Sheep & Goat Research Journal
Volume 28, 2013 – July

Technical Note: Effects of Supplementation of Expired Human Foodstuffs on Intake and Digestion by Wethers Fed a Base Diet of Grass Hay and Alfalfa/Barley Pellets

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Summary

There is potential for expired human foodstuffs to be used as an energy supplement for livestock. Sixteen crossbred wether lambs were used in a completely randomized design to investigate the effects of feeding supplemental expired human foodstuffs on DM, OM, ADF and NDF digestibility, and intake. Wethers were fed (DM basis) isocaloric amounts of the following treatments: whole barley served as the control (**BAR**: 0.20 kg·wether^{-1}·d^{-1}), potato chips (**PC**: 0.15 kg·wether^{-1}·d^{-1}), macaroni (**MAC**: 0.21 kg·wether^{-1}·d^{-1}), and donuts (**DON:** 0.15 kg·wether^{-1}·d^{-1}). Wethers were fed 0.60 kg·wether^{-1}·d^{-1} alfalfa/barley pellets and allowed ad libitum access to chopped hay. Wethers were placed in confinement crates for a 7-d acclimation period, fitted with fecal bags on d 0 and fed twice daily. Following acclimation, daily intakes, refusals, and fecal outputs were used to determine DM, OM, fiber digestibility and intake. Measures of intake and digestibility did not differ ($P > 0.23$) among treatments. It is concluded that these expired human foodstuffs have the potential to be used in ruminant diets as an alternative to traditional feedstuffs.

Key Words: Digestibility, Expired Foods, Intake.

Introduction

Every year, large quantities of retail food products are removed from the supply chain because they have expired. In 2001, more than $900 million of expired food was wasted (GMA, 2002). Forty percent of food in the United States goes uneaten, which is the equivalent of throwing $165 billion dollars into landfills (NRDC, 2012). Wasted and unused foods are a major substrate source for methane production from landfills. In the United States, methane emissions from landfills are equal to approximately 125 Tg CO_2 Eq., ranking third behind natural gas systems and enteric fermentation (EPA, 2013). In the last 10 years, barley, a common traditional energy supplement for livestock, has increased in price by 124 percent (NASS, 2012). As an alternative to expensive energy supplements, expired human foodstuffs may have the potential to be part of a ration for livestock, as well as provide an environmentally friendly method of disposal. Previous research has found negative effects of starch supplementation on fiber digestion and DMI of low-quality forages (Hoover, 1986; Chase and Hibberd, 1987). However, low proportions of starch supplementation can potentially increase dry-matter intake and digestion (Pordomingo, et al., 1991). Supplementing ruminants with fat has been reported to depress digestibility but not impact forage OM intake (Brokaw et al., 2001). Sources of supplemental energy traditionally have included grains, readily digestible-fiber sources, and high-quality forages. The effects of energy supplementation on intake and digestibility have been variable (Caton and Dhuyvetter, 1997), and little information is available on the impacts of feeding expired human foodstuff on intake and digestibility by small ruminants. The objective of this study was to compare daily intakes and digestibility of DM, OM, ADF, and NDF of sheep fed chopped hay and alfalfa/barley pellets and supplemented with expired human foodstuffs (macaroni, potato chips, and donuts).

Materials and Methods

All animal use procedures were approved by the Montana State University Animal Care and Use Committee (Protocol #1144). Sixteen crossbred

Table 1. Analysis of dietary components[1]

Item	Chopped hay	Alfalfa/ barley pellet	Barley	Donuts	Macaroni	Potato Chips
DM, %	92.1	96.2	91.7	83.8	92.7	97.9
OM, %	91.2	89.5	98.6	98.1	99.1	94.9
NDF, %	58.8	48.2	20.3	5.4	8.4	3.8
ADF, %	40.5	37.6	16.9	4.7	7.6	3.0
CP, %	9.0	16.8	10.6	5.2	13.0	7.9
EE[2, 3], %	1.0	1.3	1.8	28.5	1.7	33.0
TDN[2, 4], %	58.1	68.3	88.0	118.7	85.4	119.4

[1] All values presented on DM basis. Dietary composition was determined by analyzing subsamples collected and composited throughout the trial. Accuracy was ensured by adequate replication with acceptance of mean values that were within 5% of each other.
[2] Values for Donut, Macaroni, and Potato Chips calculated based on energy values from National Nutrient Database for Standard Reference (USDA, 1999). Values for Chopped hay and Alfalfa/barley pellets taken from NRC (1985).
[3] EE= ether extract.
[4] TDN, %= (0.5 x %Crude Fiber) + (0.90 x %Nitrogen-Free Extract) + (0.75 x %Crude Protein) + (2.25 x 0.90 x %Ether Extract)

Table 2. Values used to develop isocaloric diets that approximate energy needs and projected DMI for a 40 kg wether

Ingredient	Treatment diets[1]			
	BAR[2]	DON[3]	MAC[4]	PC[5]
	amount fed, kg; (amount TDN in amount fed, kg)			
Chopped hay	0.70; (0.39)	0.70; (0.39)	0.70; (0.39)	0.70; (0.39)
Alfalfa/barley pellet	0.60; (0.41)	0.60; (0.41)	0.60; (0.41)	0.60; (0.41)
Barley	0.20; (0.18)			
Donut		0.15; (0.18)		
Macaroni			0.21; (0.18)	
Potato chip				0.15; (0.18)
Projected DMI	1.50[6]	1.45	1.51	1.45
Projected TDN intake[7]	0.98	0.98	0.98	0.98

[1] Calculated (Alfalfa/barley pellet, Barley, Donut, Macaroni, Potato chip) and projected (chopped hay) intake to equal treatment isocaloric diets
[2] Fed barley at 0.20 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[3] Fed donuts at 0.15 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[4] Fed macaroni at 0.21 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[5] Fed potato chips at 0.15 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[6] Based on NRC (1985) estimated DMI for a 40 kg wether.
[7] Based on NRC (1985) estimate of 1.16 kg of TDN to support moderate growth of a 40 kg wether x 0.85 to prevent any potential of digestive upset associated with high energy, highly soluble carbohydrate feeds.

wether lambs (Suffolk/Hampshire x Western white face; 6-mo-old; BW = 38±2 kg) were used in a completely randomized design to investigate the effects of feeding supplemental expired human food on the intake and digestibility of treatment diets.

Treatments were: barley fed at 0.20 kg·wether^{-1}·d^{-1} (**BAR**), potato chips fed at 0.15 kg·wether^{-1}·d^{-1} (**PC**), macaroni fed at 0.21 kg·wether^{-1}·d^{-1} (**MAC**), and donuts fed at 0.15 kg·wether^{-1}·d^{-1} (**DON**), all on a DM basis. Treatments were formulated to be isocaloric based on NRC (1985) estimated TDN values for barley, brome grass hay, and alfalfa, and calculated TDN values of macaroni, donuts, and potato chips based on estimated nutrient content (USDA, 1999) (Tables 1 and 2). The BAR diet was formulated to contain 20 percent barley and provide 85 percent of the TDN requirement for a 40 kg wether consuming 1.5 kg of DM (NRC 1985). All other treatment diets were then formulated to be equal in energy to the BAR diet. Diets were formulated to provide 85 percent of NRC (1985) TDN requirements to insure no digestive problems associated with highly soluble, carbohydrate feeds. Wethers were allowed ad libitum access to chopped-grass hay and fed 0.60 kg·wether^{-1}·d^{-1} of an 80- percent alfalfa, 20-percent barley pellet (DM basis) to insure adequate CP intake.

Wethers were housed in metabolism crates (75 cm x 125 cm), fitted with fecal bags at the beginning of the acclimation period, and allowed a 7-d period to acclimate to diets and environment. The study took place under 24 h light. Wethers were offered total respective treatments and a half ration of chopped hay (60 percent of previous day's intake) and 0.30 kg·wether^{-1}·d^{-1} of alfalfa/barley pellets at 0600 h. The remaining chopped hay (60 percent of previous day's intake) and 0.30 kg·wether^{-1}·d^{-1} of alfalfa/barley pellets were fed at 1600 h. Feed samples were taken daily, and each feedstuff was compiled over the 7-d period for later analysis. Feed offered and feed refused for each wether were weighed and subsampled every 24-h and used to calculate DMI. Feces were collected from fecal bags twice daily, composited by animal, and stored for later weighing and analysis. At the end of the 7-d trial, total fecal weights for each lamb were recorded, and a subsample of feces was gathered and composited by animal for determination of nutrient component analyses, DMI, OM intake, DM digestibility, NDF digestibility, and OM digestibility *in vivo*.

Treatment samples, chopped hay, and alfalfa/barley pellets were dried in a 60° C forced-air oven and ground to pass through a 1-mm screen in a Wiley mill. Samples were analyzed for DM, OM, Kjeldahl N (AOAC, 1984), NDF, and ADF (Van Soest et al., 1991; Table 1). Values for EE (ether extract) and TDN were obtained from the National Nutrient Database for Standard Reference (USDA, 1999). Fecal samples were analyzed for DM, OM, Kjeldahl N (AOAC, 1984), NDF and ADF (Van Soest et al., 1991).

Daily intakes and digestibility of DM, OM, ADF, and NDF were calculated. Data were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, N.C.), with expired feedstuff as the fixed effect. Animal was considered the experimental unit. Differences among treatments were considered significant at $P < 0.10$.

Results and Discussion

Three wethers were removed from the trial during the adaptation period, two from the MAC treatment and one from the PC treatment, due to inability to adjust to the research environment. Daily intakes of each treatment ingredient, alfalfa/barley pellets, and chopped hay are presented in Table 3. Wethers consumed all of the alfalfa/barley pellets and treatment ingredients provided. Daily intake of each feedstuff was compiled by wether and multiplied by the feedstuff nutrient profile and presented in Table 4. Total diet digestibility of DM, OM, NDF, and ADF is presented in Table 5.

Measures of intake and digestibility did not differ ($P > 0.23$) among treatments. Chase and Hibberd (1987) reported that providing 1, 2, or 3 kg/d ground corn to mature beef cows consuming low-quality, native-grass hay resulted in a linear decrease in cellulose digestibility and hay intake. Pordomingo et al. (1991) found that supplementing steers grazing low-quality native range with 0.20 percent of BW of corn increased OM intake and *in situ* OM digestion. These authors also reported that steers supplemented with 0.40 percent and 0.60 percent of BW of corn experienced a decrease in OM intake and *in situ* OM digestibility (Pordomingo et al., 1991). Furthermore, Bodine et al. (2000) suggested that barley contains less starch and more degradable-intake protein (DIP) than corn, which may

Table 3. Actual amounts of feed ingredients consumed by wethers with ad libitum access to chopped hay and supplemented with isocaloric treatments and alfalfa/barley pellets (0.60 kg · wether^{-1} · d^{-1})[1]

Item	BAR[2]	DON[3]	MAC[4]	PC[5]	SE
No. of wethers	4	4	2	3	-
Treatment DMI, kg[6]	0.20	0.15	0.21	0.14	-
Alfalfa/barley pellet DMI, kg[6]	0.60	0.60	0.60	0.60	0.000
Chopped hay DMI, kg[6]	0.34	0.43	0.50	0.41	0.056

[1] All values presented on DM basis. Dietary composition was determined by analyzing subsamples collected and composited throughout the trial. Accuracy was ensured by adequate replication with acceptance of mean values that were within 5% of each other.
[2] Fed barley at 0.20 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[3] Fed donuts at 0.15 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[4] Fed macaroni at 0.21 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[5] Fed potato chips at 0.15 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[6] Mean daily DMI over 1 wk trial.

Table 4. Feed components[1] consumed by wethers with ad libitum access to chopped hay and supplemented with isocaloric treatments and alfalfa/barley pellets (0.66 kg · wether^{-1} · d^{-1})

Item	BAR[2]	DON[3]	MAC[4]	PC[5]	SE
No. of wethers	4	4	2	3	-
DM, kg[6]	1.150	1.190	1.320	1.150	0.068
OM, kg[6]	1.052	1.087	1.210	1.041	0.062
NDF, kg[6]	0.533	0.551	0.604	0.536	0.041
ADF, kg[6]	0.399	0.408	0.446	0.397	0.023

[1] All values presented on DM basis. Dietary composition was determined by analyzing subsamples collected and composited throughout the trial. Accuracy was ensured by adequate replication with acceptance of mean values that were within 5% of each other.
[2] Fed barley at 0.20 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[3] Fed donuts at 0.15 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[4] Fed macaroni at 0.21 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[5] Fed potato chips at 0.15 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[6] Mean daily DMI over 1 wk trial.

Table 5. Diet digestibility of wethers fed alfalfa/barley pellets (0.66 kg · wether^{-1} · d^{-1}), expired human foodstuffs, and chopped hay (ad libitum access)

Item	BAR1	DON2	MAC3	PC4	SE
No. of wethers	4	4	2	3	-
Digestibility (%)					
DM	74.7	69.8	67.3	71.4	2.40
OM	76.1	71.1	69.0	72.6	2.32
NDF	62.9	58.1	59.3	63.8	4.02
ADF	62.4	55.0	52.7	59.1	4.24

[1] Fed barley at 0.20 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[2] Fed donuts at 0.15 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[3] Fed macaroni at 0.21 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.
[4] Fed potato chips at 0.15 kg·wether^{-1}·d^{-1}, alfalfa/barley pellets at 0.60 kg·wether^{-1}·d^{-1}, and ad libitum access to chopped hay.

lessen the negative associative effects observed with cereal supplementation of low-quality forage diets. Compared to the BAR control treatment in our study, none of the expired foods impacted either measures of intake or digestibility when fed at an equivalent of 20 percent barley in the diet or the barley equivalent of 0.50 percent of BW.

Our results are in contrast to those presented by Champe and Church (1980), who found increasing digestibility of all dietary components by lambs fed increasing supplementation (0 percent, 20 percent and 40 percent of diet) of a commercially available dried bakery product. Champe and Church (1980) found no impact on daily DMI by lambs with increasing proportions of supplemental dried bakery product. It is important to note the difference in nutritional composition of the dried bakery product used by Champe and Church (1980) and the DON and PC used in this study, specifically fat content (8.5 percent and 28.5 percent, respectively). Previous research has demonstrated deleterious effects of fat on nutrient digestibility by cattle consuming forage diets. Brokaw et al. (2001) reported that heifers on high-forage diets that were supplemented daily (0.3 percent of BW) with a mixture containing cracked corn, corn gluten meal, and soybean oil (12.5 percent of supplemental DM; Oil) experienced depressed OM and NDF digestibility compared to heifers supplemented with conventional corn. The authors went on to report that forage OM intake was not affected by feeding supplemental fat at 1.5 percent to 1.74 percent of diet DM (Brokaw et al., 2001). Rahnema and Borton (2000) reported that substituting 15 percent to 20 percent of corn with potato chip scraps in nursery pig diets decreased DMI but had no effect on ADG and improved the gain:feed ratio. The PC supplement contained the most fat (Table 1) of all the treatments, but did not negatively impact digestibility.

Nutrient variation for by-product feeds, such as those examined in this study, can be considerable depending on factors, such as source, basal ingredients, and manufacturing processes. Arosemena et al. (1995) reported that the average nutrient composition of nine commonly used by-product feeds differed by more than 20 percent from tabular NRC values. Furthermore, the authors stressed that accurate nutrient analyses of these ingredients became more critical as their concentration in the diet was increased. Additionally, the potential associative effects of the by-product feeds examined in this study with the forage provided are unknown.

Conclusions

In our study, no particular treatment stood out as superior or inferior in digestibility or DMI compared to BAR. Expired human food products (macaroni, potato chips, and donuts) did not impact intake of low-quality forage or measures of digestibility. Using expired human foodstuffs as an energy supplement for livestock may be an expense-saving opportunity for producers, as well

as a favorable disposal option for otherwise wasted products. Increasing production costs challenge livestock producers to investigate novel sources of feed. Expired human foodstuffs could provide an economical alternative to traditional energy supplements, without substantial negative impacts on intake or digestibility. Further studies in larger numbers of animals in different stages of production are warranted.

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