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Original article

Nutritional value of selected former food products for ruminant

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Summary. Former food products (FFPs) that are thought of as waste products actually should be considered as a valuable alternative feed resource in ruminant nutrition. These FFPs can be reutilized and converted by ruminants to valuable products for human benefits as a new resource and in return to increase the availability of limited feed resources. But, there are limited information and research regarding the nutritive value FFPs for ruminants. For this purpose, the experiment was conducted to evaluate the nutritional potential of the selected FFPs for ruminants specifically. Eight different types FFPs that are biscuits, bread, breakfast cereals, candies, chocolates, confectionery products, pasta, puddings, and also control flaked corn were analyzed for nutritional composition and metabolizable energy values were calculated by crude nutrients for ruminants. Further, energy, dry matter digestibility, and organic matter digestibility of FFPs and corn materials were investigated by using the cellulose enzyme method. All samples were analyzed the macro minerals (calcium, phosphorus, sodium, potassium, and magnesium) and the microelements (iron, copper, manganese, and zinc) contents. In the research, heat-processed flake corn was chosen for a control feed as a generally main energy resource in ruminant rations. Compared with corn, FFPs regarding the parameters in dry matter, ash, organic matter, crude protein, ether extract, crude fiber, nitrogen-free extract, nonstructural carbohydrate, neutral detergent fiber, acid detergent fiber, starch, sugar, calcium, phosphorus, sodium, potassium, magnesium, iron, copper, manganese, zinc, dry-organic matter digestibility, and energy were different ($P \leq 0.05$). In the research, selected FFPs compared with corn have generally shown a high nutritional composition (starch, sugar and oil content), energy, and *in vitro* digestibility but low mineral concentration. These properties make them a new component valuable energy source alternative feed ingredient to corn and other cereals not only for monogastric animals but also in ruminants.

Key words: ruminant, former food products, nutrition composition, metabolizable energy, digestibility

Introduction

The growing world population has increased the demand for plant and animal foods needed to meet the basic nutritional needs of people while making the already existing pressure on agricultural production even more noticeable (1). Limited and decreasing natural resources such as arable land, fuel oil, fertilizer, and water, meanwhile engendering environmental adversities e.g. climate change, soil and water degradation, and also food competition between human and animals, all of them makes it obligatory to use existing resources in an efficient, economical and least waste way (2). The prediction by (4) that the human population will reach 9.5 billion and increase the food requirement by 70% in 2050, has made agricultural production a concern that must be considered carefully, especially in animal production (3). Therefore, it is necessary to use the limited resources most efficiently and to evaluate the foods obtained as the least waste, while raising the interest in alternative feed materials that can increase the productivity by animal species and reduce the food competition between animals and human. When the subject is considered in terms of sustainability of animal production, while farm animals consume 1/3 of the grain produced worldwide, 40% of agricultural lands are used for feed production (4). High productivity indexed selection and management systems in animal production have evolved livestock in high energy/protein content vegetable products such as cereals, soybeans competing with humans. This process has become a matter of how efficiently the livestock industry transforms pasture or not edible lands and foods that can be consumed by humans into animal products such as milk, meat, and eggs (5).

Considering that approximately 30% of food produced (1.3 billion metric tons) is waste before reaching people (6), and feed cost is 85% of animal production (7), it is clearly seen that it has a solution in the problem. Although ruminants can convert plants in pasture and grasslands that cannot be used in human food to quality animal products, today, genetic selection and management systems, which are made for obtaining high yields in today's conventional animal farming, have caused the use of energetic grains in high amounts in rations. Therefore, one of the most important strategies to reduce competition between humans and animals seems to be reevaluation food waste, which is no longer important for humans, to the feed industry (8).

According to the EU Catalogue of Feed Materials (Regulation (EU) No 2017/1017), former food products are: "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 any health risks when used as feed". Although these products have no commercial value as human food, they have an extremely valuable nutrient content as animal feed. In many countries, when these foods cannot be sold as human food for a certain period time, because of lost their commercial value, and then they return to their production locations due to the legal obligations in storage and lack of consumer demand. Thus, these types of foods, which accumulate in large quantities in storages, are ready for the feed industry as new segment energy-rich feed materials (8). Their valuable nutrient content, these materials are separated from the packs and dried, then separated and grinded and used directly or indirectly as new feed raw material in total mixed rations or concentrate feeds (9); can be recycled to the economy (10).

As it is known, with the intensive production in the last 60 years, the development of the feeding technology together with the improving genetic potential of the has significantly improved the milk and meat productivity (11). Normally ruminants do not require cereals for animal production, but when these conventional feed materials are not used in rations, their efficiency and productivity decrease. For these reasons, cereals with high energy content are used in rations to meet the energy requirement of ruminants (12). Non-structural carbohydrate (e.g. starch, sugar) and high oil FFPs can be used as ruminant feeds as energy source materials. The potential of these products has not been studied enough as feed ingredients except mononogastric farm animals such as pigs and poultry. Especially, the potential of FFPs or ex-foods as feed ingredients for ruminants have not fully exanimated. Therefore, in order to evaluate some selected FFPs or ex-foods as alternative energy feed in ruminant feeding, this study investigated nutrition composition, metabolizable energy, and *in vitro* digestibility for ruminant nutrition.

Materials and Methods

Sample collection

Eight different types of former food products were selected for nutritive evaluation based on their use in ruminant nutrition, particularly in dairy and beef rations. These samples were biscuits, bread, breakfast cereals, candies, chocolates, confectionery products, pasta, puddings, and flaked corn as a control feed ingredient. Each FFPs were collected from eight different storage facilities of food business operators or leftover processors of the confectionery or bakery food manufacturers. Each FFP consists of eight different samples; each one is analyzed in three replicates one by one for each parameter. All of them as an ex-food material were expiration of internal sell-by date products. In the experiment, all FFPs samples were performed flaked corn samples as a control feed material. Because of high starch content, the corn grain used as a main energy feed raw material in high producing dairy and beef cattle rations was selected as an experimental control ingredient and eight flaked corn samples were taken from eight different compound feed factories in Izmir/Turkey. Before chemical analyses, all experimental samples were ground through a 1 mm screen in preparation for chemical analysis and stored at 4°C in a refrigerator until analysis.

Nutrient composition

Eight samples of each type FFPs and corn were analyzed chemically for all parameters (Table 1). Nutrient contents of air-dry samples were analyzed according to the methods reported in (13), and all data were presented on a dry matter basis. All samples were analyzed for dry mater (DM) (method 934.01), ash (method 942.05), crude protein (CP) (method 990.03), ether extract (EE) (method 920.39), crude fiber (CF) (method 962.09). The sugar content of the materials was determined by the Luff-Scroll method and the starch determination by polarimetric method (14). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were determined using the methods by Van Soest (15). Nitrogen-free extracts (NFE) were calculated as 100-%(moisture+CP+EE+CF+Ash). NSC was obtained using the following equations as 100-%(NDF+CP+EE+Ash). Organic matter (OM) was calculated as OM%=DM%-Ash%.

Phosphorus (P) contents of the materials were read by spectrophotometer (model PE General TU-1880 Model Double Beam UV-V15) by calorimetric methods (13). Atomic absorption spectroscopy (Ultrospec 2100 pro UV/visible 106 spectrophotometer) was used for determining calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), zinc (Zn), iron (Fe), manganese (Mn), copper (Cu) concentrations. Estimates for crude nutrition metabolizable energy (ME_{CN}) as kcal kg^{-1} in DM were based on crude nutrients (protein, fiber, and fat levels) determined from the samples using a prediction equation (16);

ME_{CN} kcal kg^{-1}: 3260 + (0.455xCP+3.517xEE-4.037xCF) and CP, EE, CF quantities in OM (g kg^{-1}). All nutritional parameters, mineral contents, and energy values of the samples are given on a dry matter basis.

In vitro *digestibility*

The *in vitro* dry matter, organic matter digestibility, and cellulose enzyme metabolizable energy (ME_{CEL}) was determined according to the cellulose enzyme method described by (17) modified from (18). The *in vitro* organic matter digestibility was estimated by the equation developed by (19). The enzymatic procedure investigated comprises 3 steps: (1) pepsin (Sigma) in 0.1 M HCl at 40°C for 24 h; (2) starch hydrolysis in the same solution at 80°C for 45 min; (3) cellulase (from *Trichoderma viride, Serva*) at 40°C for 24 h. The *in vitro* digestibility analyzes were serially performed on each FFP and flaked corn sample in triplicate. Values are expressed on a dry matter basis in all equations. Enzymatic dry matter digestibility (DMD), organic matter digestibility (OMD) and *in vitro* cellulose enzyme metabolizable energy (ME_{CEL}) were calculated using the following equations;

$$\text{DMD, \%} = \text{IVDMD \%: } ((A_n-(A_k - A_o)) / A_n) \times 100$$

$$\text{OMD, \%} = \text{IVDOM \% : } 100 \times (940 - \text{CA}-0.62 \times \text{EULOS} - 0.000221 \times \text{EULOS}^2)/(1000 - \text{CA})$$

$$ME_{CEL}\ (\text{Mcal kg}^{-1}\text{DM}) = (1.04 + (0.00001611 \times \text{ELOS}^2) + (0.3724 \times \text{EE}) - (0.0003674 \times \text{ELOS} \times \text{EE}) - (0.0004919 \times \text{EE} \times \text{CF}) + (0.01548 \times \text{CF}))/4.186$$

*EULOS; enzyme insoluble OM, A_n; sample weight (g kg^{-1}), A_o; crucible tare (g kg^{-1}), CA% and EULOS in g kg^{-1}DM

Statistical analysis

The statistical analysis of the results included a one-way analysis of variance ANOVA using General Linear Models and Duncan's multiple range test, which were applied to the results using the SPSS 25 (20). The model included FFPs types as main effects. Differences were considered to be significant based on the 0.05 level of probability.

Results

The means and standard errors for the nutrient composition and mineral content of eight selected FFPs (biscuit, bread, breakfast cereals, candy, chocolate, confectionery products, pasta, pudding) and control flaked corns are given in Table 1 and Table 2 respectively. In addition, Table 3 showed the DMD, OMD, ME_{CN}, and ME_{CEL} values of control and eight selected FFPs.

The differences among the selected FFPs and corn samples in DM, ash, OM, EE, CP, CF, cellulose, NFE, NSC, NDF, ADF, starch, and sugar contents were significantly different P≤0.05. The DM content of the FFPs and corn were within the range from 989 to 888 g kg^{-1}. All the dry matter content most of the FFPs were greater than corn and pasta samples and moisture contents less than 120 g kg^{-1}. Candy samples had the highest DM content, while corn and pasta had the lowest DM content. The overall average means of

Table 1. Nutritional composition of control flaked corns and eight selected former food products (g kg^{-1}, in DM)

	DM	Ash	OM	EE	CP	CF	NFE	NSC	NDF	ADF	Starch	Sugar
Corn	888^{d}	16^{bc}	984^{bc}	48^{d}	93^{c}	22^{b}	787^{d}	637^{g}	202^{a}	41^{a}	645^{b}	32^{f}
Biscuit	970^{b}	15^{c}	978^{c}	164^{b}	82^{d}	4^{cd}	726^{e}	680^{f}	56^{d}	29^{bc}	411^{d}	195^{e}
Bread	913^{c}	22^{a}	968^{d}	15^{e}	155^{a}	19^{b}	783^{d}	723^{e}	81^{c}	24^{c}	613^{c}	27^{f}
Breakfast Cereals	923^{c}	18^{b}	978^{c}	133^{c}	109^{b}	21^{b}	717^{e}	596^{h}	141^{b}	42^{a}	334^{e}	214^{d}
Candy	989^{a}	4^{e}	994^{a}	4^{e}	8^{g}	—	982^{a}	982^{a}	—	—	119^{h}	921^{a}
Chocolate	972^{b}	18^{b}	976^{c}	321^{a}	80^{d}	44^{a}	525^{f}	494^{i}	84^{c}	27^{bc}	63^{i}	236^{c}
Confectionery Products	972^{b}	5^{e}	994^{a}	7^{e}	45^{e}	4^{cd}	947^{b}	911^{c}	30^{e}	—	213^{f}	207^{de}
Pasta	897^{d}	8^{d}	989^{ab}	5^{e}	146^{a}	11^{c}	828^{c}	767^{d}	71^{c}	33^{b}	734^{a}	30^{f}
Pudding	965^{b}	4^{e}	994^{a}	10^{e}	23^{f}	7^{c}	947^{b}	942^{b}	18^{e}	2^{d}	179^{g}	613^{b}
SEM	3	1	1	10	4	1	13	15	5	1	22	27
Probability	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05

$^{a,b,c,\ldots h}$ Different superscripts indicate differences among the group means in the same row at $P \leq 0.05$

Table 2. Mineral content of control flaked corns and eight selected former food products

	Ca[1]	P[1]	Na[1]	K[1]	Mg[1]	Fe[2]	Cu[2]	Mn[2]	Zn[2]
Corn	2.3^{b}	0.5^{d}	1.4^{c}	7.4^{a}	0.9^{c}	139^{a}	27^{e}	57^{b}	14^{cd}
Biscuit	2.5^{b}	2.3^{b}	4.8^{ab}	2.4^{e}	0.4^{de}	128^{ab}	59^{ab}	30^{c}	10^{e}
Bread	2.5^{b}	1.7^{c}	5.2^{a}	4.7^{cd}	0.8^{c}	117^{abc}	52^{cd}	15^{d}	18^{bc}
Breakfast Cereals	3.8^{a}	2.7^{a}	4.4^{b}	6.2^{bc}	7.0^{a}	115^{bc}	59^{ab}	37^{c}	15^{bcd}
Candy	0.5^{c}	0.1^{e}	0.4^{d}	0.1^{f}	0.2^{e}	107^{bc}	48^{d}	65^{b}	19^{a}
Chocolate	2.4^{b}	1.8^{c}	1.1^{c}	7.1^{b}	1.2^{b}	97^{c}	49^{d}	8^{d}	18^{b}
Confectionery Products	0.8^{c}	0.6^{d}	1.5^{c}	1.1^{ef}	0.3^{e}	139^{a}	62^{a}	87^{a}	13^{d}
Pasta	1.2^{c}	1.8^{c}	0.2^{d}	4.1^{d}	0.7^{cd}	127^{ab}	56^{bc}	18^{d}	23^{a}
Pudding	0.6^{c}	0.3^{de}	1.6^{c}	1.6^{e}	0.2^{e}	103^{c}	52^{cd}	35^{c}	9^{e}
SEM	0.1	0.1	0.1	0.5	0.2	2	1	2	1
Probabilty	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05

$^{ab,..e}$ Different superscripts indicate differences among the group means in the same row at $P \leq 0.05$

[1] g kg^{-1}, in dry matter

[2] mg kg^{-1}, in dry matter

Table 3. Dry and organic matter digestibility and metabolizable energy content of control flaked corns and eight selected former food products

	DMD[1]	OMD[1]	ME_{CN}[2]	ME_{CEL}[2]
Corn	94.21[ef]	94.42[cd]	3.33[d]	3.32[e]
Biscuit	93.01[e]	92.25[d]	3.86[b]	4.32[a]
Bread	96.04[bcd]	95.83[bc]	3.21[e]	3.29[e]
Breakfast Cereals	94.87[cde]	94.32[cd]	3.59[c]	3.77[c]
Candy	99.08[a]	99.28[a]	3.26[de]	3.54[d]
Chocolate	85.70[f]	85.51[e]	4.16[a]	4.15[b]
Confectionary Products	97.09[ab]	97.62[ab]	3.26[de]	3.39[de]
Pasta	96.72[bc]	97.98[ab]	3.27[de]	3.44[de]
Pudding	97.08[ab]	97.44[ab]	3.26[de]	3.43[de]
SEM	0.42	0.48	0.03	0.03
P	≤0.05	≤0.05	≤0.05	≤0.05

[ab,c,..,f] Different superscripts indicate differences among the group means in the same row at $P \le 0.05$
[1] %, in dry matter
[2] Mcalkg-[1], in dry matter

the ashes in FFPs varied between 22 and 4 g kg^{-1}, comparable with corn ash content 16 g kg^{-1}. FFPs samples such as candy, pudding, confectionary products, and pasta had the lowest and bread had the highest ash concentration while breakfast cereal, chocolate, and biscuit were the same corn. The average organic matter content of samples was quite high (968-994 g kg^{-1}). Bread, chocolate and biscuit in FFPs were lower the OM content than corn. The fat content of FFPs samples was considerably variable; chocolates, biscuits and breakfast cereals had the highest EE content (321, 164, and 133 g kg^{-1} respectively) than corn (48 g kg^{-1}). On the other hand; the oil content means of the candy, pasta, confectionery products, pudding, and bread samples were less than corn sample (4, 5, 7, 10, and 15 g kg^{-1} respectively).With regard to the protein average means, in the FFPs samples ranged from 8 g kg^{-1} to 155 g kg^{-1} and corn samples was 93 g kg^{-1}. When compared with the corn; bread, pasta, and breakfast cereal in FFPs were higher CP content while others were lower.

The NFE values calculated for FFPs and corn ranged the lowest in chocolate 525g kg^{-1} to the highest in candy 982 g kg^{-1}. Except for the chocolate samples, all other samples showed more than 500 g kg^{-1} NFE average value. Similarly, NSC means as NFE were the lowest in chocolate 494 g kg^{-1} and breakfast cereal (596 g kg^{-1}) and the highest in candy 982 g kg^{-1} in FFPS.

Except for the chocolate (44 g kg^{-1}), all the other FFPs samples showed less CF content when compared with corn (22 g kg^{-1}). Similarly, other fiber content, the NDF value was the highest in corn (202 g kg^{-1}) compared with FFPs samples (between 18 and 141g kg^{-1}). The ADF showed that corn and breakfast cereals had higher values than other FFPs means (41 and 42 g kg^{-1} respectively).

The starch content in pasta was the highest in all samples (734 g kg^{-1}) and other samples for FFPs, bread had the third highest starch value (613 g kg^{-1}) after corn (645 g kg^{-1}) and all other FFPs were lower than corn. The sugar content ranged from 27 g kg^{-1} to 921 g kg^{-1} in FFPs and corn, with the lowest content, in bread, pasta and corn (27, 30 and 32 g kg^{-1} respectively) and highest value recorded for candy 921 g kg^{-1}.

The means and standard errors for the mineral content of eight selected FFPs (biscuit, bread, breakfast cereals, candy, chocolate, confectionery products, pasta, and pudding) and corn are given in Table 2. All the observed parameters related to mineral contents as Ca, P, K, Mg, Na, Zn, Fe, Mn, and Cu of the FFPs and control corns samples were found significantly different P≤0.05. When the breakfast cereals had the greatest concentration of Ca (3.8 g kg^{-1}); the candies, puddings, and confectionery products had the lowest concentrations of Ca (0.5, 0.6 and 0.8 g kg^{-1} respectively) compared with all the other FFPs and the corn samples. The average P content was the highest in breakfast cereals (2.7 g kg^{-1}) and the lowest in candies (0.1 g kg^{-1}). The phosphorus content was less than 30% in all samples. The potassium content in corn (7.4 g kg^{-1}) is highest and significantly higher than all other FFPs materials. Except for the breakfast cereals (7.0 g kg^{-1}), all the other samples were less than 1.2 g kg^{-1} mean values for the Mg content. When the Na content was the lowest for pasta, and candies (0.2 and 0.4 g kg^{-1} respectively), the highest for the bread samples (5.2 g kg^{-1}).

The zinc content in terms of micro minerals for FFPs and corn ranged from 23 to 9 mg kg^{-1} and the average was 15 mg kg^{-1} for all samples. The iron content was the highest for confectionary products and corn (139 and 139 mg kg^{-1} respectively), the lowest the chocolates (97 mg kg^{-1}). The manganese content was greater than the confectionery products (87 mg kg^{-1}) compared with the other FFPs and corn. The Cu content was the lowest for the corn (27 mg kg^{-1}) and the other FFPs samples ranged 48 to 62 mg kg^{-1}.

The values of *in vitro* dry and organic matter digestibility, ME_{CN} and ME_{CEL} contents of flaked corns and eight selected former food products are shown in Table 3 and all parameters were observed significantly differences P≤0.05. The dry matter digestibility values that were high in all samples and obtained in FFPS (ranged 85.70 to 99.08%) were comparable with that of corn (94.21%). The organic matter digestibility values of the FFPs samples were ranged from 85.51% for the chocolate to 99.28% for candy and corn showed a 94.42% average value. The ME_{CN} value in FFPs was the highest for chocolate (4.16 Mcal kg^{-1}) and the lowest for bread samples (3.21 Mcal kg^{-1}) and corn had a 3.33 Mcal kg^{-1} average mean. The ME_{CEL} value was ranked biscuit, chocolate, breakfast cereal, candy, pasta, pudding, confectionery products, corn, and bread respectively. The corn and bread had the lowest ME_{CEL} value.

Discussion

The present study was performed to evaluate the nutrition composition of some selected FFPs by comparing them with corn grains on ruminant nutrition. The DM content of all FFPs and corn was greater than 880 g kg^{-1}.The DM in FFPs was close to 950 g kg^{-1} indicating that FFPs have a greater concentration of DM than most other cereal feed ingredients commonly used in the ration for ruminants. The high concentration of dry matter in the some selected FFPs used in this research indicates that the food ingredients were used to produce the food products such as candy, pasta, bread, breakfast cereals, biscuits that have been cooked and/or heat-treated during their production process in the food industry than what is usual for farm animal feed ingredients (7, 21). Also the high DM or low moisture content in ruminant nutrition is very important because of providing easy storage and use for ration or compound feed industry. Meanwhile high moisture content in food waste can increase the susceptibility to microbial growth and spoilage (22, 23). The findings of DM content of FFPs and corn grain are consistent with the findings of the relevant studies in general (24, 25, 10).

The ash and calculated OM contents of the FFPs were found similar to the corn. FFPs had a low quantity of ash contents that were ranged from 4.2 to 22 g kg^{-1}. However, the low concentrations of ash in some selected FFPs (candy, pudding, confectionery product and pasta) were less than what is usually present in cereal grains (24) and previously reported values for FFPs (10, 25). The reason for these selected FFPs samples in the study consist of the same type of materials rather than other studies that were mixed different types ex-food materials. On the other hand; the low ash and high OM contents of these FFP sources suggest that they may be valuable feed ingredients in ruminant nutrition.

In the experiment, some ex-food as chocolates, biscuits, and breakfast cereals had the greatest concentration of EE compared with all the other selected waste foods (25, 26). On the other hand, considering the origin of FFPs for the oil or fat content of the selected samples which was over 300 g kg^{-1}(chocolates), is similar to demonstrated values (27, 28). The relatively high concentration EE is the result of that fat or oil is one of the main contributors for some confectionary products e.g. chocolates, biscuits. Nutritional characteristics of byproduct feed and former food products are very variable, owing to different models of production processing, consumption habits, and/or the mixing of different types of ex-food materials (29). It is well known that unsaturated fatty acids are toxic to many of the species of the rumen bacteria, particularly those that are involved in fiber digestion, and may negatively affect rumen cellulolytic bacteria and performance (30). However, fat additives in intensive farming systems are used to improve the energy density of rations to meet the energy requirements of dairy cows or fattening cattle (31). Also, approximately 65% of the fat in chocolate is saturated, composed mainly of palmitic acid and stearic acid, while the predominant unsaturated fat is oleic acid (28). For this reason, no negative effect on the health or performance of animals should be expected from using chocolate or other ex-food in a balanced ration with other feed ingredients. (32) decelerated total ration oil content should not exceed 7% of the DM, and usually will be adequate at 6% or less, therefore the having high EE content former food products as chocolate should not be completely replaced by corn, but they may be present at rations up to 2.5 kg/day/head which is approximately 6% of concentrate feed DM or 4% of total mixed ration (33, 34). The study showed that the protein contents of the food wastes are low, highly variable, and at the same time, their averages are similar to corn. The findings about CP contents of some FFPs types and corn grain are consistent with the findings of the relevant studies in general (10, 24, 35). The results related to the protein contents suggest that the FFPs should not be considered as a good source of protein because of the low concentration and origin (25). But the protein quality may be improved due to the high heat and long baking process as a rumen undegradable protein fraction.

In the research, all ex-food samples that selected mainly produced from cereals and sugar-containing herbs showed the good average starch and sugar concentrations. At the same time, some FFPs had higher sugar and starch consents (e.g. candy and pudding for sugar, pasta, and bread for starch respectively) than corn in this study. For this reason, the former food products in the research may be a good alternative to grains as a good source of energy for ruminants. As known, corn contains the highest level of starch (600-700g kg^{-1}) and has the lowest percent of ruminal starch digestion. These characteristics make it a valuable energy source for cattle (35). Because of the processing, the bread and pasta (heating, baking) have chanced chemical structure of the carbohydrate, effectively increasing the level of bypass nutrients (36) and can be used up to 75% corn in growing-finishing beef diets without reducing the performance (37, 38).

Most of the research or literature has focused on the starch concentration of FFPs, while limited information is available on sugar content. This study showed that sugars constitute an important part of carbohydrates in the ex-food samples. It is reported that FFPs were defined as a high simple sugar and satisfactory starch concentrations with sufficient fat or oil content (25, 10). However, in the present study, analyzed FFPs have high starch concentrations combining enough sugar and oil content. But also, the candy and pudding in the experiment have higher sugar content than other reported study by (10), and they may be used as an excellent alternative sugar source to corn grain in dairy or beef cattle ration. As known, carbohydrates that are especially starch and fiber as primary nutrition components which contribute up to 70% of the diets, used to dairy cows and beef steers (39). Also, sugars may be good alternative energy sources for any adverse effect on rumen fermentation and animal performance. Generally, sugars are known as water-soluble carbohydrates that are readily available in the rumen, and consist of disaccharides, such as sucrose, lactose, and maltose, and monosaccharaides, such as glucose, galactose, and fructose (40). Thus, feeding sugar or when sugar replaced dietary starch, improves rumen degradable protein utilization (41) dry matter intake and milk fat content.

Based on the structural carbohydrate contents such as cellulose, NDF, ADF, and CF contents of the FFPs, were significantly lower than corn grain and other cereals commonly used in ruminant nutrition (24). Furthermore, these parameters for the same ex-foods materials (e.g. candy, confectionery products) were none defined or had too low value, because these products were composed primarily simple or water-soluble sugar. This funding agrees with previously reported research that FFPs samples characterized by comparable fiber or limited content with other cereal grains (25). Fiber is the main carbohydrate fraction of ruminant rations, and is necessary to provide adequate amounts of complex carbohydrates to slow digestibility and control the acidity in the rumen for healthy rumen fermentation. Because of dairy or beef steers require fibrous feedstuffs in the diet, the ADF and NDF content of the feeds are important fiber fractions that need to be carefully considered in balancing the ration formulation (42). Utilizing this kind of formal foodstuffs for ruminant feeding, ADF and NDF contents should be carefully considered in ration making.

Data for concentrations of ME and have indicated that selected FFPs samples contained more ME_{CN} and ME_{CEL} than corn, which may be a result of the high concentration of starch, sugar, and oil and also low content fiber fractions in the product (25, 43). The only exceptions were bread samples that had less ME than corn. This result does not agree with the results from (37), who suggested that bread by-products which therefore had more rapidly fermentable carbohydrates (starch and sugar) have higher energy value than corn. Controversially, this research has agreed with (21) suggested that bakery meal contains less ME than corn. The reason for this observation may be that although the mainly of the ingredients originate from flours and possibly whole cereal grain foods, high fiber ingredients (e.g. bran) are also included in the product blend to produce bakery dough. Another possible reason may be that salt and other minerals are often added to bread, which results in a relatively high concentration of ash in the product (21, 44). The metabolizable energy values obtained by the calculation systems based on the chemical composition of feeds cannot accurately determine the true energy values, so an *in vitro* energy assessment was performed enzymatically and the FFPs were similar or even slightly higher (4.3%) than the energy values found by the calculation.

Considering DMD and OMD means of the FFPs samples have shown higher digestion values than the control corn samples except for the chocolates. These results compare with previously reported by (25) that FFPs are highly digestible depending on the origin or the mixture used their preparation. Also, the small variations observed between selected FFPs and lower digestion rate (DMD and OMD) for the chocolates which are thought to be due to nutrition composition, especially EE content and nonstructural carbohydrate level (25). So, both the high EE and the low nonstructural carbohydrate content significant decrease in the DMD and OMD values of the chocolate may be interpreted as oil content negatively affects the digestion of the feeds comparing with ruminant. On the other hand, the all other FFPs having higher DMD and OMD values than the corn may be seen related to the fact that selected FFPs were cooked products in which the starch and other carbohydrates had been heat processed (26, 10). Taken together, the nutrition composition and energy contents (ME_{CN} and ME_{CEL}) of the selected FFPs were in line with the literature which declared that the oil content (46) and the amount and the type of non-fiber carbohydrate contents (25) of a feed highly affect its digestibility (45).

The calcium concentrations of the selected FFP samples were observed a little variation in this study, and were for the most part higher previously reported values (24) but same with (21). The breakfast cereals had the highest Ca content than other samples and control flaked corn. The reason for this may be due to calcium carbonate and limestone supplemented within food enrichment techniques during the preparation process (47). The contents of P in the selected FFPs and corn observed in this study were within the range of previously published values (24, 33, 35, 37). The concentrations of Ca and P in all of these selected FFP sources are not great enough to be thought of as sources of these minerals in ruminant nutrition. Thus, the concentrations of K, Mg, and Na relating to selected FFPs in the research were in line with the literature decelerated by (24, 27, 35). The Na concentration of the bread, biscuit and muesli products, and also Mg content of muesli among the FFPs in the study were greater than corn in the research and other cereal grains in demonstrated literature by (24, 35). The findings observed in the present study are in agreement with a previous study reporting that salt (21) and Mg (46) supplements adding during the production of these foods increases the Na and Mg content. In contrast to Na, the K concentration of the FFPs was lower than corn, therefore, it is thought that this mineral was not added to these foods. The concentration of Fe, Cu, Mn, and Zn investigated as micro minerals for selected FFPs in this study were close to what is expected in cereal grains. There was no report focusing on the mineral concentration of the ex-food in ruminant nutrition, thus the present results could not be compared with other studies in the literature.

Conclusion

The increasing global food and feed require to find an alternative energy sources, which has led to researches in the field of non-conventional feed materials as former food products. Therefore, based on this research results regarding the nutrition composition of some selected FFPs indicates that (i) the FFPs have valuable starch (pasta, bread, biscuit, and breakfast cereals), sugar (candy, pudding, chocolate), starch-sugar (biscuit, breakfast cereals and confectionery products) and oil (chocolate) content that are the main compounds making them high energetic feeds; (ii) the most of selected FFP sources show a higher digestibility and metabolizable energy than heat proceed corn and conventional cereal grains; (iii) they are characterized by high technologic processes and nutritional quality standards; (iv) also a result are the low macro and micro mineral concentrations for ruminant.

In conclusion, it seems to be possible that former food products can be used as alternative energy feed sources instead of conventional cereal grains in ruminant diets. Also, using such valuable FFP source as feed helps to reduce waste and minimize the adverse effect on the environment.

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