.67	8.00	80.85	13.7	2.72	1.79	10.98	0.94
SD	0.59	0.00	0.00	0.22	0.24	0.07	1.43	0.13	0.16	1.32	0.06

DM*: Dry matter (air-dried), OM: Organic matter, Ash: Crude Ash, CP: Crude protein, EE: Ether extract, NFE: Nitrogen-free extract, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, HCEL: Hemicellulose, CEL: Cellulose, SD: Standard deviation.

The crude protein content of biscuit industrial residues (BIR) in this study (%8.67 DM) is similar to the findings reported by Kapusuz [2] (7.63-9.04), but it is slightly higher than the value reported by Oruç et al. [3] (7.0). In general, it is observed that the crude protein content of BIR is suitable for the feeding of sheep as it meets the recommended CP values for sheep nutrition by the NRC [14] (9.5-10.0%).

Kapusuz [2] reported that the crude fat content of BIR ranges from 18.03% to 18.46%, while Shahryar et al. [4] reported it as 4.05%, and Eniolorunda [8] reported it as 5.25%. In this study, the crude fat content differs from the values mentioned above, but it is consistent with those reported by Oruç et al. [3] and Sayed et al. [9]. The variation

in crude fat content can be attributed to the different products used and differences in the amount of fat and oilseeds present in the samples.

It is known that biscuit and wafer products are typically produced with readily soluble carbohydrates. In this regard, it is observed that BIR also contains high levels of readily soluble carbohydrates. In this study, the easily soluble carbohydrate (nitrogen-free extracts) content of the BIR used was determined to be 80.58% DM. Kapusuz [2] reported this value to be between 73.01% and 70.57%, whereas Eniolorunda [8] reported it as 77.00%, and Sayed et al. [9] reported it as 81.00%. The observed variations among different BIRs in terms of readily soluble carbohydrate content, like other nutrients, can vary depending on the factors such as the product obtained, the processing method, and the materials used.

The crude ash content of BIR determined in the study was found to be 2.48% DM. The value reported by Kapusuz [2] (1.32-1.93%) and the crude ash content reported by Shahryar et al. [4] (2.20%) are partially consistent with the findings of this study. However, the value reported by Sayed et al. [9] (1.10%) is lower than the present study, while the value reported by Oruç et al. [3] (4.0%) and Eniolorunda [8] (6.0%) are higher than the values obtained in this study. It can be stated that the differences observed are due to the variations in the raw materials used in production and the salt and spice ingredients.

In a study by Romero-Huelva et al. [15] It was reported that the use of bakery residues in the diets of goats instead of concentrated feeds resulted in a reduction in methane production. Considering that the BIR used in this study is similar to bakery residues and it is expected to show the same effects.

It was observed that the contents of cell wall structural components of the biscuit industry residues were significantly low as expected, and the contents of NDF, ADF, ADL, HCEL and CEL were determined as 13.70%, 2.72%, 1.79%, 10.98% and 0.94% on a dry matter (DM) basis, respectively. Among these components, NDF indicates feed intake, while ADF signifies the digestibility of feeds. Therefore, the lower these values, the higher the feed intake and the increased digestibility of feeds. Considering the content of cell wall components similar to values found in concentrated feeds, it indicates that BIR will have high digestibility rate like concentrate feeds.

The in vitro true digestibility of BIR determined in the study ranged between 88.34-93.54% on the basis of dry matter as shown in Table 2. The average in vitro true digestibility value was determined to be 91.49% DM. This value indicates that BIR has a significantly high digestibility. Due to its characteristic, it is possible to incorporate a certain amount of BIR into many diets instead of concentrated feeds.

Table 2: IVTD of biscuit industry residues, (% DM)

BIR	Min	Max	Mean
	88.34	93.54	91.49

4. Conclusion

According to the results of the study, it is believed that BIR shows nutrient contents, digestibility, and potential feed value similar to concentrated feeds. Therefore, if used in animal feeding, it could potentially replace a portion of concentrated feeds in the diet and result in significant savings in concentrated feed usage.

By utilizing BIR as a feed ingredient, significant contributions can be made not only in terms of converting industrial residues into economic value but also in preventing environmental pollution. However, due to various factors such as the production method, product variability, differences in raw materials, and the use of additives, BIR may not always have a consistent standard in terms of nutrient composition. As a result, significant variations can be observed in the nutrient content of BIR. Therefore, it is of utmost importance to analyse and evaluate each new batch of BIR for its nutrient composition when using it in ration formulation. Maximum care should be taken to ensure that the nutrient composition is determined accurately and applied accordingly

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