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Evaluation of tea waste or tea residue, orange peels and pigeon pea pods for proximate composition, fodder quality and digestibility parameters

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Abstract
Tea waste or tea residue (TW), orange peels (OP) and pigeon pea (*Cajanus cajan*) pods (PPP) were assessed as animal feed using the proximate analysis and fodder quality and digestibility parameters based on factorial methods. CP was 20.82%, 6.92% and 7.39% while CF was 17.06%, 10.89% and 26.02% in TW, OP and PPP respectively. Other than CF recorded in the OP the CF of the TW and PPP was higher than the conventional ingredients used generally for non-ruminant livestock. Hence TW and PPP may probably suit to ruminant and pseudo-ruminants. TA (4.92%, 4.27% and 7.72%), moisture content (13.69%, 72.51% and 57.69%) and lipid content (5.23%, 2.90% and 1.43%) in TW, OP and PPP respectively. Calcium was 0.54%, 0.42% and 0.38%, Phosphorous was 0.36%, 0.37% and 0.31% in TW, OP and PPP respectively. NDF was 73.87%, 26.76% and 70.10% and ADF was 59.91%, 23.14% and 51.28%) in TW, OP and PPP respectively. The estimated DMI was (1.62%, 4.48% and 1.71% on DM basis) and estimated digestibility parameters i.e. Relative Feed Value (RFV) are 53.18%, 246.39% and 64.96%; Relative Feed Quality (RFQ) are 60.62%, 261.21% and 72.29% in TW, OP and PPP respectively. ADL 53.07%, 15.04% and 39.91%, HC 13.96%, 3.62% and 18.82%, AIA 0.44%, 0.17% and 0.88% and silica 0.18%, 0.81% and 1.32% in TW, OP and PPP respectively. The results of TW, OP and PPP depicts potential nutritional uses as animal feed which has to be further tested *in vivo* at various levels of inclusion.

Keywords: Orange peels, proximate, pigeon pea pods, RFQ, RFV, tea waste, tea residue

1. Introduction
Livestock rearing is a vital element of rural life (Dagar 2017, Ghosh *et al.*, 2016, Kumar, Agrawal, *et al.*, 2012, Vijay *et al.*, 2018) [8, 13, 21, 36]. Feeds and fodder shortage is a burden to have an economical and sustainable production in livestock (Pathak & Dagar, 2015, Antil & Raj, 2020, Babu *et al.*, 2020) [26, 4, 5]. Along with shortage in cultivable land for fodder (Dagar 2017 [8], Halli *et al.*, 2018 [15], Meena *et al.*, 2018) [8, 15, 24] there is no clear data on actual feed and fodder availability (Jitendra, 2017) [17]. At village and mandal level number of options are available to include unconventional resources (Shashikala *et al.*, 2017) [30] some of which are Tea waste or tea residue (TW) like from students hostels, tea stalls and hotels, orange peels (OP) from juice selling vendors and factories and pigeon pea (*Cajanus cajan*) pods (PPP) as agricultural crop residue after removal of pigeon pea grains. Wadhwa and Bakshi (2013) [37] concluded that 50% of fruits and vegetables are wasted during agricultural production, processing and distribution which (Wadwha *et al.*, 2015, Orosz and Davies, 2015) [38, 25] can be diverted as feed after appropriate processing.
Brief reviews of the above ingredients show how they can be a useful alternative to the conventional feed resources and for other uses. Belpagodagamage *et al.*, 2021 [7] used tea waste as an alternative to litter material in poultry. Zahedifar *et al*, 2019 [42] reported that the Tea waste can be included in the diet of ruminants but with a caution that its level should be restricted owing to presence of anti-nutritional factors. Theeraphaksirinont *et al*, 2009 [32] studied the effect of dietary green tea waste (GTW) in cross-bred lactating cows as TMR and found no harmful effects on the performance of lactating cows. Santoso *et al*, 2011 [28] found that secondary metabolites in coffee ground, green tea and oolong tea residues effected fermentation characteristics and CH4 production as well can be incorporated as TMR in order to mitigate methane emission in ruminants (Knapp *et al.*, 2014, Herrero *et al.*, 2016) [18, 16]. Sevim *et al.*, 2020 [29] showed that inclusion of the orange peels oils reduced the cholesterol and improved mineral metabolism in quails.

Valença *et al*, 2016 [34] studied the orange peel with bark, seeds and pulp and found that it was an optimal feed resource having nutritional value for feeding to ruminants. De Cabras Saanen Em Lactação *et al*, 2018 [10] recommended that pigeon pea can be used at the rate of 24% of the voluminous fraction of the diet without compromising animal intake and digestibility in lactating Saanen goats in contrast (White *et al.*, 2007, Watson *et al.*, 2017) [40, 39] reported lower animal performance.

Hence, in the present scenario wherein the feeds and fodder limitation is critically recognized (Banakar *et al.*, 2017) [6], it is also equally important on how the available unconventional feeds and wastes are resourcefully utilized and at a later stage developing of technology to utilize these unconventional feedstuffs to reduce the cost of total ration (Ginwal *et al.*, 2019) [14], and in so doing would be an economical and realistic feeding approach for livestock production in village conditions.

In view of the above the present study was taken up to assess the nutritional as well and feeding value of the TW, OP and PPP as a likely feed or fodder for livestock. Above resources are almost available all through the year and the quantity can also be predicted beforehand based on the tie up with the institutions and farmers. Hence systematic evaluation of TW, OP and PPP can open up economical and novel utilisation and inclusion approaches in the livestock diets or rations during normal or scarcity or disaster conditions in various forms.

2. Materials and Methods

2.1 Location of the study

The experiment was conducted on the samples that were pooled from Korutla Veterinary College campus Hostels, various tea and fruit stalls, hotels, juice centers and agricultural fields in and around of Korutla Mandal, Jagityala District of Telangana State, India located at 18.8301°N, 78.6787° E and has an average elevation of 286 meters (938 ft).

2.2 Quality measurements

For forage quality assessment from the pool of whole sample approximately 1 kg was taken and then dried in the oven for 48 hours at 60°C and prepared for chemical analysis. The samples were grounded with a Wiley mill to pass a 1 mm screen and analyzed for quality components. Proximate composition (Anonymous, 2005) [3] and cell wall constituents (Van Soest *et al.*, 1991) [35] were estimated in the dried and pooled samples. Hemi-cellulose content was calculated by the difference between NDF and ADF. Ca and P content were determined by titration method (Talapatra *et al.*, 1940) [31].

Total digestible nutrients (TDN), dry matter intake (DMI), digestible dry matter (DDM), digestible crude protein (DCP), net energy for lactation (NEL), digestible feed energy (DFE), relative feed value (RVF), relative forage quality (RFQ) and Digestible Energy DE were estimated according to the following equations adapted from Lithourgidis *et al.* (2006) [23], Lebas (2013) [22] and Kumar *et al.* (2016) [20] from the measured variables:

1. Total digestible nutrients (TDN %) =87.84 − (0.7 × ADF)
2. Dry matter intake (DMI, % DM basis) =120 / NDF
3. Dry matter digestibility (DDM %) =88.9 – (0.779 × ADF)
4. Digestible crude protein (DCP, %) =(0.929 × CP) − 3.77
5. NE_l (M Cal Kg^{-1})=(1.044-(0.0119x % ADF)) x2.205
6. Digestible feed energy (DFE, M Cal Kg^{-1}) =4.4 × (TDN / 100)
7. Relative feed value (RFV, %) =(DDM × DMI) / 1.29
8. Relative feed quality (RFQ, %) =(TDN × DMI) / 1.23
9. Digestible Energy (DE) =15.627 + 0.000982 (CP^2) + 0.0040 (EE^2) - 0.0114 (Ash^2) - 0.169 (ADF) ± 1.250 MJ kg^{-1} DM

3. Results and Discussion

The proximate compositions of the TW, OP and PPP are presented in Table 1. Das *et al.* (2018) [9] reported in TW 88.25% dry matter (DM), crude protein 22.06%, crude fat 17.80%, crude fibre 17.80% and total ash 5.40% on dry matter basis which are comparable with the values of the present study except for the higher crude fat percentage which might be due to the presence of fat from milk during tea preparation. Adewole *et al.*, 2014 [1] reported 16.40% crude protein, 2.78% ether extract, 5.51% ash and 12.47% crude fibre on proximate evaluation of the orange peels. The lower crude protein percent value of 6.92% in the present study might be due to the variation in the species, variety and maturity of the oranges from which the peels were analysed. PPP recorded low values in the present study when compared to the reported values by Krauss, 1921 [19] which were 87.3% DM, 20.3% crude protein, 35.2% crude fibre, 1.7% crude fat and total ash 3.3% on DM basis which might be due to the variation in PPP maturity, species and soil fertility.

Fibre level in TW and PPP was higher than that of the majority conventional ingredients that are used for producing feed for non-ruminant livestock species. It can be inferred that TW and PPP may not be suitable to be used as feed ingredient for non-ruminant livestock species, but will probably better suit to ruminant and pseudo-ruminant. The crude protein content of up to 20% in TW is comparable to those of feed ingredients such as brans, usually used in rations of livestock indicating its potential to be used accordingly.

Estimated digestibility parameters and nutritional quality are presented in Table 2. TW analysis *in vivo* in cattle by Ananthasubramaniam and Menachery, 1977 [2] recorded a digestable crude protein (DCP) percent of 9.7 and a total digestible N (TDN) percent of 43.0 and has indicated that tea waste is a potential feed source for livestock. Present study has almost comparable TDN % but a higher DCP % in the present study may be due to variation in the source of tea waste, type of tea variety, ingredients used during tea making process that ultimately add up to the tea waste or tea residue. Whiteman *et al*, 1980 [41] reported comparable values with regard to the voluntary DM intake (16 g kg^{-1} BW) in sheep which were fed solely on the pigeon pea pods and *in vivo* DM digestibility as 44%.

TW, OP and PPP showed Relative Feed Value (RFV) of 53.18%, 246.39% and 64.96% which were equivalent to the values of the Brome grass in late bloom 58%, sorghum grain 246% and barley straw 68% (Fekadu *et al*, 2017, Dunham, 1998) [12, 11]. Approximate forage quality of TW, OP and PPP based on above comparison can be used as an indicative to include them in the future experimental *in vitro* or *in vivo* trials to know the true nutritional potential for livestock feeding. High RFV index signifies superior forage quality. The RFV index estimates the digestible dry matter (DDM) from ADF, and calculates the DM intake potential (as a percent of body weight, BW) from NDF. RFV is an accurate measure for quality over protein content alone which provides an indication of digestibility and how much forage an animal can eat.

The RFQ index includes the differences in digestibility of the fiber fraction and can be used to more accurately guess animal performance and match animal needs. TW, OP and PPP showed Relative Forage Quality (RFQ) percent of 60.62%, 261.21% and 72.29%. In this context it has to be noted that as per Undersander, 2003 [33], RFQ must be from 100 to 200 in order to support Cattle Type of Heifer and 18 to 24 months dry cow. While the RFQ-based Forage Quality Grading system given by Saha *et al*, 2010 [27] classifies the RFQ of >185 as Supreme and RFQ of <90 as Utility. Based on the above two approaches defining RFQ, the values recorded in the present study have to be interpreted cautiously while including in the future feeding or nutritional evaluation trials. The RFQ stresses upon the fiber digestibility while RFV uses DDM intake. Accordingly, to some extent it can be inferred that TW and PPP can only be fed as a partial replacement in the diets while OP can be fed as such with due care after further *in vivo* trials.

Table 1: Chemical composition

S. No.	Item	Tea waste or tea residue (TW)	Orange peels (OP)	Pigeon pea pods (PPP)
		Percent		
1	Moisture	13.69	72.51	57.69
2	Dry Matter	86.31	27.49	42.31
		Percent Dry Matter basis		
3	Crude Protein	20.82	6.92	7.39
4	Crude Fat	5.23	2.90	1.43
5	Crude Fibre	17.06	10.89	26.02
6	Total Ash	4.92	4.27	7.72
7	Nitrogen free extract (NFE)	51.96	75.02	57.43
8	Neutral detergent fibre (NDF)	73.87	26.76	70.10
9	Acid detergent fibre (ADF)	59.91	23.14	51.28
10	Acid detergent lignin (ADL)	53.07	15.04	39.91
11	Cellulose	4.58	5.47	7.71
12	Hemicellulose (HC)	13.96	3.62	18.82
13	Acid insoluble ash (AIA)	0.44	0.17	0.88
14	Calcium	0.54	0.42	0.38
15	Phosphorous	0.36	0.37	0.31
16	Silica	0.18	0.81	1.32

Table 2: Estimated digestibility parameters and quality

ITEM	TDN (%)	DMI (%)	DDM (%)	DCP (%)	NEL, Mcal kg^{-1}	DFE, Mcal kg^{-1}	RFV (%)	RFQ (%)	DE, MJ kg^{-1} DM
Tea waste or tea residue (TW)	45.90	1.62	42.23	15.57	0.73	2.02	53.18	60.62	7.01
Orange peels (OP)	71.64	4.48	70.88	2.66	1.69	3.15	246.39	261.21	12.84
Pigeon pea pods (PPP)	51.94	1.71	48.95	3.10	0.96	2.29	64.96	72.29	7.59

TDN =Total digestible nutrients; DMI =Dry matter intake; DDM =Digestible dry matter; DCP =Digestible crude protein; NEL=Net lactation for energy; DFE =Digestible feed energy; RFV =Relative feed value; RFQ =Relative forage quality; DE=Digestible energy

4. Conclusion

Results of experiment appeared comparable with that of the available literature. Effects on feed intake, nutrient utilization and growth performance at various inclusion levels and forms has to be taken up based on the above proximate composition, fodder quality and digestibility parameters. Their application as animal feed has to be further tested *in vivo.*

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