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Biological evaluation of tomato waste seed meals and protein concentrate

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Abstract

Whole meal, deoiled meal and protein concentrate (PC) of tomato seeds were fed to male albino rats to study weight gain, along with standard and non-protein diets. Corrected protein efficiency ratio was 1.82 for whole meal, 1.93 for deoiled meal and 1.99 for PC as compared to 2.5 for casein. The net protein retention (NPR) was highest for casein (2.91), followed by whole meal (2.65) and deoiled meal (2.52) and least for PC (2.51). Tomato seeds contained high quality plant proteins that could be supplemented into various food products.

Keywords: Tomato; Waste; Seeds; Meals; Protein concentrate; Biological evaluation

1. Introduction

Tomato (*Lycopersicon esculentum L*) is grown throughout the world for its fruit. Its high nutritive value and multiple uses in culinary preparations have made it a most important vegetable. The majority of tomatoes for processing are made into products such as juices, ketchup, sauce, paste, puree and powder. The solid waste, remaining after the juice/pulp extraction process, consists of skin, seeds, fibrous matter, trimmings, cores and cull tomato. This waste is dumped, flushed into sewage, streams and rivers or to some extent used as fertilizers.

Tomato seed protein has been found to have a high lysine content; therefore, could substantially improve the protein quality of cereal products, which are low in lysine (Brodowski & Geisman, 1980). Tomato seed supplemented bread had improved loaf volume, texture and crumb quality, due to anti-staling properties (Morrison, 1976). Reports are available on the incorporation of tomato seed meal in bread (Carlson, Knorr, & Watkins, 1981; Knorr & Betschart, 1978; Sogi, Sidhu, Arora, Garg, & Bawa, 2002; Yaseen, El-Din, & El-Latif, 1991).

Biological evaluation is the best tool for judging the quality of protein since numerous factors decide the ultimate quality of the protein in vivo. Studies on nutritive value of tomato seed proteins in vivo could not be found, however, reports involving the use of microorganism and enzymes are available. Kramer and Kwee (1977) studied the growth of *Tetrahymena pyriformis* on tomato protein concentrate, as well as casein, and observed that nutritive value of tomato seed protein was less than that of casein but equivalent to other plant proteins. Rahma, Moharram, and Mostafa (1986) reported that in vitro digestibility employing pepsin and pancreatin, was 61.8% for tomato seed meal as compared to 80% for casein.

The present study was under taken for evaluation of the protein qualities of tomato seed in biological system.

2. Materials and methods

2.1. Materials

2.1.1. Tomato seeds

Pomace from a tomato paste-manufacturing unit located at Amritsar was collected, used for seeds separation

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by sedimentation technique (Sogi, Bawa, & Garg, 2000) and dried in a cabinet dryer (Sogi, Shivhare, Bawa, & Garg, 2003).

2.1.2. Feed ingredients

Casein (M/S G.S Chemical Testing Lab and Allied Industries, New Delhi), refined groundnut oil (M/S Amrit Banaspati Company, India) and cornstarch were procured from the local market. Mineral and vitamins mixes were prepared from AR grade chemicals.

2.2. Methods

2.2.1. Preparation of whole meal, deoiled meal and protein concentrate

Dried tomato seeds were ground to get whole meal. The oil from whole meal was extracted with hexane to get deoiled meal. Dissolving deoiled meal in 1% NaOH solution, filtering, precipitating protein with HCl solution, centrifuging, neutralizing the pellet and drying at 50 °C prepared protein concentrate (PC).

2.2.2. Preparation of dietary regimen: (43.183, AOAC, 1975)

Three test protein diets (whole meal, deoiled meal and protein concentrate), one standard protein diet (casein) and one non-protein diet were prepared by mixing the protein source, groundnut oil, mineral mix, vitamin mix and corn starch. Standard and test protein diets were adjusted to 10% protein, whereas, non-protein diet was devoid of protein.

2.2.3. Feeding trial (43.184-6, AOAC, 1975)

Male albino rats with average body weight 53.65 g and age 21–28 days were selected and housed in individual cages. The animals were fed with standard rat diet (M/S Hind Lever Ltd, India) and conditioned to the laboratory environment for 5 days. The animals were segregated into five groups, allocating six rats, with similar mean body weights to each group, namely test protein group (TPG), standard protein group (SPG) and non-protein group (NPG). Diets were moistened and fed to the respective groups of animals for 21 days. Observations on daily feed intake and weekly body weight changes were made.

2.2.4. Nutritional indices (43.187, AOAC, 1975)

The amount of the feed given on dry weight basis was computed, based on moisture content while moisture-free refusal was obtained by drying overnight at 100 °C. The difference between diet given and refusals was taken as feed intake, which was further used to compute protein intake. Feed intake, protein intake and body weight gain were used to compute the following nutritional indices:

- Feed efficiency (FE) = Gain in body wt (g)/Feed intake (g)
- Feed utilisation (FU) = Feed intake (g)/Gain in body wt (g)
- Protein efficiency ratio (PER) = Gain in body wt (g)/ Protein intake (g)
- Corrected Protein efficiency ratio (C-PER) = PER of Casein (2.5) × PER of Test Protein/Exp. PER of Casein
- Protein utilisation (PU) = Protein intake (g)/Gain in body wt (g)
- Net protein retention (NPR) = [Wt gain of TPG (g) + Wt loss of NPG (g)]/Protein intake of TPG (g)

2.2.5. Statistical analysis (Gomez & Gomez, 1984)

The data were analyzed using one-way analysis of variance (ANOVA). The least significant different (LSD) values were computed in case the *F*-test showed significant difference. The comparison was done with the standard protein as well with one another.

3. Results and discussion

3.1. Feed /protein intake

The feed intake was 220.8 g for casein, 180.1 g for whole meal, 215 g for deoiled meal, 209.6 g for PC and 112.1 g for non-protein diets on a d.b., respectively (Table 1). It was observed that the casein diet was consumed maximally, followed by the deoiled meal diet while the non-protein diet was consumed the least. Statistical analysis revealed that there were no significant differences in feed intake of deoiled meal and PC diets compared to casein diet while whole meal and non-protein diet intakes were significantly lower than those of the casein diet ($p < 0.05$). Among test proteins, the feed intake of deoiled meal and PC did not differ significantly while that of whole meal was significantly lower. Protein intakes of casein, whole meal, deoiled meal and non-protein diets were 22.3, 18.5, 21.6, 22.9 and 1.18 g, respectively. Statistical analysis showed a similar trend to feed intake.

3.2. Weight gain

The average body weight gain in 21 days was 40.74 g for standard diet, 24.90 g for whole meal, 30.62 g for deoiled meal and 33.45 g for PC while average loss of weight was 23.99 g in the non-protein diet (Table 1). Statistical analysis revealed that weight gain for the casein diet was significantly higher than for all the test proteins ($P < 0.05$). The weight gain was significantly lower for whole meal but was higher in the case of deoiled meal and PC among the test proteins ($p < 0.05$).

Table 1
Nutrition indices of whole meals, deoiled meal and protein concentrate of tomato waste seeds ($n = 6$)

Parameter	Casein	Whole meal	Deoiled meal	Protein concentrate	Non-protein	LSD
Feed intake (g)	220.8 ± 26.64^{aa}	181.1 ± 23.47^{bb}	215.0 ± 9.15^{ca}	209.65 ± 18.07^{ca}	112.1 ± 25.41^{db}	24.94
Protein intake (g)	22.30 ± 2.69^{aa}	18.52 ± 2.40^{bb}	21.61 ± 0.92^{ac}	22.91 ± 1.98^{ac}	1.18 ± 0.27^{bd}	2.22
Weight gain (g)	40.74 ± 5.15^{aa}	24.90 ± 5.13^{bb}	30.62 ± 6.26^{bc}	33.45 ± 4.89^{bc}	-23.99 ± 6.30^{bd}	6.64
Feed efficiency	0.184 ± 0.004^{aa}	0.137 ± 0.009^{bb}	0.142 ± 0.24^{bb}	0.159 ± 0.011^{bc}	–	0.017
Feed utilization	5.43 ± 0.12^{aa}	7.32 ± 0.48^{bb}	7.23 ± 1.24^{bb}	6.32 ± 0.50^{bc}	–	0.86
Protein efficiency ratio	1.83 ± 0.12^{aa}	1.33 ± 0.11^{bb}	1.41 ± 0.23^{bb}	1.45 ± 0.10^{bb}	–	0.17
Corrected protein efficiency ratio	2.50 ± 0.00^{aa}	1.82 ± 0.14^{bb}	1.93 ± 0.31^{bb}	1.99 ± 0.12^{bb}	–	0.22
Protein utilization	0.55 ± 0.01^{aa}	0.76 ± 0.07^{bb}	0.73 ± 0.12^{bb}	0.69 ± 0.05^{bb}	–	0.09
Net protein retention	2.91 ± 0.12^{aa}	2.65 ± 0.07^{bb}	2.52 ± 0.19^{bb}	2.51 ± 0.06^{bb}	–	0.15

Mean ± SD. Different superscripts in rows indicate significantly ($P < 0.05$) different values. First letter gives comparison with casein while second letter gives comparison with each other.

The non-protein diet showed significantly lower weight gains than standard and test diets.

3.3. Feed efficiency

Efficiency is the gain in body weight per unit feed intake. Results revealed that the feed efficiency was 0.137 for whole meal, 0.142 for deoiled meal, 0.159 for PC and 0.184 for casein (Table 1). Hence there was maximum feed efficiency for casein and minimum for whole meal diet. Statistical analysis showed that test diets had significantly lower feed efficiencies than the casein diet. However, among the test diets, PC showed significantly lower feed efficiency than whole and deoiled diets ($P < 0.05$).

3.4. Feed utilization

Feed utilisation is ratio of feed intake to that of gain in body weight. Results revealed 5.43 feed utilization for casein, 7.32 for whole meal, 7.23 for deoiled meal and 6.32 for PC (Table 1). Hence there was maximum feed utilization for whole meal, followed by deoiled meal. Statistical analysis showed a similar trend to the feed efficiency.

3.5. Protein efficiency ratio (PER)

Protein efficiency ratio is gain in body weight per unit protein intake. The results revealed that the PER value for casein was 1.83, for whole meal 1.33, for deoiled meal 1.41 and for PC 1.45 (Table 1). The whole meal and deoiled meal diets gave lower PER values than did the casein diet, indicating deficiency in essential amino acids. Statistical analysis showed significantly higher PER in casein as compared to test proteins but no significant difference among the test protein diets ($P < 0.05$).

3.6. Corrected protein efficiency ratio (C-PER)

Corrected protein efficiency ratio is defined as ratio of PER of test protein to that of standard protein multiplied by standard value of reference proteins. The standard PER of casein is taken as 2.5 (Chapman & Mitchell, 1959). The corrected PER was 1.80 for whole meal diet, 1.96 for deoiled meal and 2.34 for PC diet. Plant proteins can be categorized into three groups (Hsu, Sutton, Banjo, Satterlee, & Kendrick, 1978), high PER (Cottonseed meal-2.3, rice-1.7, Red gram-1.7, Peanut-1.6), medium PER (Oat-1.5, Soybean flour-1.5, Corn-1.4, Wheat 1.3, Sesame seed-1.2, Maize-1.0) and low PER (Peas-0.7, Rapeseed meal-1.41).

The present study revealed that whole meal, deoiled meal, PC and standard protein diets all had high PER. The C-PER values of whole meal and deoiled meal indicated that tomato seeds contained high quality plant proteins. Statistical analysis revealed that standard protein had significant higher C-PER than test protein diets; however, the test proteins did not vary significantly among themselves.

3.7. Protein utilization (PU)

Protein utilization is ratio of protein intake to gain in body weight. The results revealed that the PU value for casein was 0.55, whole meal diet 0.76, deoiled meal 0.73 and PC 0.69. PU of whole meal diet was maximum, followed by deoiled meal. The statistical analysis showed significantly higher PU in the test protein diets than casein diet but no difference among the test proteins diets.

3.8. Net protein retention (NPR)

Net protein retention is defined as the ratio of sum of weight gain of TPG and weight loss of NPG to that of protein intake of test protein group. The results revealed that NPR was maximum for casein (2.91), followed by whole meal (2.65), deoiled meal (2.52) and minimum for PC (2.51). Statistical analysis showed similar trend to PER.

It can be concluded that protein quality of tomato seeds is comparable to other plant proteins but lower than animal proteins.

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