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Ali Roshanianfard
Assistant Professor, Department of Biosystem Engineering, Faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Iran, ali.roshanian@yahoo.com

Samira Nematzadeh
Ph.D. Candidate, Department of Biosystem Engineering, Faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Iran, alirf@uma.ac.ir

Tarahom Mesri-Gundoshmian
Professor, Department of Biosystem Engineering, Faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Iran, ali.roshanianfard@gmail.com

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PARAMETERIZATION OF FOOD WASTES TO DEVELOP AN AUTOMATIC RECYCLING SYSTEM FOR LIVESTOCK AND POULTRY FEED

Ali Roshanianfard[1*], Samira Nematzadeh[2], Tarahom Mesri-Gundoshmian[3]

1- Assistant Professor, Department of Biosystem Engineering, Faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Iran

alirf@uma.ac.ir, ali.roshanian@yahoo.com

2- Ph.D. Candidate., Department of Biosystem Engineering, Faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Iran

s.nematzadeh@student.uma.ac.ir

3- Professor, Department of Biosystem Engineering, Faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Iran

mesrigtm@gmail.com

** Corresponding author and first author*

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التحويل المعياري لمخلفات الطعام إلى تطوير نظام إعادة تدوير أوتوماتيكي لتغذية المواشي وعلف الدواجن

ملخص

تُعرف نفايات الطعام بأنها أحد الاهتمامات الكبيرة في الإدارة الحضرية بسبب مكاسب استهلاك الحبوب والتلوث البيئي وطرق إدارة النفايات التقليدية. يمكن أن تؤدي إعادة استخدام نفايات المطاعم إلى تقليل تكلفة إنتاج الغذاء الحيواني. تحاول هذه الدراسة إيجاد معايير ذات صلة لاستخدامها في تطوير آلة إعادة التدوير الأوتوماتيكية وأيضًا طريقة مناسبة لإدارة مخلفات الطعام (نفايات المطاعم في الجامعات والبيئات الأكاديمية الأخرى) لاستخدامها في النظم الغذائية الحيوانية المختلفة. تم في هذا البحث تحديد العوامل المختلفة بما في ذلك نسبة المادة الجافة (باستخدام المجفف) والبروتين (باستخدام اختبار Kjeldahl) والدهون (باستخدام مستخرج Soxhlet) والطاقة (باستخدام اختبار قنبلة Calorimeter). كما تم استخلاص المعلمات ذات الصلة من الوجبات الشائعة المستخدمة في أعلاف المواشي والدواجن ثم مقارنتها بالمعايير التي تم الحصول عليها من النفايات. أظهرت النتائج أن متوسط قيمة المادة الجافة في العلائق المختلفة بنسبة 89.82٪ يزيد بثلاث مرات عن هذا المعامل في الغذاء المستخلص بنسبة 42.29٪. نسبة البروتين ونسبة الدهون وقيمة الطاقة في الغذاء المستخلص (59.25٪ ، 26.13٪ ، 4.41 كالوري / كغ ، على التوالي) كافية للاستخدام في الحميات الغذائية المختلفة. متوسط قيمة نسبة البروتين ونسبة الدهون وقيمة الطاقة في الأنظمة الغذائية المختلفة 75.23٪ و 27.4٪ و 3.50 كالوري / كغ على التوالي. أشارت النتائج المؤرشفة إلى أنه من الممكن استخدام مخلفات الطعام المعالج في أعلاف الماشية والدواجن ويمكن أن تكون هذه المواد بديلاً جيدًا لبعض الأنظمة الغذائية. ستستخدم مخرجات هذا البحث في تطوير نظام مستدام لإعادة تدوير النفايات. أخيرًا ، يتم استخدام المعلمات المستخرجة في تصميم نظام إعادة التدوير.

الكلمات المفتاحية: مستدام ، نفايات غذائية ، ماشية ، دواجن ، حمية

Abstract

Food wastes are known as one of the big concerns in urban management because of grain consumption gain, environmental pollution, and traditional waste management methods. The reuse of restaurant waste can reduce the cost of producing animal food production. This study attempts to find related parameters to use in the development of an automatic recycling machine and also a suitable method for food waste management (wastes of restaurants in universities and other academic environments) to use in various animal diets. Determination of various parameters including the percentage of dry matter (using a dryer), protein (using Kjeldahl test), fat (using Soxhlet extractor), and energy (using Calorimeter bomb test) were done in this research. Relevant parameters were also extracted from common diets used in livestock and poultry feed and then compared with the parameters obtained from the wastes. The results showed the average value of dry matter in different diets by 82.89% is three times more than this parameter in extracted food by 29.42%. The protein percentage, fat percentage, and energy value in extracted food (25.59%, 13.26%, and 4.41 cal/Kg, respectively) is sufficient to use in different diets. The average value of the protein percentage, fat percentage, and energy value in different diets is 23.75%, 4.27%, and 3.50 cal/Kg, respectively. The archived results indicated that it is possible to use processed food waste in livestock and poultry diets and these substances can be a good alternative to some of the diets. The output of this research will use in developing a sustainable waste material recycling system. Finally, the extracted parameters are used in designing a recycling system.

Keywords: Sustainable, Food waste, Livestock, Poultry, Diet

1. INTRODUCTION

Waste management is a series of activities for the planning, organizing, and executive operations related to the storage, collection, transportation, disposal, and processing of waste. The priority in waste management is reducing waste production at the source [1]. The next steps are recycling, energy conversion, incineration, and finally burial, respectively. Proper training also can help to reduce waste volume. According to the FAO[1] reports, one-third of the food produced for human consumption is wasted each year which is about 1.1 billion tons per year [2-14]. The effect that this improvidence has on the planet is obvious in water wastage and energy concerns. Based on WMO[2] reports, 60 to 70 percent of municipal waste is wet waste, which is about 2 to 2.5 times the percentage of wet waste in the world. This amount of wasted can produce food for more than 18 million people per year. Population explosion and food consumption growth generate a huge amount of waste which requires specific consideration and careful and practical management. Food waste is a part of municipal waste which if not properly separated and managed, can cause numerous environmental pollutions and also it may make other waste non-recyclable. This requires a solution for food waste management is needed. On the other hand, providing food for livestock, poultry, and aquatic animals as the main source of human daily consumption has encountered problems. Production of a low-cost diet that meets the nutritional consumption of animals is an important and considerable option in the livestock, poultry, and aquaculture industries. If the food waste is managed properly, we can use them as food for livestock, poultry, and aquatic animals.

Thanks to many researchers who present various alternatives, such as composting, anaerobic digestion, incineration, or producing animal food. Among them, producing animal food directly addresses food security challenges. Using cheaper food with the same content can present more options to reduce production costs in the livestock industry. Restaurant waste has high nutritional value for ruminants and poultry. Environmental pollution reduction and waste disposal cost management are other benefits of using food waste in animal feed [15]. Using recycled food waste improves the self-sufficiency of livestock and poultry production [15]. According to the GFS 3reports, Iran ranked as a high-risk country. The food wastes produced in Iran is equal to 38% of the European Union food waste [16].

The use of food waste in animal feed was proposed by Minkler in 1914. Many researchers have studied the food waste in different animal diets [17] and examined processed waste in ruminant diets, then calculated its digestibility and palatability. Many of them reported the nutritional value of food waste equal to and even greater than foods such as forage [18]. Using food waste for the animal can be considered as a solution for food recycling. Japan and South Korea use 40% [19], and 45% [20] of food waste for animal feed. Researches showed animal weight gain and consumption efficiency depend on animal type, experimentation period, and alternatives percentage [19]. Food wastes are usually rich in animals' required nutrients. For example, the average crude protein (CP=19.2%) is 200% compared to kernels (10-8%) [19]. The results of researches done by Westendorf, Dong [17] showed the dry matter of 22.4% (DM), protein of 21.4% (CP), detergent-soluble fiber Acidic (ADF) of 14.1%, ether or fat extract (EE) of 27.2%, and ash (Ash) of 3.2%. Moradi, Hoseinkhani [21] reported that using restaurant waste does not have any negative effects on meat production performance. Walker et al (2000) reported that using food waste in the diet of small ruminants can improve the performance of livestock up to 25% and also it can reduce production costs by 1.35% [22]. It reduced the cost of feed consumption in lambs so that the use of 50 and 100% levels of restaurant waste instead of barley grains reduced production costs by 24% and 33.7%, respectively [18]. Westendorf et al. (1998) reported that the food waste has high protein (21%), high fat (26%), low fiber (CF) (6%), low dry matter, and minerals (27%) [17]. Garsiya et al. (2005) reported that restaurant food waste contains relatively high crude protein (CP= 28%), nitrogen-free extract (NFE=27%), and ether extract (EE= 29%) [23].

According to the mentioned cases; despite the widespread use of wastes in livestock diets; and the possibility of solving the problem by providing inputs for animal consumption, more scientific research is still required to determine food waste's nutritional value in the animal diet in Iran. This research presents the nutritional value of food waste comparing with commonly used diets and tries to present a solution to improve the nutritional value of waste. The main purpose of this study is the determination of the nutritional value of academic environment wastes more focused on the resultant of University of Mohaghegh Ardabili (UMA)-Iran.

The main novelties of this study are: (1) using the waste material of academic environment for the first time in Iran, (2) investigation of detailed parameters of the mentioned target material, and (3) development of a new and an innovative recycling machine for the target material.

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[1] Food and Agriculture Organization

[2] Waste Management Organization

[3] Global Food Security

2. MATERIALS AND METHODS

2.1. TARGET MATERIAL

In this research, the food waste of a restaurant at the University of Mohaghegh Ardabili was collected and analyzed for 5 consecutive days (based on the menu) and three repetitions. One of the dominant features of these wastes is their similar composition due to the special diet of these center, which includes the residues of rice with chicken (named M), grilled chicken (named G), shredded (named K), minced meat (named E), and vegetable broth (named O). The samples were randomly collected and transported to the laboratory in the Faculty of Agriculture and Natural Resources of the university to perform the relevant operations.

2.2. EXPERIMENTS AND METHODS OF ANALYSIS

As food waste is a heterogeneous material with a different content range, its internal structure and ingredients should be examined. In this case, some of the important parameters of animal diets studied including (1) dry matter (DM), (2) crude protein (Cp), (3) crude fat (EE), and (4) crude energy (E). Other parameters such as ash (Ash), calcium (Ca), phosphorus (P), soluble fibers in acidic detergents (ADF), and soluble fibers in neutral detergents (NDF) which evaluate the quality of diets will present in future studies.

2.2.1. DRY MATTER

In waste management science, the total amount of nutrients regardless of the moisture content is known as dry matter. This includes the protein, fat, crude fiber, and minerals of the food. Moisture content is obtained by drying the food and calculating the weight lost [24]. The moisture in diets dissolves nutrients, creates elasticity and hardness of cells, regulates temperature, excrete acidic substances, and regulates osmotic pressure. Lack of moisture in diets can reduce food intake and livestock production, lose weight, disrupt rumination, and increase nitrogen excretion. Based on the microbiological analysis, after heat treatment at temperatures above 65 °C for 20 minutes, food waste was enough healthy to feed animals. Heat treatment of 15 minutes at 121 °C or 30 minutes at 100 °C is sufficient is also mentioned in other references [25]. In this study, to measure the amount of dry matter and produce a healthy diet, food waste was first poured into a mixer and mixed at medium speed for 2 minutes. The mixed mixture was weighed and placed in glass containers in an oven at 65 ° C for 48 hours. After 48 hours, the mixture took from the oven and placed in a desiccator for 2 hours until it reaches ambient temperature. The dried sample was milled for 3 minutes at medium speed and then the residual weight was measured (Figure 1). The percentage of dry matter as shown in Eq. 1:

$$\text{Wet based dry matter (\%)} = \frac{\text{weight of the dry sample}}{\text{weight of the wet sample}} \times 100 \quad (1)$$

Figure 1. Dry matter measurement: (1) mixing, (2) drying in the oven, (3) placing in a desiccator, (4) grinding, (5) weighing the dry sample

2.2.2. PROTEIN

Protein is a major component in the structure of wastes. It can be found in the structure of muscles, nerves, skin, connective tissue, blood cells, hormones, enzymes, hair, wool, feathers, horns, toxins, and bone tissue, and it continuously repairs worn tissue. In this study, First, nitrogen, protein, and other acid-digesting compounds were converted to ammonium sulfate using concentrated sulfuric acid. The product of acid digestion was diluted with distilled water after cooling. Then, during the distillation step, ammonia was released by adding an alkali (sodium hydroxide) to the digested mixture. The released ammonia was adsorbed on boric acid and then released during the titration step of ammonia bonded with boric acid (ammonium borate complex) using a standard acidic solution (sulfuric acid) as shown in Eq. 2 ~ 6 and Figure 2.

$$\text{Sample} + H_2SO_4 \rightarrow NH_3 + CO_2 + SO_4 + NO_2 \quad (2)$$

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4 \quad (3)$$

$$(NH_4)_2SO_4 + 2NaOH \rightarrow 2NH_4OH + Na_2SO_4 \quad (4)$$

$$NH_4OH + H_3BO_3 \rightarrow NH_4B(OH)_2 \quad (5)$$

$$2NH_4B(OH)_2 + H_2SO_4 \rightarrow (NH_4)_2SO_4 + 2H_3BO_3 + 2H_2O \quad (6)$$

On average the amount of nitrogen in biological materials is about 16% based on dry matter, usually, the total measured nitrogen must be multiplied by a factor of 6.25 to measure the crude protein content. The protein percentage was calculated using Eq. 7:

$$\text{Protein } (\%) = \frac{\text{protein in sample}}{\text{sample weight}} \times 100 \quad (7)$$

Figure 2. Protein measurement, (1) digestion, (2) distillation, and (3) titration

2.2.3. RAW FAT

A suction machine and filter paper No. 42 were used to measure the amount of fat. First, the weight of the filter paper was measured. Then, two grams of milled samples were poured on paper and, after folding, the samples were placed vertically inside the machine. For each sample, 80 cc of hexane was poured into the tank and remained at 70 ° C for 4 hours. The samples evaporated and the hexane condensed and their fat washes completely after 4 hours. Then it was removed from the device and placed in a desiccator for 2 hours to completely evaporate the hexane. The samples were placed in an oven at room temperature for 24 hours to dry completely (Figure 3). Finally, the total weight was measured and the paperweight was subtracted from the sample weight and the fat percentage was obtained from the Eq. 8.

$$\text{Fat } (\%) = \frac{\text{weight}_{\text{secondary}} - \text{weight}_{\text{primary}}}{\text{sample weight}} \times 100 \quad (8)$$

Figure 3. Fat measurement. (1) weighing and filter paper, (2) fat extraction machine

2.2.4. ENERGY

Energy production for vital activities is one of the important functions of food in the body. Energy cannot be a nutrient, but the nutrients in food such as carbohydrates, fats, and proteins produce energy. In this section, a calorimeter bomb was used to measure the amount of energy in the samples. The basis of this method is to increase the temperature of two liters of distilled water inside the device by one degree Celsius. In this process, first, a gram of sample was hung from 10 cm of wire and placed inside the calorimeter bomb device. Charge the calorimeter bomb to 300 atmospheres with pure oxygen to completely burns the sample in the presence of oxygen. The bomb was placed inside a device filled with distilled water until the temperature stabilized. After the temperature stabilized, an explosion occurred. The time interval between fixing the temperature in this test is two minutes. The calorimeter bomb was taken after the temperature stabilized. The vapors of the bomb blast poured into a container, and 3 drops of methyl orange or methyl red were added as reagents. Sodium carbonate was added again and shaken until the solution turned yellow. The amount of sodium carbonate added was calculated (Figure 4). Finally, using the following formula, the energy of each sample calculated using the Eq. 9:

$$\text{Energy (cal/g)} = \frac{\left(\begin{array}{c}\{(\text{temp}_{\text{final}} - \text{temp}_{\text{initial}}) \times \text{device hydrothermal}\} \\ -(\text{burnt wire length} \times \frac{2}{3} + \text{sodium carbonate consumption})\end{array}\right)}{\text{sample weight}} \quad (9)$$

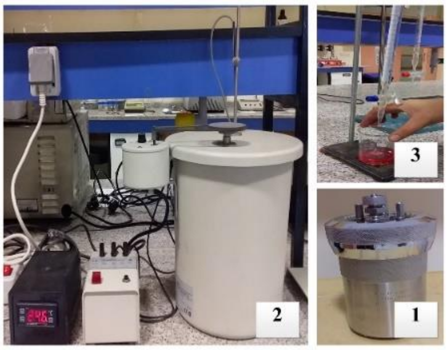

Figure 4. Energy measuring using a calorimeter bomb: (1) Combustion chamber, (2) Calorimeter bomb device and temperature sensor, (3) Adding sodium carbonate

2.2.5. DIETS REVIEW

To compare the results of the study and the tests performed on the samples, the diets available for livestock, poultry, and pets were collected and reviewed. In this section, after reviewing various researches on broiler chickens [16], fishes [26], poultries [27], chickens [28]; and on triticale seed [1], barley [29], barley grain protein [30], and information from books [31] Table 1 was completed.

Table 1. Classification of chemical analyzes and compounds of animal diets

Type of ration	Diet code	name of the ration	Dry matter (%)	Crude protein (%)	Fat (%)	Energy (cal/g)	Sources
Ready rations	P-1	Poultry ready foreheads	90.47	20.99	2.79	4013.21	[19]
	P-2	Poultry ready medium	91.59	19.35	2.53	4145.89	
	P-3	Poultry ready finish	91.52	18.64	2.71	4145.35	
	P-4	broilers Feed	91.25	18.64	2.71	4145	
(A) Diet from agricultural products	A-1	Triticale	93.23	13.26	1.52	4116.88	[2]
	A-2	Different wheat cultivars	95.95	14.69	1.25	4206.8	[14]
	A-3	Sprouted barley	52.63	10.31	2.78	4296	[15]
	A-4	Sprouted barley	90	27.5	2.8	NA	[13]
	A-5	Silage Alfalfa	31.85	18.05	1.48	4270	[16]
	A-6	Sunflower meal	92.27	29.46	6.1	4561	
	A-7	Rice straw	93.16	4.05	0.84	3634	
	A-8	Rice bran	92.29	7.1	6.59	4029	
	A-9	Barleycorn	91.97	11.33	1.69	4195	
	A-10	corn	89.86	9.22	3.73	4355	
	A-11	Silage corn	25.91	8.34	1.61	3938	
	A-12	Grain corn residues	92.81	5.95	1.34	3680	
	A-13	Dry grass	94.75	7.27	1.82	3983	
	A-14	Soybean meal	91.17	42.53	6.19	4448	
	A-15	Sesame straw	92.47	6.16	1.13	4230	
	A-16	Wheat bran	90.71	14.78	3	42.17	
	A-17	Wheat straw	94.57	3.22	0.79	3976	
(S) Diet from slaughterhouse products	S-1	filling Powder	90	87.4	2.9	NA	[13]
	S-2	bone powder	97.53	27.1	8.67	2440	[16]
	S-3	Blood powder	75	65.42	7.83	NA	
	S-4	Meat powder	86.36	52.21	11.81	4828	
	S-5	fish powder	91.81	58.98	13.52	4513	
	S-6	Poultry slaughterhouse powder	90.05	60.3	22.1	3907.7	[18]
Food waste	F-1	Waste of leek fields	10.91	14.13	1.08	3262	[16]
	F-2	dried bread	91.73	12.48	0.6	4021	
	Average		82.89	23.75	4.27	3495.93	

3. RESULTS AND DISCUSSION

3.1. RESULTS OF TESTS PERFORMED ON SAMPLES

The required information such as the weight of each food collected from the university. Based on analyzes performed on the samples, calculations related to various parameters, and according to the available information, Table 2 was resulted.

Table 2. Coding of food waste used and chemical analysis and compounds in them

Type of food	Dry ration weight (g)	Each food press weight (g)	Waste sample weight (g)	Dry matter (%)	Crude protein (%)	Fat (%)	Energy kcal/g
K	460	500/40	201/80	28.06	21.875	13.3	4341
E	450	502/80	219/11	27.97	17.938	8.25	4100

O	450	515/95	208/89	29.09	30.406	14.7	4182
G	460	509/50	181/78	30.03	33.031	6.95	4102
M	574	512/32	225/20	31.94	24.719	23.1	5310
Average	478/8	508/19	207/35	29.41	25.59	13.26	4407

3.2. INVESTIGATION OF DRY MATTER

The dry matter percentage of the university restaurant waste compared to other diets is shown in Figure 5. This parameter in food waste varies between 28.06 and 31.94%. These values indicate that about one-third of the weight of the waste is its moisture. Compared to the mentioned diets, it is obvious that the average amount of dry matter in food waste is only more than the F-1 diet and is approximately equal to the A-5 and A-11 diets. This result can be due to the high moisture content of fruit and vegetable wastes as well as the retention of moisture in the silage forage or corn due to storage in the grain depot. Accordingly, if the scale of dietary supply is their moisture content and dry matter, the evaluated food waste can be a good alternative to F-1, A-5, and A-11 diets. But in comparison with other diets, it can be said that the use of food waste as the main diet for animals has disadvantages. It is because the dry matter is one of the most important food elements in animal nutrition. But this parameter can be increased by combining food waste with bread waste which is mostly used in the abundance of restaurants. This deficiency can be compensated and the percentage of dry matter in food waste can be increased to the appropriate amount. Accordingly, if the scale of dietary supply is their moisture content and dry matter, the evaluated food waste can be a good alternative to F-1, A-5, and A-11 diets. But in comparison with other diets, it can be said that the use of food waste as the main diet for animals has disadvantages. It is because the dry matter is one of the most important food elements in animal nutrition. But this parameter can be increased by combining food waste with bread waste which is mostly used in an abundance of restaurants. This deficiency can be compensated and the percentage of dry matter in food waste can be increased to the appropriate amount.

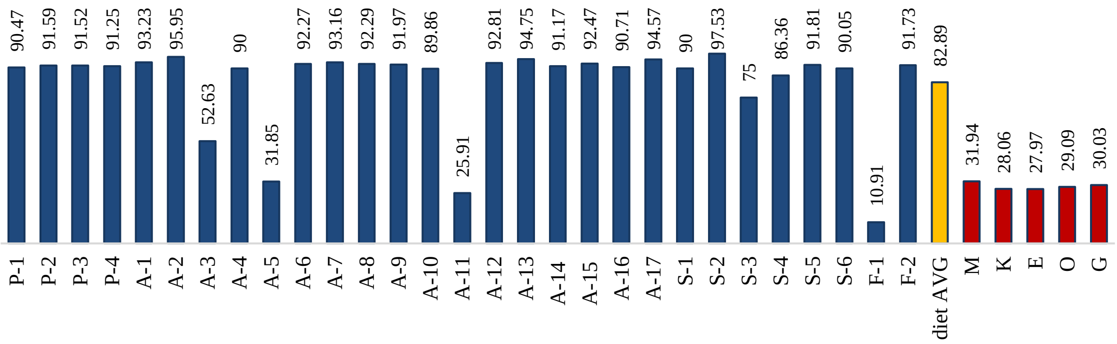

Figure 5. Comparison of dry matter percentage of existing diets with food waste rations

3.3. INVESTIGATION OF PROTEIN PERCENTAGE

The results of protein in diets and food waste is shown in Figure 6. The percentage of protein in food waste is significantly different from each other and this difference in the percentage is because of their composition. Food waste G has the highest percentage of protein due to chicken (chicken) tissue remaining in the food containers, followed by waste O, which is in the second place due to the high percentage of beans and meat. Food waste E has the lowest percentage of protein. It is because of the low percentage of meat. In general, comparing the percentage of protein in diets with food waste showed that the percentage of protein in food waste is close to the average percentage of protein in diets and can easily be used as a source of protein in animal diets. This conclusion is except for diets A-14 and diets of group S. The protein percentage of group S is very different from other diets and food wastes. Slaughterhouse wastes are a rich source of protein and there is no substitute for them, but compared to other diets, food waste can be a protein source required for animals.

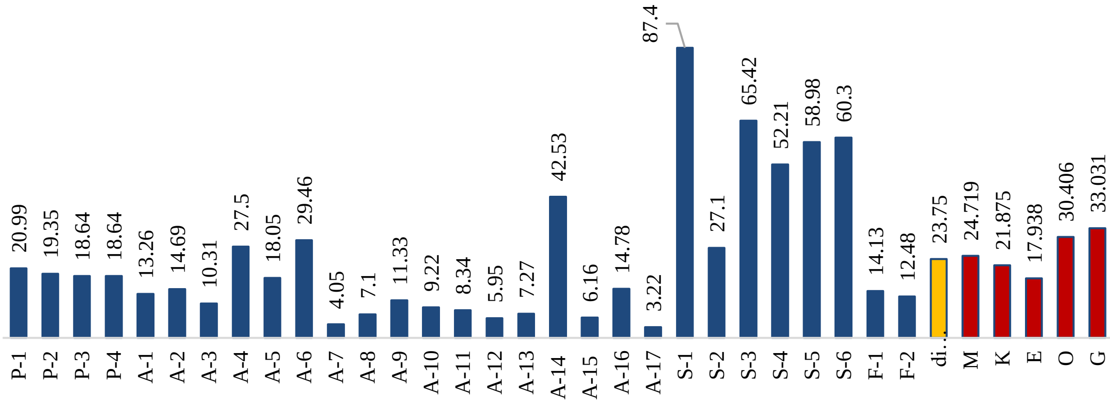

Figure 6. Comparison of protein percentage of existing diets with food waste rations

3.4. INVESTIGATION OF FAT PERCENTAGE

Figure 7 shows the percentage of fat in diets and food waste. The highest percentage of fat is related to food waste M. Using this waste which is a rich source of fat can supply the required fat of any diet. food waste O and K are in second place with a small difference and with a high percentage of fat (except in the case of S-6). They can be the next alternative to supply the fat required for animals' food. The reason for the high percentage of S-6 fat is related to the use of fatty parts of poultry such as their skin. The lowest amount is related to G food waste. It is important to note that Group S diets are not the main diet but are used as a dietary supplement to supplement some of the potential deficiencies or to strengthen the animals. So if this point is taken into account it can be stated that the food waste can easily be used as a source of fat for animals.

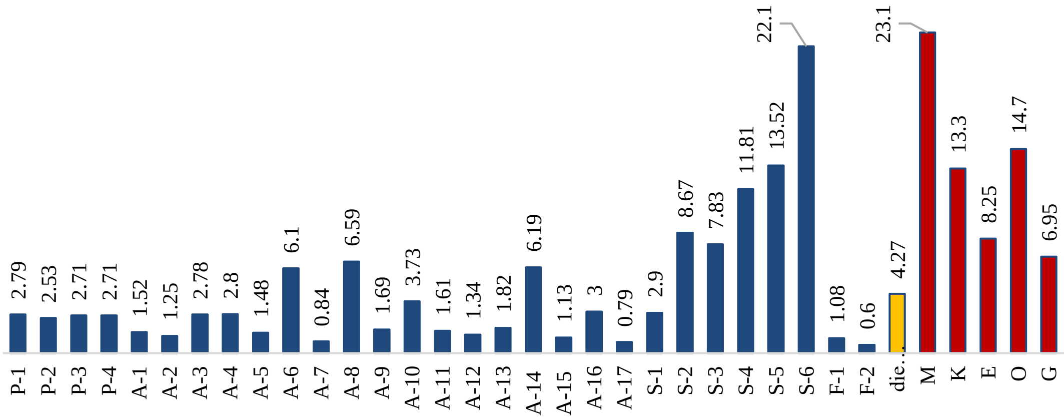

Figure 7. Comparison of fat percentage of available diets with food waste rations

3.5. INVESTIGATION OF ENERGY

Figure 8 examines the amount of energy in diets and food waste. According to the presented diagram, it can be said that diet M has the highest amount of energy compared to other food waste. Other wastes have almost the same amount of energy. Diet M can easily be used as a source of energy for animals because the amount of energy available to animals is higher than other diets. The second place is for the food waste K. This type of waste can be used as an alternative to the required energy source, except in diets S-5, S-4, A-14, and A-6. Other food wastes that have almost the same amount of energy can be considered as a suitable alternative to the energy of other diets. However, the average energy of food waste (4407 kcal/kg) comparing with the average energy of diets, it can be said that food waste can be a source of energy for animals.

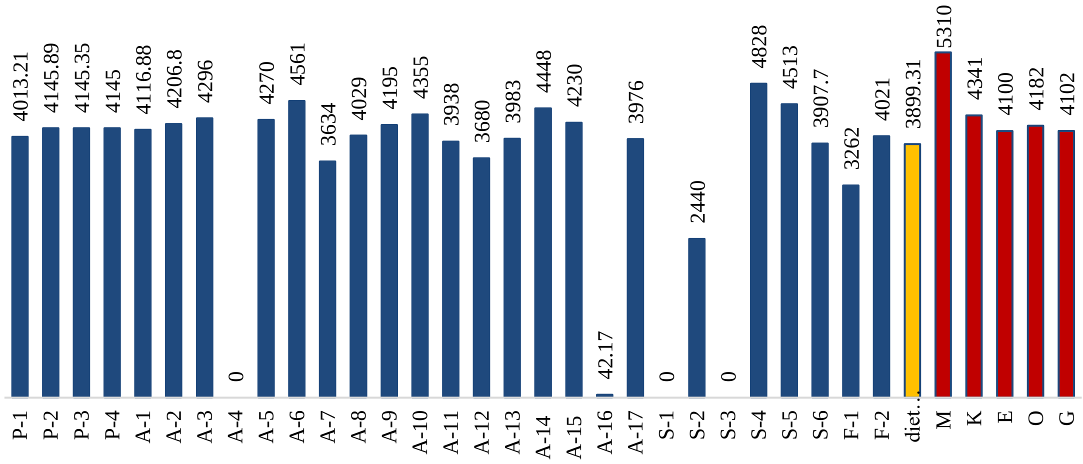

Figure 8. Comparison of the energy content (cal/Kg) of diets with food waste rations

3.6. FEASIBILITY OF USING FOOD WASTE IN DIETS

Type M food waste: According to the performed analyzes, the percentage of dry matter, percentage of moisture, percentage of fat are equal to 31.94, 24.71, 23.1%, and the amount of energy of chicken pilaf waste is equal to 5310 kcal per Kg has been obtained. Considering the low percentage of dry matter of all food wastes, it is observed that this food is in the highest amount in terms of fat percentage and energy content compared to other wastes and diets. It indicates the suitability of this waste to provide fat and energy requirement for animals. But, its protein content is in the third place and it is deficient compared to some diets. By adding some supplements, this nutritional need can be improved to turn chicken waste into a complete diet.

Type K food waste: A high percentage of this waste is related to rice and a little tomato with butter. Since this type of food is customer-friendly, its protein percentage is lower than the average required amount. In terms of fat percentage, it has an acceptable percentage and has a high amount of energy that can be used to supply fat or used the required energy.

Type E food waste: Minced stew waste is in the last rank in terms of all the compounds tested and this is because of its component and materials used in this food. The amount of meat left in this food is very low, which has led to a low percentage of protein. In this food, soybean may be used instead of/with meat. Its fat content and energy content are also lower than others. This waste can be used as a supplement to existing diets or to strengthen diets derived from food waste.

Type O food waste: Vegetable waste is in the second place among food waste in terms of protein percentage, fat percentage, and energy content, and also above the average amount of these items. The high percentage of protein is due to the presence of beans in this type of wastes. According to the above-mentioned reasons, vegetable waste can be used to provide a source of protein, fat, and energy needed by animals.

Type G food waste: Grilled chicken waste has the highest percentage of protein among the tested waste. The percentage of chicken leftover in this type of food is high and increases its protein percentage. Finally, it can be said that this type of waste will be a source of protein. The percentage of fat in this type of waste is the lowest among other wastes, but since it is higher than the average percentage of fat required in diets, it can be used as a determining source of fat. The amount of energy in it is also higher than the average value and it is possible to use it as a source of energy supply.

According to Figure 9, a general comparison can be made between food waste and diets used in animal nutrition. The percentage of dry matter in food waste is about one-third of the average dry matter required, and in this case, waste cannot be considered as a source of consumption, but by performing various tests such as combining food waste with bread waste in restaurants. Its dry matter percentage can be increased. The average percentage of protein in food waste is almost higher than the average protein in conventional diets, which shows the importance of this waste in providing the protein needed by animals. The percentage of fat in food waste is about three times more than the percentage of fat in conventional diets. It indicated that the food waste can be used as a source of fat for animal feed. In addition to the fact that process, we can expect an effect on weight gain. Finally, according to the diagram, it can be seen that the average energy of food waste is higher than the average amount of energy in diets.

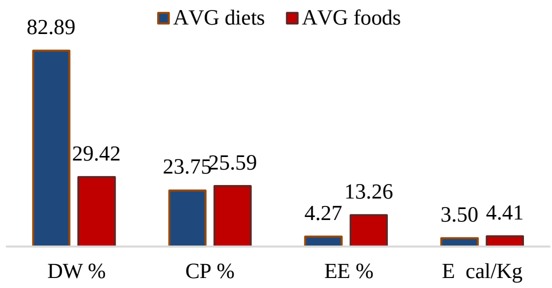

Figure 9. Comparison of compounds in food waste with existing diets

3.7. Limitations and Challenges

However, the mentioned results clearly indicate that using recycled wasted material to feed animals can be feasible, but there are many concerns to reach these ideal as mentioned below:

- A detailed review of various methodologies to sort, dewater, dry, blend and shape of product is required to development of a new device.
- Various tests of the outcome product such as product health tests, being tasty tests for target animals, and durability tests, should be done.
- The developed system has to be designed in various sizes and flexibilities to use in different environments and scales.

4. CONCLUSION

Food waste is one of the valuable materials that is discarded due to improper use or lack of adequate equipment. They also cause environmental pollution. Products can be provided to meet the nutritional needs of livestock, poultry, and aquatic animals if thermal processes are performed on food waste. These are compatible with the chemical composition of diets and are much more economical. On the other hand, to provide an optimal supply of other vitamins and minerals needed by animals, it is possible to use the wastes produced in the food preparation stage, such as vegetables and meat. Also, to minimize the possibility of spoilage in food waste, it is better to transfer the waste off each meal separately and quickly to processing places.

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