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# RUMINAL DEGRADABILITY CHARACTERISTICS IN VEGETABLE PROTEIN SOURCES OF PAKISTAN

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## ABSTRACT

Fifteen different vegetable protein sources found in Pakistan were evaluated for ruminal degradability characteristics through *in situ* procedure using rumen fistulated Nili-Ravi buffalo steer. Samples of soybean meal, corn gluten meal 60%, maize gluten feed, guar meal, sunflower meal, rapeseed meal, rapeseed cake, canola meal, cottonseed cake, cottonseed meal, coconut cake, coconut meal, palm kernel cake, almond cake and sesame cake were obtained from 10 different locations. Crude protein (CP) ruminal degradability was determined at 0, 3, 6, 12, 24 and 48 hours in triplicate. Data obtained at different hours of ruminal incubation were fitted to Orskov and McDonald equation to determine fractions a, b, degradation rate and effective degradability at 2, 5 and 8 percent. In CP degradation kinetics, fractions a, b, and degradation rate were different (P<0.001). Effective CP degradability at different rumen passage rates (2, 5, 8 %) was also affected (P<0.001) by the source of protein. It was concluded that at 5% rumen passage rate, coconut meal and corn gluten meal showed least degradability and therefore can be incorporated in growing and lactating ruminant rations for higher bypass protein value.

**Key words:** Ruminal degradability, vegetable protein sources, undegradable protein, Nili-Ravi buffalo

## INTRODUCTION

The availability of feed resources in Pakistan is far less than the optimal needs of ruminant's animals. This situation is further aggravated due to inefficient management and utilization of available feeds for animal productivity (Walli, 2009). The common example is protein supplementation of ruminant's diet. However, maximizing crude protein in the diet of ruminants particularly for growing and early lactating animals is not the reasonable way out because wide-ranging breakdown of feed protein in the rumen by rumen microbes results in inefficient use of dietary protein (Castillo *et al*. 2001). During fermentation in the rumen, protein is degraded to peptides, amino acids and finally to ammonia. In such situations, the benefit of feeding quality protein having balance of essential amino acids and digestibility is lost. It is now accepted that balancing a feed based on crude protein percent can not fully met animal's requirement for amino acids (Kamalak *et al*., 2005). Diets need to be formulated based on rumen degradable protein and rumen undegradable protein proportions (NRC, 2001). Reported literature has significant differences in laboratories results (Madsen and Hvelpund, 1994). Due to wide variation in agronomic practices and processing technologies, each country has to evaluate their own feed resources (Marghazani, 1998). In Pakistan, such information on locally available protein sources is scanty and insufficient. It is hence, this study planned to evaluate different degradable levels in vegetable origin protein sources found in Pakistan.

## MATERIALS AND METHODS

Fifteen different protein sources i.e., soybean meal, corn gluten meal 60%, maize gluten feed, guar meal, sunflower meal, rapeseed meal, rapeseed cake, canola meal, cottonseed cake, cottonseed meal, coconut cake, coconut meal, palm kernel cake, almond cake and sesame cake were collected from feed mills and main feed markets of different districts of Punjab province, Islamabad and Karachi. Representative sample (approximately one kg) of each test feed was collected, labeled, ground though 2 mm screen in laboratory mill and pooled in labeled bottles. Ten samples of each test feed were collected from those different locations. Later, these test feeds were chemically analyzed for dry matter, ash, crude protein, crude fiber and ether extract according to the standard procedures of AOAC (2000).

**a) *In situ* procedure:** *In situ* degradability of test feeds was measured in an adult buffalo steer (Nili-Ravi, body weight = 410 kg) fitted with a permanent rumen fistula. The steer was fed a commercially prepared TMR *ad libitum* (Table 1). Triplicate, 5 g samples, of each protein source were placed in pre-weighed dacron bags (pore size 50 µm), which were then incubated in the rumen for 3, 6, 12, 24 and 48 h. The incubation of samples was done in reverse order so that after 48 h all bags were removed from the rumen simultaneously. These were then washed with water cold running tap water until the water flowing out of the bags was with no visible color. Zero hour degradability was determined without ruminal incubation; the dacron bags containing sample were rinsed with cold water in the same way as the other bags that were removed from rumen (Woods *et al*., 2003; Kamalak *et al*., 2005). After complete washing, the samples were oven-dried at 60 $^0$C for 48 h. After cooling in a dessicator the dried bags were weighed. The residue from each of the (sample) triplicate bags was pooled and stored (in labeled bottles) for subsequent CP analyses.

Data obtained on CP degradability at different hours of incubation were subjected to the following equation (Orskov and McDonald, 1979) to find out degradation kinetic parameters (a, b and c) and effective degradability.

$$Y = a + b\ (1\text{-}\exp^{-ct})$$

Where, Y= Degradability of CP at time "t"; a= quickly soluble fraction; b= potentially degradable fraction; c= rate of degradation of fraction "b".

The effective degradability (ED) at different (0.02, 0.05 and 0.08) rumen passage rates was calculated as;

$$ED= a+ [(bc)/ (c+k)]$$

Where, k= fractional passage rate

**Statistical analyses:** Data on ruminal degradation kinetics (a, b and c fractions) and effective degradability (0.02, 0.05, 0.08 kp ) of CP in the test feeds were statistically analyzed using analysis of variance (Steel *et al*., 1997), where difference among test feeds were examined. Means were compared for significance by applying Duncan's multiple range test (Duncan, 1955).

## RESULTS AND DISCUSSION

The chemical composition of the vegetable protein sources is given in Table 2. The DM, ash, CP, ether extract and crude fiber contents varied significantly ($P<0.001$) among the test feeds. Among the test feeds (n= 15), CGM 60% had the maximum ($P<0.05$) CP content followed by SBM while, the minimum CP content ($P<0.05$) was contained in PKC. Crude fiber contents were maximum ($P<0.05$) in sunflower meal while the lowest ($P<0.05$) were in SBM, CGM 60% and sesame cake respectively. Maximum fat contents ($P<0.05$) were recorded in CSC and RSC whilst SBM, CSM, SFM, CGM 60%, coconut cake and canola meal had the lowest ($P<0.05$) fat contents, ranging from 0.98 to 1.56 %. Ash contents were highest ($P<0.05$) in almond cake and CSC whilst lowest ($P<0.05$) in CGM 60%.

The obtained chemical composition of the vegetable protein sources used falls in close range of the values reported in the literature. Crude protein contents of SFM, coconut meal and RSM were similar to those reported by Woods *et al*. (2003); however, they reported higher CP contents in CSM (42.14%) and SBM (52.38%). Weisberg *et al*. (1996) reported similar CP values in the case of RSM, coconut cake and PKC but higher values for CGM (70.4%), SFM (36.5%) and CSC (33.6%) and a lower value for RSC (33.7%). Chumpawadee *et al*. (2005) reported a similar range of CP contents in SBM and coconut meal. Mondal *et al*. (2008) reported lower CP content in RSC (33.18%) but higher CP contents in SFM (36.31%), SBM (54.81%), CSC (29.19%), coconut cake (25.50%) and CGM 60% (70.31%). These variations in chemical composition particularly in CP contents of test feeds may result from differences in agronomic practices and industrial processing methods used in different countries.

Crude protein degradation kinetic parameters and ED of the vegetable protein sources are given in Table 3. All the degradation kinetics viz "a", "b" and "c" varied significantly ($P<0.001$) among the test feeds. Quickly soluble fraction "a" was highest ($P<0.05$) in sesame cake and lowest ($P<0.05$) in CGM 60%, coconut meal and PKC. Fraction "b" was maximum ($P<0.05$) in CGM 60%, PKC, SBM and guar meal while minimum ($P<0.05$) in sesame cake and CGM 30%. Protein degradation rate "c" was highest ($P<0.05$) in CSC (0.21 $h^{-1}$) while lowest ($P<0.05$) in coconut meal, coconut cake and CGM 60%.

When comparing the CP degradation kinetics (a, b and c) of the test feeds used in this study with those reported by Woods *et al*. (2003); in case of SFM, values were lower for quickly soluble fraction "a" and degradation rate "c" while higher for potentially degradable fraction "b". In RSM and CSM, values (from this study) were lower and higher for potentially degradable fraction "b" and degradation rate "c", respectively. Degradation rate "c" in SBM and CGM 30% did not vary to those reported by Woods *et al*. As compared to the findings of Mondal *et al*. (2008), results from this study for RSC had a lower value for fraction "a", a similar value for fraction "b" and a higher degradation rate "c". In case of coconut meal, results (from this study) were similar for quickly soluble fraction "a", but lower and higher values for fractions "b" and 'c", respectively. Coconut cake showed higher potentially degradable fraction "b" and lower degradation rate "c". In CSC and CGM 60%, values were higher in fractions "a" and "c" but lower in fraction "b". Sesame cake showed lower values for fractions "a" and "b" and higher degradation rate "c" than the findings of Mahala and Gomma (2007).

Effective degradability of CP at 0.02, 0.05 and 0.08 rumen passage rates was varied significantly ($P<0.001$) among the test feeds. Sesame cake showed highest ($P<0.05$) ED of CP at all rumen passage rates with no difference with CSC at 0.02 rumen passage rate.

Conversely, the lowest (P<0.05) ED of CP was recorded in coconut meal followed by CGM 60%.

In CP ED, Woods *et al*. (2003) reported a similar range of values at 0.05 rumen passage rate in SFM, RSM, SBM and coconut meal. However, in CSM and CGM 30%, they reported higher CP ED at 0.02, 0.05 and 0.08 rumen passage rates. Kamalak *et al*. (2005) reported lower ED of CP in SBM (71.1-60.40%), CSM (60.2-50.50%), SFM (59.13-49.10%) and RSM (65.90-56.60%) at 0.02 and 0.05 rumen passage rates. Mondal *et al*. (2008) reported lower ED of CP in SFM (72.38%), SBM (68.21%), CSC (60.33) and CGM 60% (30.94%) at 0.02 rumen passage rates and higher CP ED in coconut cake (77.5%) at the same rumen passage rate. In this study, sesame cake had a higher CP ED than all the other test feeds. It had the highest quickly soluble fraction (58.11) among the test feeds and the second highest degradation rate (0.19 $h^{-1}$) (after CSC). However, it had similar ED of CP at 0.02, 0.05 and 0.08 rumen passage rates to that reported in the literature (Mahala and Gomma, 2007).

Results for the degradation kinetics and ED of CP of the test feeds are similar as well as varied to those values reported in the literature. These variations are due to many factors, including potential differences between laboratories. Agronomic practices and processing technologies have profound influences on CP degradation rate, quickly soluble and potentially degradable fractions. Feeds nature, fiber contents and adulterations would also contribute to differences in results. Difference in the use of small or large ruminants and their breeds, species, age, sex and their feeding during *in situ* study are other factors that would contribute to variations in reported results. Further, laboratory analyses, mathematical approach and interpretation of data in different studies can cause significant differences in results (Stern and Satter, 1984; AFRC, 1987; Nocek, 1988, Wadwa *et al*., 1998).

It is concluded that studied vegetable protein sources showed more than 50 % ruminal degradability at 5% rumen passage rate except coconut meal and corn gluten meal 60%. Hence, these protein sources can be incorporated in growing and lactating ruminant rations to obtain maximum bypass protein value.

**Table 1. Composition of total mixed ration fed to Nili-Ravi buffalo steer during *in situ* experiment**

| Ingredients | Inclusion % |
|---|---|
| Wheat straw | 50 |
| Wheat bran | 15 |
| Rice polishing | 6 |
| Molasses | 8 |
| Corn gluten meal 60% | 5 |
| Sunflower meal | 2 |
| Cottonseed cake | 2 |
| Rapeseed cake | 5 |
| Soybean meal | 5 |
| *Mineral mixture | 1.9 |
| Vitamins | 0.1 |
| **Total** | **100** |
| **M.E Mcal/kg** | **2.1** |
| **C.P %** | **11.92** |

ME Mcal/kg= Metabolizable energy mega calories per kilogram ; C.P= crude protein

*Mineral mixture composition (per kilogram): Dicalcium phosphate 708g; Sodium choloride 189g; Magnassium sulphate 86.0g; Ferous sulphate 8.9g; Manganese sulphate 4.9g; Zinc sulphate 3.2g; Copper sulphate 0.3g; Potassium iodide 0.087mg and Cobalt chloride 0.0089mg ; Sodium selenate 0.015mg.

**Table 2. Chemical composition of vegetable protein sources**

| Feeds | DM | Ash | CP | EE | CF |
|---|---|---|---|---|---|
| | | (as percent in DM) | | | |
| Soybean meal | 94.08 ±0.58[de] | 8.56 ±0.46[b] | 46.81 ±0.49[b] | 0.98 ±0.12[d] | 1.16 ±0.13[i] |
| CGM 60 % | 93.25 ±0.52[e] | 1.45 ±0.24[f] | 61.68 ±0.37[a] | 5.69 ±0.20[c] | 1.71 ±0.24[i] |
| CGM 30% | 94.34 ±0.56[cde] | 8.18 ±0.60[b] | 26.18 ±0.57[g] | 1.23 ±0.21[d] | 5.58 ±0.38[h] |
| Guar meal | 97.21 ±0.44[a] | 5.83 ±0.64[b] | 42.24 ±0.65[c] | 5.51 ±0.37[c] | 10.14 ±0.99[dc] |
| Sunflower meal | 94.56 ±0.6[cde] | 6.16 ±0.54[e] | 30.73 ±0.58[f] | 1.48 ±0.14[d] | 25.53 ±0.76[a] |
| Rapeseed meal | 96.91 ±0.45[ab] | 8.67 ±0.80[b] | 38.17 ±0.59[e] | 1.69 ±0.19[d] | 9.02 ±0.60[ef] |
| Rapeseed cake | 94.62 ±0.52[cde] | 6.14 ±0.61[e] | 36.74 ±0.45[e] | 8.50 ±0.55[a] | 10.1 ±0.65[def] |
| Canola meal | 93.89 ±0.58[e] | 6.46 ±0.54[d] | 38.17 ±0.54[e] | 1.05 ±0.11[d] | 11.4 ±0.51[cd] |
| Cottonseed cake | 94.79 ±0.41[cde] | 4.87 ±0.43[ef] | 23.76 ±0.49[h] | 8.70 ±0.44[a] | 21.80 ±0.85[b] |
| Cotton seed meal | 95.73 ±0.40[abc] | 5.80 ±0.38[e] | 40.54 ±0.46[d] | 1.13 ±0.09[d] | 8.43 ±0.33[fg] |
| Coconut cake | 94.00 ±0.52[de] | 6.35 ±0.23[cd] | 20.57 ±0.31[j] | 8.05 ±0.33[ab] | 12.61 ±0.38[c] |
| Coconut meal | 95.60 ±0.41[bcd] | 8.81 ±0.56[b] | 22.08 ±0.28[i] | 1.56 ±0.22[d] | 9.56 ±0.48[ef] |
| Palm kernel cake | 75.95 ±0.74[g] | 4.23 ±0.33[e] | 17.08 ±0.45[k] | 7.91 ±0.21[ab] | 12.64 ±0.52[c] |
| Almond cake | 93.83 ±0.46[e] | 21.71±0.74[a] | 41.25 ±0.62[cd] | 5.74 ±0.46[c] | 7.04 ±0.39[gh] |
| Sesame cake | 91.79 ±0.38[f] | 7.81 ±0.37[bc] | 37.84 ±0.53[e] | 7.35 ±0.34[b] | 3.97 ±0.30[i] |
| **Significance level** | P<0.001 | P<0.001 | P<0.001 | P<0.001 | P<0.001 |

Means with different superscripts within same column are significantly different (P<0.05).

DM= dry matter; CP= crude protein; EE= ether extract; CF= crude fiber; CGM= corn gluten meal

**Table 3. *In situ* crude protein degradation kinetics and effective degradability of vegetable protein sources at different rumen passage rates**

| Particulars | Crude Protein degradation kinetics | | | Effective degradability (%) | | |
|---|---|---|---|---|---|---|
| | a (%) | b (%) | c ($h^{-1}$) | k= 0.02 | k=0.05 | k=0.08 |
| SBM | 16.45± 0.93$^{h}$ | 71.77± 1.67$^{abc}$ | 0.1776±0.15$^{bc}$ | 80.51± 0.78$^{ef}$ | 71.72± 0.59$^{e}$ | 65.60± 1.05$^{e}$ |
| CGM 60% | 5.90± 1.09$^{j}$ | 76.68± 3.33$^{a}$ | 0.0724±0.01$^{ef}$ | 65.26± 1.18$^{i}$ | 50.35 ± 0.29$^{i}$ | 41.47± 0.31$^{h}$ |
| MGF | 43.37± 2.29$^{b}$ | 39.76± 2.79$^{g}$ | 0.1419±0.01$^{d}$ | 78.12± 1.48$^{f}$ | 72.59 ± 1.36$^{e}$ | 68.60± 1.37$^{de}$ |
| Guar meal | 22.74± 1.69$^{g}$ | 72.54± 1.5$^{7ab}$ | 0.1523±0.01$^{cd}$ | 86.82± 0.75$^{c}$ | 77.26 ± 0.96$^{d}$ | 70.20± 1.11$^{d}$ |
| SFM | 27.08± 1.35d$^{ef}$ | 68.61± 1.10$^{bc}$ | 0.1686±0.01$^{bcd}$ | 88.37± 0.46$^{bc}$ | 79.92± 0.61$^{c}$ | 73.52± 0.73$^{c}$ |
| RSM | 25.32± 1.26d$^{efg}$ | 52.48± 1.06$^{e}$ | 0.1741±0.01$^{bc}$ | 72.08± 1.04$^{h}$ | 65.54 ± 1.16$^{g}$ | 60.64± 1.22$^{f}$ |
| RSC | 32.21± 1.42$^{c}$ | 56.02± 1.61$^{e}$ | 0.1511±0.01$^{cd}$ | 82.63± 0.56$^{de}$ | 75.20± 0.69$^{d}$ | 69.74± 0.80$^{d}$ |
| Canola meal | 23.99± 0.78$^{efg}$ | 68.23± 1.02$^{bc}$ | 0.0934±0.00$^{e}$ | 79.99 ± 0.79$^{f}$ | 68.19± 0.94$^{f}$ | 60.50± 1.01$^{f}$ |
| CSC | 29.26± 1.84$^{d}$ | 66.99± 1.80$^{cd}$ | 0.2149±0.01$^{a}$ | 90.36± 0.69$^{ab}$ | 83.25± 1.04$^{b}$ | 77.63± 1.30$^{b}$ |
| CSM | 35.04 ± 1.26$^{c}$ | 45.23± 1.00$^{f}$ | 0.1758±0.01$^{bc}$ | 75.56± 0.37$^{g}$ | 70.11± 0.40$^{ef}$ | 65.97± 0.45$^{e}$ |
| Coconut cake | 23.31± 0.80$^{fg}$ | 62.02± 1.00$^{d}$ | 0.0729±0.00$^{ef}$ | 71.57± 0.83$^{h}$ | 59.62± 1.25$^{h}$ | 52.46 ± 1.34$^{g}$ |
| Coconut meal | 12.02± 0.53$^{i}$ | 62.78± 0.68$^{d}$ | 0.0569±0.00$^{f}$ | 58.12± 0.51$^{j}$ | 45.11± 0.76$^{j}$ | 37.87± 0.78$^{i}$ |
| P.K. cake | 14.58± 1.00$^{hi}$ | 75.01± 0.83$^{a}$ | 0.0861±0.00$^{e}$ | 75.19± 0.92$^{g}$ | 61.73± 1.27$^{h}$ | 53.19± 1.37$^{g}$ |
| Almond cake | 27.63± 1.12$^{de}$ | 62.76± 1.48$^{d}$ | 0.1664±0.01$^{bcd}$ | 83.55 ± 0.78$^{d}$ | 75.72± 0.89$^{d}$ | 69.83± 0.99$^{d}$ |
| Sesame cake | 58.11± 2.02$^{a}$ | 38.26±2.15$^{g}$ | 0.1865±0.02$^{b}$ | 92.37± 0.55$^{a}$ | 87.77 ± 0.89$^{a}$ | 84.29± 1.15$^{a}$ |
| **Significance** | *** | *** | *** | *** | *** | *** |

Means with different superscripts within same column are significantly different (P<0.05).
NS= non significant (P>0.05); Sig.= significance level; ***= (P<0.001); a= quickly soluble fraction; b= potentially degradable fraction by rumen microbes; c= degradation rate of fraction b; k= rumen passage rate

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