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Facial Tissue Paper as a Feedstuff for Lambs

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A ton of a pelleted ration was prepared containing 25% by weight facial tissue paper mixed with corn, soybean and alfalfa meals, molasses, minerals, and vitamins. The facial tissue paper consisted entirely of virgin cellulose fibers from which almost all lignin had been chemically removed during manufacture. The ration was fed to four 3-month-old wethers for 125 days. A similar pelleted ration containing proportionately more alfalfa meal to replace the facial tissue was fed to wethers as a control diet. The in vivo dry matter ration digestibilities averaged 74 and 71% for the replicated lambs fed the control and facial tissue paper-containing diets, respectively. No significant differences ($p > 0.05$) were observed in the average daily feed consumed or average daily weight gains among the two treatment groups.

The incorporation of waste paper as a substitute form of cellulose in farm animal rations has been studied by several investigators. Sherrod and Hansen (1973), Dinius and Oltjen (1971, 1972), Mertens et al. (1971), Daniels et al. (1970), and Kesler et al. (1967) investigated newspaper and magazines as feedstuffs. Nishimuta et al. (1969) studied office bond paper and Becker et al. (1975) and Coombe and Briggs (1974) investigated a variety of others.

The digestibility of various types of paper by ruminants depends upon their lignin content since lignin is not digestible. Newspaper typically contains largely mechanical fibers but also some fibers chemically treated to remove lignin. Magazine paper contains about one-third mechanical fibers (no lignin removed), one-third "chemical fibers" (lignin removed), and one-third fillers such as starch, clays, and alumina which are added to impart opacity to the paper. Magazine, office bond, and computer printout paper, all of which are partially delignified during manufacture, are therefore more digestible by ruminants than newspaper. Other delignified wood products which have been studied as additives to farm animal rations have included various wood pulp fines and residues (Dinius and Bond, 1975; Millett et al., 1973) and wood cellulose (Riquelme et al., 1975).

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Table I. Composition of the Complete Pelleted Animal Rations

Constituent	Percent dry weight in: Facial tissue paper ration	Control ration
Facial tissue paper	25	
Corn meal	34	40
Soy bean meal	25	12
Alfalfa meal	11	43
Molasses	4.7	4.7
Minerals	0.25	0.25
Vitamins (A, D, and E)	0.05	0.05

Table II. Content of Ash, Fat, Protein, Fiber, and Energy in the Pelleted Rations

Constituent	Percent (dry weight) in: Facial tissue paper ration	Control ration
Ash	4.9	6.3
Fat	1.9	3.8
Protein	16.3	19.0
Crude fiber	22.0	9.4
Energy	4309[a]	4453[a]

[a] Calories per gram (dry weight).

Table III. Data Pertaining to Animal Performance

Animal code no.	Ration	Average daily feed consumed,[a,b] dry wt, g	Average daily weight gain,[a,b] g	Average dry matter ration digestibility (in vivo),[a] %
40-43	Control	1163 ± 33[c]	210 ± 27[c]	74 ± 2[c]
45-48	Facial tissue paper	1232 ± 108[c]	226 ± 28[c]	71 ± 2[c]

[a] Mean ± standard deviation for the replicated animals. [b] Average for the entire 125-day feeding period. [c] No significant differences among treatment means ($p > 0.05$).

About 10 million tons of facial tissue-type paper is produced in the United States annually. This paper consists of cellulose fibers from which almost all lignin has been removed chemically. Facial tissue paper might therefore expectedly be very digestible as a feed additive for ruminants. About 5% of the facial tissue paper produced is not immediately packaged for sale owing to machine breakdown. This material must therefore be recycled and is available, for instance, for animal feeding studies. In the work reported a pelleted ration containing 25% by weight of facial tissue paper was prepared and fed to lambs for 125 days in order to assess animal acceptance, performance, weight gain, and ration digestibility.

EXPERIMENTAL PROCEDURE

A 500-lb bale of facial tissue paper was obtained. The tissue had been manufactured entirely from virgin cellulose fibers chemically treated to remove most lignin. No wet strength or other additives were contained in the finished product. The tissue paper was milled through a 0.6-cm mesh screen. The paper was thoroughly mixed and incorporated (25% by weight) into a ration for lambs and pelleted (0.4-cm pellets). The composition of this ration and that of a similarly prepared control ration without paper are listed in Table I.

Eight 3-month-old Dorset wethers were used in the feeding trial. Four of the lambs were fed the paper-containing ration and the remaining four were fed the control diet. The lambs were located in individual metabolic stalls throughout the feeding period. The animals were first adapted from a ration of hay and grain to a diet of pellets over a period of 15 days. The feeding continued for 125 days. Salt (without iodine or trace minerals) and water were provided ad libitum. The dry matter digestibility of the rations was measured in vivo during the last 9 days of the feeding experiment.

The animals were weighed at 2-week intervals throughout the feeding period. Fat, fiber, and ash were determined in the rations by the procedures cited, respectively, in Official Methods of Analysis (1975). Protein was determined as Kjeldahl nitrogen × 6.25. Table II lists the ash, fat, protein, fiber, and energy contents of the rations.

RESULTS AND DISCUSSION

Table III summarizes data on animal performance. There was no significant differences ($p > 0.05$) in the average daily feed consumed, average daily weight gain, or average in vivo dry matter ration digestibility among the two treatment groups. In an earlier study with lactating Holstein cows (Furr et al., 1974) the in vivo dry matter digestibilities of rations containing 30% (dry weight) of either brown cardboard, grey cardboard, newspaper or computer paper were, respectively, 51.6, 52.7, 59.8, and 77.9%. These percentages were approximately proportional to the inverse of the content of indigestible lignin in the respective rations. The low content of lignin (1.2%) in the facial tissue fed in our study as determined by the method of Van Soest (1963) would expectedly contribute to the relatively high percent digestibility observed for the ration containing it (Table III).

The comparatively high percent digestibility, animal acceptance, and their rate of weight gain would favor the inclusion of facial tissue paper in lamb rations. Since it is manufactured from virgin cellulose fibers it is also free of additives such as glue, plastic, clay, and inks which may contain toxic metals and synthetic organic compounds (Van Soest and Mertens, 1974; Heffron et al,, 1977; Furr et al., 1974). As with any product its use would depend on a continuing supply of the tissue of uniform chemical composition. As pointed out by Van Soest (1975) many factors may influence the digestibility of fibers. These include the species of plant, its age, and environmental factors during growth such as temperature, light, and fertilization which can markedly influence the extent of lignification. Aside from lignin content, the crystalline form of cellulose can also notably affect its digestibility (Van Soest, 1973). The future use of facial tissue paper in lamb rations would therefore require further feeding studies of animal performance with facial tissue paper produced from a variety of sources so that the effects of varying types of woods and manufacturing processes on the feeding quality of the final product could be ascertained.

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Low Molecular Weight Enzymatic Fish Protein Hydrolysates: Chemical Composition and Nutritive Value

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Low molecular weight enzymatic fish protein hydrolysates were produced from deboned cod filleting offal (DCO) and from functional fish protein (FFP, produced by low-temperature isopropanol extraction of DCO), by treatment with Alcalase followed by pancreatine. The yields of soluble nitrogen were between 85–90% and the hydrolysates had a balanced amino acid composition. The hydrolysates had an average molecular weight of less than 1000 and a free amino acid content between 15–45%. Treatment of DCO with only Alcalase gave a high percentage of free amino acids (30%), owing to the presence of exopeptidases in the raw material. Nutritional evaluations of hydrolysates in nitrogen balance experiments and growth experiments on rats showed the hydrolysates to have a high nutritional value. Taste evaluations showed that treatment with Alcalase followed by pancreatine gave bitterfree hydrolysates.

Elemental diets are increasingly used when there is a need for a diet which can be rapidly absorbed because of malfunction of the digestive system. Many elemental diets are made up of synthetic free amino acids, low molecular weight carbohydrates, vitamins, minerals, and minimal amounts of fat. These diets can be absorbed even in the absence of digestive enzymes and after extensive resection of the intestine. Due to the high degree of absorbtion, they give a very low fecal output, which is sometimes of value in pre- as well as postoperative nutrition (Spiller et al., 1975). A further advantage is that the composition can be clearly defined and adjusted to specific requirements.

Elemental diets based on free amino acids have, however, some disadvantages. The cost is relatively high (Woolfsson et al., 1976), mainly owing to the high prices of the amino acids. The palatability is often poor, due to bitterness of some free amino acids (Solms, 1969). One physiological problem is diarrhea, owing to the high osmolality (Lancet, 1975). The demonstration of a peptide transport system which is distinct from the amino acid transport and the finding that dietary protein is absorbed in the form of oligopeptides as well as free amino acids have also suggested that a protein hydrolysate might have some physiological advantages over a mixture of free amino acids (Matthews, 1971; Imondi and Stradely, 1974; Silk, 1974).

Protein hydrolysates as a source of readily assimilable protein have been prepared from, e.g., casein (Clegg et al., 1974). However, the preparation of protein hydrolysates will also sometimes give bitter-tasting products, depending on the protein raw material and enzymes used for proteolysis. For example, casein and soy protein are known to give bitter protein hydrolysates. Particularly, exhaustive protein hydrolysis with endopeptidases produces bitter-tasting peptides which make the end product unpalatable.

These peptides have a predominantly hydrophobic amino acid composition and are more bitter than their free corresponding amino acids (Fujimaki et al., 1971). Arai et al. (1970) have found that if a bitter-tasting soy hydrolysate is treated with acid carboxypeptidase from *Aspergillus* or with carboxypeptidase A (exopeptidases), it reduces the bitterness with formation of significant amounts of free amino acids, especially hydrophobic amino acids.

Fish protein has in several studies been tested as raw material for production of protein hydrolysates. Hale, in an extensive paper (1972), reported the effects of various processing conditions and commercially available proteolytic enzymes on yield and composition of water-soluble fish protein hydrolysates. He concluded that the hydrolysis of raw fish with protease of *Bacillus subtilis* at pH 8.5 or above gave the best balance of essential amino acids and a high yield of soluble product. Quite recently, Yãnez et al. (1976) reported production of a fish protein hydrolysate from hake for supplementation of cereal protein. The present experiments were undertaken to study the possibility of making an extensively hydrolyzed but still bland-tasting protein hydrolysate from fish protein for use in elemental diets. Fish protein was used as raw material because of its well-balanced amino acid composition. The nutritional value of the fish protein hydrolysates was also tested in rat experiments and compared with a diet based on free amino acids with the same amino acid composition. Also, commercially available elemental diet and casein were used as reference diets.

MATERIALS AND METHODS

Substrates and Enzymes. The following substrates were used: deboned cod filleting offal (DCO) (17.5% dry substance; analytical data of freeze-dried sample: 86.3%

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