THE POTENTIAL OF SWEET ORANGE (*CITRUS SINENSIS*) PEEL TREATED WITH BOVINE RUMEN FILTRATE FOR LIVESTOCK FEEDING

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ABSTRACT
The study investigated the proximate nutrients, anti-nutrients and fibre fractions in sweet orange peel (SOP) biodegraded with bovine rumen filtrate as a natural inoculum, to determine its suitability for feeding livestock. Rumen filtrate (RF) was obtained after adding water to rumen content at v/v ratio 1:1. SOP was divided into 4 batches T_1, T_2, T_3, T_4 of equal weight. T_1 was poured into polythene bag without RF for 24 hrs, while RF was mixed with T_2, T_3. T_4 in a ratio of 1 RF; 2 SOP, poured into polythene bags and allowed 24, 48 and 72 hrs, respectively for biodegradation. Each biodegraded sweet orange peel (BSOP) treatment was sun-dried to less than 12% moisture, milled, analysed for proximate nutrients, anti-nutrients and fibre fractions. BSOP contained 88.12% - 89.90% DM, 6.83% - 8.48% CP, 2.24% - 2.89% EE, 16.97% - 24.00% CF, 9.42% - 10.62% ash, 56.94% - 61.24% NFE and 2071.57 - 2358.53 kcal/kg ME. Except phytate (0.03 – 0.07%), saponin (0.02 – 0.05%), tannin (0.50 – 0.62%), alkaloid (2.69 -3.42%), flavonoid (1.10 – 3.15%), oxalate (0.020 – 0.03%) which are anti-nutrients, and NDF (25.63 – 32.4%), ADF (22.50 – 28.00%), cellulose (21.00 – 26.74%), hemicellulose (1.13 – 5.35%) and lignin 0.32 – 3.50%) all fibre fractions, varied significantly ($P<0.05$) across the treatments. Biodegradation of SOP with bovine rumen filtrate improved its feed value especially the proximate nutrients and anti-nutrients for it to be a feed resource in livestock feeding, while the development of a processing method to reduce its NDF and ADF to further enhance its suitability is recommended.
Keywords: Nutrients, Orange peel, Rumen filtrate

INTRODUCTION
The shortage of animal protein for human consumption especially in developing and lower middle income countries like Nigeria has been a cause of malnutrition to several individuals thus affecting their mental development and productivity. Hence, the awareness on the importance of animal protein for food, health and survival, has caused increasing demand of livestock and poultry products. The report of a joint IFPRI/FAO/ILRI study showed that the global intake of meat will rise from 233million metric ton in the year 2000 to 300 million metric ton in year 2020 (Delgado *et al*., 1999). The consequent rise in domestic animal population has particularly created a problem on how much food/feed resources will be available for feeding animals since humans are good consumer of some of the food resources. This is a threat to the nutrition of man and animals. Aye (2016) reported that the soaring price of conventional feedstuffs reduces the net profits that should accrue to livestock farmers, and the economic viability of farm animal enterprises. Recourse to unconventional feedstuffs as partial or full replacement of conventional ones, if their inherent anti-nutrients characteristics are eliminated seems a good option to mitigate this situation, and possibly enhance availability of feed ingredients all year round. This study investigated the chemical composition of biodegraded sweet orange peel an abundant agro-allied by-product in Nigeria, using bovine rumen filtrate

MATERIALS AND METHODS
Experimental site, source of sweet orange peel and processing
The study was conducted at Joseph Sarwuan Tarka University Makurdi, Nigeria. It has a temperature range of 22.8 - 40.0 °C with annual rainfall of 1105 mm to 1600 mm (TAC, 2009).
Fresh sweet orange peels (SOP) were collected from sweet orange retail outlets within Makurdi metropolis and Gboko town in Benue State, foreign materials were manually removed, and the SOP divided into four batches T1, T2, T3 and T4. Rumen content (RC) was collected in covered plastic buckets from white fulani cattle slaughtered at the Wurukum abattoir in Makurdi metropolis early morning of the preceding evening after orange peel collection, Potable water was added to rumen content at a ratio of 1:1 (1 L water to 1 kg RC) and the mixture thoroughly stirred to obtain a homogenous mass which was filtered to obtain rumen filtrate (RF) The RF was used to inoculate T_2, T_3 and T_4 at a ratio of 1:2 (1 L RF to 2 kg SOP), manually mixed with a wooden stirrer, thereafter poured into separate empty feed sacs and allowed to ferment for 24 hrs, 48 hrs and 72 hrs, respectively under shade of trees. Sweet orange peel in batch T1 was not treated with RF but poured also into an empty feed sac and allowed to ferment for 24 hrs. After the stipulated period of fermentation for each, the mass was then sun dried to less than 12 % moisture level. Samples of T1, T2, T3 and T4 were milled and used for chemical assay to determine their proximate nutrients, anti-nutrients and fibre fractions.

Microbial analysis of bovine rumen filtrate
The rumen filtrate used was analyzed for its microbial content at the Veterinary Microbiology Laboratory, Joseph Sarwuan Tarka University using the procedure outlined by Chessbrough (2005).

Proximate analysis of biodegraded sweet orange peel (BSOP)
The proximate analysis of the sweet orange peel was done using the standard methods (AOAC, 2002). Metabolisable energy (ME) was calculated (Pauzenga, 1985).

Anti-nutrients analysis
Anti-nutrients determinations of oxalate, phytate, alkaloid, flavonoid, saponin and tannin were done with the methods in Harbone (1973).

Fibre fractions determinations
The fibre fractions of sweet orange peel; neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) hemicellulose and cellulose were determined using the procedures outlined by Van Soest (1967).

Statistical analysis
All chemical analyses data were subjected to the analysis of variance (ANOVA) using SPSS (2011) version 20, and statistically significant means were separated using the least significance difference.

RESULTS AND DISCUSSION

Microbial constituents found in RF were bacterial species (*Staphylococcus aureus, Klebsiella spp*.) in the range of $2.00 \times 10^7 \pm 0.10$ - $2.35 \times 10^7 \pm 0.05$ cfu and fungal species (*Aspergillus species*) with a total fungal count of $9.00 \times 10^6 \pm 1.00$. *Staphylococcus* and *Klebsiella* have the advantage of being facultative anaerobes (Andre *et al*., 2021), while Aspergillus spp. are obligate aerobes (Scheld, 2012). These rumen microbes though pathogenic in nature will nonetheless facilitate biodegradation of SOP by breaking down its structural carbohydrates, and in the process enhance its nutritive value.

The proximate composition of BDOP gave dry matter range of 88.12% - 89.90%, 6.83% - 8.48% CP, 2.24% - 2.89% ether extract, 16.97% - 24.00% crude fibre, 9.42% - 10.62% ash, 56.94% - 61.24% NFE and 2071.57 - 2358.53kcalME/kg. Dry matter is high in BSOP comparable to 89.70% in sweet orange peel (Adewole *et al*., 2014). High dry matter content of feed ingredient enhances shelf-life in storage and if BSOP is kept in a cool dry store, it may be preserved for an appreciable time lag before utilisation. While, crude protein in BSOP is lower than 8.90% in maize (Aduku, 2012), 8.48% CP in T_3 and 8.45% CP in T_4, are comparable to that of maize. The use of bovine RF as source of natural inoculum for biodegradation of SOP increased the CP content of SOP at 48 and 72 hours. The crude fibre of BSOP is considerably higher than 2.70% in maize (Aduku, 2012). However, T_2, T_3 and T_4 have lower crude fibre values of 19.78%, 16.97% and 18.53% than 24% crude fibre in T_1, and comparable to CF level of up to 18% a concentrate feed stuff can have (Reddy, 2001). The ash content in BSOP is very high and its NFE moderate and these possibly reduced the energy level of BSOP compared to 3432 kcal/kg ME in maize (Aduku, 2012) and lowers its feed value.

The anti-nutrients determined in BSOP (Table 1) were saponin, tannin, alkaloid, flavonoid, oxalate and phytate.

Table 1: Anti-nutrients in Sweet orange peel treated with bovine rumen filtrate (mean ± SE)

Anti-nutrients	Biodegraded sweet orange peel			
	T_1	T_2	T_3	T_4
Saponin (%)	0.50 ± 0.05^{a}	0.20 ± 0.01^{c}	0.35 ± 0.04^{b}	0.40 ± 0.01^{ab}
Tannin (%)	0.60 ± 0.00^{a}	0.62 ± 0.00^{a}	0.50 ± 0.00^{b}	0.57 ± 0.00^{ab}
Alkaloid (%)	2.90 ± 0.06^{c}	3.08 ± 0.04^{b}	2.69 ± 0.05^{d}	3.42 ± 0.02^{a}
Flavonoid (%)	3.15 ± 0.05^{a}	1.80 ± 0.06^{b}	1.49 ± 0.05^{c}	1.10 ± 0.03^{d}
Oxalate (%)	0.03 ± 0.02^{a}	0.03 ± 0.03^{a}	0.02 ± 0.01^{c}	0.02 ± 0.01^{b}
Phytate (%)	0.07 ± 0.05^{a}	0.03 ± 0.02^{a}	0.04 ± 0.03^{a}	0.05 ± 0.33^{a}

^{a,b,c,d}Means with different superscripts in the same row differed significantly ($p<0.05$). T_1 = SOP biodegraded without RF for 24 hours, T_2 = SOP biodegraded with RF for 24 hours, T_3 = SOP biodegraded with RF for 48 hours, T_4 = SOP biodegraded with RF for 72 hours, SE = standard error.

They differed significantly ($p<0.05$) among the treatments except phytate ($p>0.05$). None of the anti-nutrients has a sequence of significant variation except flavonoid which decreased and alkaloid which tended to increase with higher duration of biodegradation. Saponin up to 0.71% in chick diet will reduce feed intake (Shimelis *et al.,* 2013), while Kumar (1991) reported a toxic level of 3.0% for chickens. However, saponin concentrations of 0.50%, 0.20%, 0.35% and 0.40% in T_1, T_2, T_3 and T_4, respectively in this study were lower and may not adversely affect the performance of chickens. Tannin in BSOP varied from 0.50% to 0.62% and less than 1- 20% considered to have negative effect on animal (Price and Butler, 1980). The major effect of tannins is decreased efficiency in converting absorbed nutrients to new body substances. The alkaloid in BSOP is more than 0.05% which has been reported to produce signs of toxicosis in chickens (MSD Veterinary Manual). Flavonoids values obtained in the BSOP decreased from 3.15% to 1.095% as the duration of fermentation increased to 72 hrs. Like other phytonutrients, they are antioxidants with anti-inflammatory and immune system benefits (Szalay, 2015). Oxalate content of BSOP is lower than 0.5% and 2.0% soluble oxalate acceptable as safe levels for non-ruminants and ruminants, respectively. The phytate concentration is lower than 0.062% and 0.082% reported to be safe for broiler chicken (Oluremi *et al.*, 2007) and may not cause decreased mineral or protein bio-availability, and hence safe for domestic animals.

Neutral detergent fibre, ADF, cellulose, hemicellulose and lignin content in BSOP each varied significantly ($p<0.05$) among the treatments (Table 2) and these variations can be attributed to the use of the RF as a source of natural inoculum. BSOP tended to increase in NDF, ADF and cellulose with time. while the other fibre fractions had no sequence of variation.

Table 2: Fibre fractions of sweet orange peel treated with bovine rumen filtrate (mean ± SE)

Fibre fractions	Biodegraded sweet orange peel			
	T_1	T_2	T_3	T_4
Neutral detergent fibre	27.13 ± 0.08^{c}	25.63 ± 0.03^{d}	32.40 ± 0.40^{a}	30.80 ± 0.04^{b}
Acid detergent fibre	22.50 ± 0.10^{d}	24.50 ± 0.30^{c}	27.05 ± 0.15^{b}	28.00 ± 0.20^{a}
Cellulose	21.08 ± 0.02^{b}	21.00 ± 0.31^{b}	26.74 ± 0.19^{a}	26.49 ± 0.17^{a}
Hemicellulose	4.63 ± 0.03^{d}	1.13 ± 0.28^{c}	5.35 ± 0.25^{a}	2.80 ± 0.16^{b}
Lignin	1.42 ± 0.12^{b}	3.50 ± 0.01^{a}	0.32 ± 0.04^{c}	1.52 ± 0.04^{b}

[a,b,c,d]Means with different superscripts in the same row differed significantly ($p<0.05$). T_1 = SOP biodegraded without RF for 24 hours, T_2 = SOP biodegraded with RF for 24 hours, T_3 = SOP biodegraded with RF for 48 hours, T_4 = SOP biodegraded with RF for 72 hours, SE = standard error

Neutral detergent fibre, ADF and ADL are used as indicators of dietary energy and intake especially for ruminants (Foss, 2018), and the lower the NDF and ADF the higher the feed value (Schroeder, 2006). The lignin and hemicellulose content were low, < 4% and < 5.5%, respectively. This implies that the carbohydrate contained in BSOP will be easily digestible by livestock and poultry.

CONCLUSION

Biodegradation of sweet orange peel with bovine rumen filtrate improved its feed value especially the proximate nutrients and anti-nutrients for it to be a feed resource in domestic animal nutrition. The development of a processing method to reduce its NDF and ADF will further enhance its suitability.

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