NUTRITIVE VALUE OF SILAGES PREPARED FROM FIBER AND LIQUID RESIDUES AFTER THE SEPARATION OF LEAF NUTRIENT CONCENTRATE FROM ITALIAN RYEGRASS IN GOATS

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Summary

Italian ryegrass (*Lolium multiflorum* Lam.) was fractionated into leaf nutrient concentrate, fiber and deproteinised juice (DPJ). The fresh and fermented DPJs were concentrated and referred to as fresh deproteinised juice concentrate (FDPJC) and fermented deprotenised juice concentrate (FMTD DPJC). The FDPJC and FMTD DPJC were separately mixed with dried fiber and ensiled. Wilted crop silage and fresh fiber silage were also prepared from the same material crop. The nutritive value of these four silages were compared using four goats by 4 × 4 Latin square design.

Green crop fractionation resulted lesser amount of crude protein and ash, and higher amount of neutral detergent fiber, acid detergent fiber, cellulose and hemicellulose in fresh fiber. The pH of fresh fiber silage was lower than that of the other silages. Addition of FDPJC or FMTD DPJC to the dried fiber at ensiling did not improve the silage qualities; but all the silages were satisfactorily preserved.

Goats fed these silages showed similar ruminal pH and total volatile fatty acid concentrations. But addition of FMTD DPJC was effective on increasing ruminal acetic acid concentration reducing propionic acid concentration. Ruminal n- and iso- butyric acid concentrations were proportional to that of propionic acid. High ammonia content of the silage containing FMTD DPJC was reflected to the ruminal ammonia concentration, urinary nitrogen excretion and serum urea level of goats. Inclusion of FDPJC or FMTD DPJC added 15 to 25% dry matter to the fiber silages with a little reduction in the digestibilities of most components of the silages.

(**Key Words**: *Lolium multiflorum*, Fiber, Deproteinised Juice, Silage, Goats)

Introduction

In the preparation of silage from fibrous residue (fiber) left after the extraction of green juice, there were some failures (Raymound and Harris, 1957; Vartha et al., 1973) until molasses were added. Success of early trials at Rothamsted experimental station was with addition of fermentable carbohydrate in deproteinised juice (DPJ) as well as of the exclusion of air. Sugar cane tops, which Kasture et al. (1984) found as a beneficial addition to fiber silage may act by supplying fermentable carbohydrate. Removal of some of the protein and cations diminishes the buffering capacity of the original crop (Wallace, 1975; Ohshima and Oouchi, 1979) and thus enables a smaller amount of carbohydrate to effect the diminution of pH needed for good silage. Quality can be improved by adding formic acid and formaldehyde (Fujihara and Ohshima, 1980).

The components in DPJ would, of course, be consumed by ruminant animals as part of the unextracted crop. Although the content of non protein nitrogen (NPN) is high, it would probably be used efficiently for microbial protein synthesis in the rumen in view of the high water soluble components in DPJ (Worgan, 1975; Ream et al., 1983; Reddy, 1985).

Bris et al. (1970) reported the successful feeding of concentrated (50% dry matter (DM)) alfalfa DPJ to cattle at 10% of the ration. In this work growth rates tended to be higher when DPJ was used to replace molasses. The return of the evaporated DPJ to the fiber has been a feature both of the Vepex (Koch, 1974) and Pro-Xan (Kohler et al., 1979) processes. Its return

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is likely to improve the stability of the pellets of the pressed forage as well as increase the nutritive value. The DPJ contains high carbohydrates, NPN, peptides, free amino acids and amides. All of these kinds of components are easily metabolized by rumen miroorganisms (Blackburn, 1965). The objective of the present study was to test the effect of the supplementation of the syrup-like (concentrated) DPJs from Italian ryegrass with intact or fermented form to their dried fiber on the chemical and the nutritional qualities of the silages. Fermented DPJ was that remained after the yeast cultivation.

Materials and Methods

The first growth of Italian ryegrass (*Lolium multiflorum* Lam.) at growing stage (1 meter height) was harvested by a forage harvester on April 19 and 20, 1988 and disintegrated 2 tons with a herbage crusher (Nihon Sharyo Co. Ltd., Nagoya, Japan) and pressed the crushed material to release green juice and fiber with a twin-screw press (TP-24-2, Stord Bartz Ltd., Japan). The green juice coagulation and deproteinised juice (DPJ) separation was done as mentioned (Kayama, 1984). The released fiber still contained about 70% of moisture because of a low pressing rate to ensure enough nutrients for the feeding of goats. A part of fresh fiber was sun-cured to dry by spreading on cemented surface on pavement. Italian ryegrass (IRG) was harvested in the evening of 19th April and silage was prepared after wilting for 22 hours. The yeast (*Candida utilis* H49) fermentation on DPJ was done according to Reddy et al. (1990). After separation of yeast, the DPJ was concentrated to three times lesser than original volume in a steam-heated fermentation tank. Fresh DPJ was also concentrated in the same way. Four and a half kilograms of dried fiber was mixed with 10.5 l of fresh deproteinised juice concentrate (FDPJC) or fermented deproteinised juice concentrate (FMTD DPJC) using a concrete mixing motor-driven drum for 3 minutes. Silages were prepared from the wilted herbage, fresh fiber and the mixtures of fiber and DPJs by packing them in polyethylene bags (600 mm in width, 800 mm in height and 0.06 mm in thickness) at a rate of 10 kg per bag for wilted crop, and 15 kg per bag for the fresh fiber and the dried fiber and added with DPJs. The bags were closed by string tying after vacuum pump air removal. All the bags were kept in a dark room at ambient temperature until they were opened. The bags were opened one by one from March 2, 1989 and content of each bag was subdivided into small portions and repacked in smaller bags as to feed one bag to one animal at one time. The small bags were kept in a refrigerator until they were used.

Four Shiba strain Japanese pygmy castrated mature goats weighing about 17 kg were individually housed in metabolism cages and they were arranged in a cabin. Experiment was conducted from March 3, 1989 to April 20, 1989. The goats were fed with silages twice daily at 9 A.M. and 3 P.M. as to offer 2.5% DM of goat body weight per day. Two grams of table salt and 10 g of $CaHPO_4$ were also fed to each animal everyday with their diets. Water was given *ad libitum*. The four diets were offered to all goats in a 4 × 4 Latin-square design over four periods. During each period, faeces and urine were collected for 5 days after 7 days of preliminary feeding.

The faeces were dried in a draft-oven at 80 ℃ and the urine was acidified with H_2SO_4 and kept in a freezer before analysis. Rumen fluid samples were taken using a stomach tube by the Morimoto method (1971) before and after the feeding (9 : 00 A.M. and 1 : 00 P.M.) on the final day of each trial. Rumen fluid was immediately filtered through four layers of cheesecloth and the pH was determined. Then, a few drops of saturated mercury chloride solution was added to the rumen fluid in screw-type test tubes and stored in a freezer. Blood samples were taken once at 1 P.M. on the final day of each trial from the jugular vein with multiple purpose syringe (NM 20G, Nipro Co. Ltd., Osaka, Japan) and vacuum neotube (S-L10, Nipro Co. Ltd., Osaka, Japan).

General compositions of silages, faeces and other samples were determined according to AOAC (1984) using samples dried with the draft oven except for the DM content of the silages and the N content of urine. The dried samples were ground to fine powder using a screen (80 mesh) in a hammer mill. The samples were stored in air-tight bottles at room temperature until analysed. The dry matter content of the silages was determined by the toluene distillation method

(Dewar and McDonald, 1961) and used for calculating the composition of the silages and DM intake of animals. Urine and fresh silage were directly subjected to analysis of N content by the Kjeldahl method as well as the other dried samples except for DPJs. Carbon and nitrogen of DPJs were estimated with a C/N corder (MT-500, Yanagimoto Mfg. Co. Ltd., Kyoto, Japan).

Cell wall constituents (CWC) and neutral detergent fiber (NDF) were deterimined as ash free by Van Soest (1963), Van Soest and Wine (1969) and Golding et al. (1985) methods for forage and silage samples. Acid detergent fiber (ADF) and acid detergent lignin (ADL) contents were determined according to AOAC (1984) Gross energy (GE) of forage, silage and faeces samples were measured by an automatic bomb calorimeter CA-3 (Shimadzu Corporation, Kyoto, Japan).

Serum urea nitrogen, protein and cholesterol were analysed using Uni Clinical Kit (Chugai Phamaceutical Ltd., Tokyo, Japan) with a rapid blood analyser.

Determination of silage quality was made by the method of Ohshima and Kogure (1984). The pH values were determined with a glass electrode pH meter (Horiba-F12). Lactic acid was estimated photometrically (Barnett, 1951). Volatile fatty acids were determined on the distillates of acidified samples (Ohshima, 1982) using a gaschromatograph (Shimadzu GC-12A). Ammonia concentration of silage filtrates was determined by distillation method (Ohshima, 1982). Statistical analysis was made by using Duncan's Multiple Range test with a personal computer (NEC PC-9801 F).

Results and Discussion

The fractional compositions of Italian ryegrass are shown in tabel 1. Both the FDPJC nd FMTD DPJC were maintained almost at same pH (5.0) before ensiling with dried fiber. The FDPJC and FMTD DPJC were reduced to one third of the original volumes as is evident from the DM contents of them shown in table 1. The present, and in previous experiments, we have observed at least 1% loss of DM was recorded out of 4% of the original DPJ DM due to the fermentation of yeast on it. Therefore, less DM content can be seen in FMTD DPJ. Yeast fermentation also reduced the large amount of carbon (C) content from the deproteinised juice. In return, high yeast protein yield was obtained (Reddy and Ohshima, 1990; Reddy et al., 1990). A little higher residual nitrogen content was accounted in FMTD DPJ in comparison with FDPJ. The reason for this result is supplementation of N source during yeast fermentation. Hence the crude protein content also resulted bit higher than other fractions. Crop fractionation led fiber to contain less CP and ash.

Chemical composition of silages prepared from wilted grass, fresh fiber, and dried fiber with DPJs are shown in table 2. Crop fractionation resulted lesser amount of CP, ash and silica, and

TABLE 1. ITALIAN RYEGRASS (IRG) AND ITS FRACTIONAL COMPOSITION

Components	IRG fresh crop	IRG wilted crop	IRG fresh fiber	FDPJ[1]	FDPJC[2]	FMTD DPJ[3]	FMTD DPJC[4]
pH	–	–	–	5.5	4.9	6.1	5.0
Dry matter (%)	20.0	33.7	32.5	4.2	12.0	2.7	8.0
Carbon (C) (%)[5]	–			35.3		20.5	–
Nitrogen (N) (%)[5]	2.4	2.1	1.7	2.2	–	2.8	–
C/N ratio	–	–	–	16.0	–	7.3	–
Crude protein (%)[5]	14.7	13.0	10.9	13.7	–	17.5	–
Ash (%)[5]	9.8	9.1	5.7	25.1		42.1	–

[1] Fresh deproteinised juice.
[2] Fresh deproteinised juice concentrate.
[3] Fermented deproteinised juice.
[4] Fermented deproteinised juice concentrate.
[5] On dry matter basis.

TABLE 2. CHEMICAL COMPOSITION OF THE ITALIAN RYEGRASS (IRG) SILAGES AS PERCENT OF DRY MATTER

Components	IRG wilted silage	Fresh fiber silage	Dried fiber ensiled with	
			FDPJC[1]	FMTD DPJC[2]
Crude protein (%)	12.3^{b}	11.3^{c}	12.8^{ab}	13.3^{a}
Crude ash (%)	10.2^{c}	5.9^{d}	10.8^{b}	12.9^{a}
NDF(%)[3]	48.2^{c}	58.8^{a}	49.5^{c}	53.0^{b}
ADF(%)[4]	29.2^{d}	37.4^{a}	31.7^{c}	33.7^{b}
ADL (%)[5]	2.6^{b}	2.7^{ab}	3.3^{a}	3.1^{ab}
Cellulose (%)	26.5^{d}	34.4^{a}	28.2^{c}	30.5^{b}
Hemicellulose (%)	18.9^{bc}	21.4^{a}	17.8^{c}	19.3^{b}
Silica (%)	1.8^{a}	0.9^{b}	0.6^{b}	0.9^{b}
Gross energy (kcal/g)	3.9^{b}	4.2^{a}	3.9^{b}	3.8^{b}

[1] Fresh deproteinised juice concentrate.
[2] Fermented deproteinised juice concentrate.
[3] Neutral detergent fiber.
[4] Acid detergent fiber.
[5] Acid detergent lignin.
Means with different superscript letters are significantly different at 5% level.

higher amounts of NDF, ADF, cellulose and hemicellose contents in fiber. The reason may be due to the removal of soluble components of the crop from the fiber by pressing. The addition of FDPJC or FMTD DPJC into dried fiber rather reduced the gross energy content because of the high ash content of the juices.

It was one of the rare instances on large-scale experiments where moisture was well controlled in all the treatments. The pH of the silages was ranged between 3.83 to 4.37 (table 3). The pH of the fresh fiber silage was signigificantly lowest among the silages. This is due to the lesser buffering constituent contents which are partially removed in pressing of the fiber (Ohshima and Oouchi, 1979).

High lactic acid production was recorded in the dried fiber ensiled with FMTD DPJC. More acetic and propionic acids were produced in fresh fiber silage. High acetic acid content of fresh fiber silage was also reported by Ohshima et al. (1988). Butyric acid was found in very little quan-

TABLE 3. FERMENTATION QUALITY OF ITALIAN RYEGRASS (IRG) SILAGES

Components	IRG wilted silage	Fresh fiber silage	Dried fiber ensiled with	
			FDPJC[1]	FMTD DPJC[2]
Moisture (%)	66.05^{a}	67.23^{a}	66.40^{a}	67.00^{a}
pH	4.37^{a}	3.83^{d}	4.13^{b}	4.05^{c}
Lactic acid (%/DM)	3.37^{b}	4.39^{ab}	5.26^{a}	3.93^{b}
VFA (%/DM)[3]				
Acetic	1.85^{b}	3.06^{a}	2.22^{b}	2.86^{a}
Propionic	0.02^{c}	0.07^{a}	0.02^{c}	0.04^{b}
iso-Butyric	OT	0.01	OT	OT
n-Butyric	0.06^{ab}	0.03^{b}	0.12^{a}	0.10^{a}
NH_3-N (%/TN)	9.33^{b}	6.93^{c}	8.62^{b}	16.93^{a}

[1] Fresh deproteinised juice concentrate.
[2] Fermented deproteinised juice concentrate.
[3] Volatile fatty acid.
OT = Occasionally traceable.
Values are mean of 4 silos. Means with different superscript letters are significantly different at 5% level.

tities and *iso*-butyric acid was occasionally found in traces. Almost a double quantity of ammonia nitrogen was found in dried fiber silage ensiled with FMTD DPJC because of the addition of ammonium sulphate at the time of yeast production. It is recognised that fractionation of the crop reduces moisture in the fresh fiber and offers suitable material for making good silage.

The rumen fluid componential concentrations are shown in table 4. The pH and total volatile fatty acids (VFAs) of the rumen fluids of goats were not affected by the dietary treatments. More acetic, less propionic, and consequent higher acetic to propionic acid ratio (A/P ratio) were observed for dried fiber ensiled with FMTD DPJC. These results indicate that the addition of FMTD DPJC is effective on enhancing acetic fermentation in the rumen and increase the potential of milk fat production. Because it is known that acetic acid is a precursor of milk fat and propionic acid cannot contribute to milk fat production (Woodford et al., 1986). The ruminal concentration of *iso*-butyric acid of goats fed FMTD DPJC silage was lower than that of others. The butyric acid concentration was also low but the difference was not significant. Ruminal ammonia concentration was significantly higher on feeding of FMTD DPJC silage than other feedings reflecting the higher ammonia concentration in the silage.

TABLE 4. RUMEN FLUID COMPONENTAL CONCENTRATIONS OF GOATS FED WITH ITALIAN RYEGRASS (IRG) SILAGES

Components	IRG wilted silage	Fresh fiber silage	Dried fiber ensiled with	
			FDPJC[1]	FMTD DPJC[2]
pH	6.60[a]	6.63[a]	6.73[a]	6.51[a]
Total VFA (mmol/dl)[3]	7.13[a]	6.82[a]	7.08[a]	7.24[a]
Molar % of VFA[3]				
Acetic	65.58[b]	66.55[b]	62.80[b]	74.43[a]
Propionic	20.95[b]	19.73[b]	24.03[a]	17.08[c]
A/P ratio[4]	3.13[bc]	3.37[b]	2.61[c]	4.36[a]
iso Butyric	1.48[ab]	1.55[a]	1.30[ab]	0.95[b]
n-Butyric	9.90[a]	10.13[a]	10.18[a]	6.43[a]
NH_3 (mg/dl)	21.47[b]	21.99[b]	22.59[b]	30.87[a]

[1] Fresh deproteinised juice concentrate.
[2] Fermented deproteinised juice concentrate.
[3] Volatile fatty acid.
[4] Ratio of acetic to propionic acid.
Values are mean of 4 goats. Means with different superscript letters are significantly different at 5% level.

Nitrogen balance of goats fed those silages are presented in table 5. There were no significant differences found in all the data obtained among wilted silage, fresh fiber silage and dried fiber ensiled with FDPJC. Ohshima et al. (1988 & 1991) reported that N retention of IRG dried fiber (pressed cake hay) was low when compared with that of corresponding silage. We have not observed such kind of difference in the nitrogen retention between fresh fiber silage and dried fiber ensiled with FDPJC. The facts suggest that nitrogen in FDPJC was somewhat utilized by the animals. But the goats fed the silage containing FMTD DPJC excreted significantly more urinary N and showed higher UN/DN and lower RN/IN compared with others reflecting the high ruminal ammonia concentration, though the differences in the latter two values were not significant. These results indicate the low availability of N in FMTD DPJC.

The results of various nutrient digestion in goat trials are shown in table 6. Every diet was so palatable that goats consumed it immediately when offered to them every morning and evening. There was no change in the digestibilities of DM, organic matter (OM), N (crude protein), NDF, ADF, cellulose, hemicellulose and energy. Present results of CP content and DM digestibility of IRG and its fiber silages were similar to those

TABLE 5. NITROGEN BALANCE IN GOATS FED WITH ITALIAN RYEGRASS (IRG) SILAGES

Nitrogen flow	IRG wilted silage	Fresh fiber silage	Dried fiber ensiled with	
			FDPJC[1]	FMTD DPJC[2]
Intake N*	4.64[ab]	4.48[b]	5.10[ab]	5.30[a]
Faecal N*	1.93[a]	1.94[a]	2.33[a]	2.37[a]
Urinary N*	1.98[b]	1.87[b]	2.10[b]	2.75[a]
Digested N (g)	2.71[a]	2.53[a]	2.77[a]	2.93[a]
Retained N (g)	0.74[a]	0.66[a]	0.67[a]	0.18[a]
UN/DN (%)[3]	73.10[a]	73.90[a]	75.82[a]	93.90[a]
RN/IN (%)[3]	15.95[a]	14.73[a]	13.14[a]	3.40[a]

* Expressed as g/kg B.W. $^{0.75}$/5 days.
[1] Fresh deproteinised juice concentrate.
[2] Fermented deproteinised juice concentrate.
[3] Urinary nitrogen/Digested nitrogen.
[4] Retained nitrogen/Intake nitrogen.
Values are mean of 4 goats. Means with different superscript letters are significantly different at 5% level.

TABLE 6. DIGESTIBILITY OF NUTRIENTS FROM ITALIAN RYEGRASS (IRG) SILAGES BY GOATS (%)

Components	IRG wilted silage	Fresh fiber silage	Dried fiber ensiled with	
			FDPJC[1]	FMTD DPJC[2]
Dry matter	67.4	66.3	63.3	65.2
Organic matter	69.6	68.3	64.8	65.4
Nitrogen (CP)	58.4	56.5	54.2	55.4
NDF[3]	71.2	71.5	68.8	69.6
ADF[4]	72.2	73.2	67.8	70.1
Cellulose	80.9	80.6	77.4	79.7
Hemicellulose	69.7	68.5	67.6	68.9
Energy (DE/GE)	65.7	64.5	60.4	61.7

[1] Fresh deproteinised juice concentrate.
[2] Fermented deproteinised juice concentrate.
[3] Neutral detergent fiber.
[4] Acid detergent fiber.
Values of means of 4 goats. There were no significant differences in all the data.

reported by Ohshima et al. (1991).

Table 7 shows the urea nitrogen, total protein, glucose and cholesterol levels in the serum of goats fed with IRG silages. Blood urea nitrogen was a little higher in dried fiber ensiled with FMTD DPJC. The reason may be the high ammonia concentration in rumen fluid. While, no significant differences were found in total protein, glucose and cholesterol among all the dietary treatments.

In conclusion, the fiber from Italian ryegrass is as nutritious and as palatable as the original crop in the ruminant in spite of being taken off some soluble components in green juice. The addition of FDPJC left after separation of leaf nutrient concentrate to dried fiber may supply some nutrients, but addition of FMTD DPJC obtained after fermentation of yeast on FDPJ to dried fiber is not effective on increasing nutritional nitrogen content of the silages. But the inclusion of FMTD DPJC in the silage is effective on increasing ruminal acetic acid concentration of goats fed on it.

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TABLE 7. CONCENTRATIONS OF UREA NITROGEN, TOTAL PROTEIN, GLUCOSE AND CHOLESTEROL IN THE SERUM OF GOATS FED WITH ITALIAN RYEGRASS (IRG) SILAGES

Components	IRG wilted silage	Fresh fiber silage	Dried fiber ensiled with FDPJC[1]	Dried fiber ensiled with FMTD DPJC[2]
Urea nitrogen (mg/dl)	33.7[b]	35.1[ab]	33.1[b]	38.7[a]
Total protein (g/dl)	8.1[a]	7.8[a]	7.8[a]	7.9[a]
Glucose (mg/dl)	53.5[a]	50.4[a]	54.9[a]	48.1[a]
Cholesterol (mg/dl)	72.0[a]	60.5[a]	59.6[a]	60.0[a]

[1] Fresh deproteinised juice concentrate.
[2] Fermented deproteinised juice concentrate.
Values are mean of 4 goats. Means with different superscript letters are significantly different at 5% level

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