



ASSESSING THE FEED PREFERENCE AND NUTRITIONAL VALUE OF ORANGE (*Citrus sinensis*) AND WATERMELON (*Citrullus lanatus*) PEELS BASED WAFERS FOR SHEEP AND GOAT IN NIGERIA.

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ABSTRACT

This study evaluated the feed preference, acceptability, and proximate composition of orange and watermelon peel-based wafer diets in sheep and goats in Nigeria. Dried orange and watermelon peels were formulated with maize, soybean, starch, molasses, urea, potassium, and salt to produce wafer feeds. A total of 1000 g of each wafer type was offered separately to experimental animals for 15 minutes daily over a 7-day period, and intake was determined by difference. Results showed that orange peel wafers were more preferred than watermelon peel wafers, with mean intakes of 830 g and 524 g, respectively. Proximate analysis revealed higher crude protein in orange peel wafers (9.85%) compared to watermelon peel wafers (4.63%). However, both diets contained crude protein levels below the recommended requirement for growing ruminants, indicating the need for supplementation. The study concludes that both orange and watermelon peel-based wafers are acceptable to sheep and goats and have potential as alternative feed resources. Their utilization can reduce feed costs and minimize environmental waste. Further research should focus on incorporating other agro-industrial by-products and evaluating long-term animal performance. It is recommended that farmers in Nigeria should consider incorporating these orange and watermelon peels-based wafers in to the diets of their sheep and goat, especially during the period feeds scarcity or when seeking cost-effective feeds options. Further should focus on optimizing the proportion of orange and watermelon peels, as well as incorporating other locally available feeds ingredients and by-product to enhanced the nutritional profile (particularly protein and energy contents) and overall palatability of the wafers.

Keywords: Feed preference, orange peels, watermelon peel, nutritional value, feed wafers.



1.0

INTRODUCTION

Feed is one of the most critical constraints limiting livestock production in tropical regions, particularly during the dry season when high-quality forages become scarce. In the rainy season (May-November), pastures are generally abundant and of relatively good nutritional quality; however, during the dry season (November-April), forages become fibrous, less digestible, and nutritionally inadequate. This seasonal fluctuation negatively affects rumen microbial fermentation, volatile fatty acid production, and overall animal performance in terms of maintenance, growth, and reproduction (Lamidi and Ologbose, 2009; Olafadehan *et al.*, 2009).

Ruminant animals, particularly sheep and goats, play an important socio-economic role in developing countries by contributing to food security, income generation, and cultural practices (Kosgey, 2004). In Nigeria, small ruminant production is significant; however, productivity remains low due to inadequate nutrition, disease challenges, and poor management practices (FAO, 2016; Lawal-Adebawale, 2012). Sheep are well adapted to marginal lands and crop residues and are primarily raised for meat production in Nigeria (FAO, 2016). They contribute about 16% of domestically produced meat. Among the indigenous breeds, Yankasa sheep are the most widely distributed, found across the Sahel, Sudan, and Guinea savannah zones of northern Nigeria (Gefu, 2002).

Feed cost represents approximately 70% of total livestock production expenses (Alqaisi *et al.*, 2011), making the search for alternative and low-cost feed resources essential for sustainable ruminant production. Consequently, increasing attention has been given to the utilization of agro-industrial by-products that are not directly consumed by humans. The high cost and seasonal scarcity of conventional feed ingredients continue to limit livestock productivity in Nigeria. This has encouraged livestock producers to explore alternative feed resources that are inexpensive, readily available, and capable of supporting rumen function and animal performance without adverse effects (Oluremi *et al.*, 2007).

Fruit peels such as those from orange and watermelon are abundant agricultural wastes that contribute to environmental pollution when not properly utilized. These materials contain varying levels of nutrients, fiber, and bioactive compounds that make them potential ingredients for ruminant feeding. In particular, citrus by-products have been reported to provide energy and functional nutrients in ruminant diets (Aggey, 2003; Bampidis and Robinson, 2006). Processing these wastes into wafer-based feed forms may further enhance their handling, intake, and acceptability by animals. However,



limited information exists. Therefore, this study was designed to evaluate the feed preference and nutritional composition of orange and watermelon peel-based wafers in sheep and goats, with the aim of assessing their potential as alternative feed resources in ruminant production systems.

2.0 MATERIALS AND METHOD

2.1 Study Area

The study was conducted at the Livestock Teaching and Research Farm, Department of Animal Science, Bayero University Kano.

2.2 Formulation of Orange and Water melon peels wafers

Orange and watermelon peels were collected, sun-dried, and ground. Other ingredients included maize, soybean, starch, molasses, urea, potassium, and salt (Table 1). Cassava starch was cooked in boiling water and used as a binder. Molasses was mixed with starch and combined with other ingredients to form a homogenous mixture. The mixture was molded using wooden frames (35 cm × 21 cm × 6 cm), compressed, and sun-dried for 7 days. After drying, samples were taken to the Animal Science Laboratory, Bayero University Kano, for proximate analysis.

Table 1. Ingredient Composition (%) of Wafer Diets

Ingredients	Orange peel wafers	Watermelon peel wafers
Peels	50	50
Maize grains	18	18
Soybeans	10	10
Starch	18	18
Potassium	0.5	0.5
Urea	0.5	0.5
Molasses	2	2
Salt	1	1

2.3 Preference Trial

Four Yankasa rams and four Sokoto Red goats were used. Animals were divided into two groups, each offered either orange peel wafers or watermelon peel wafers. Each diet (1000 g) was placed in labeled feeders and offered for 15 minutes daily for seven days. Feed intake was determined by subtracting leftover feed from the amount offered. Coefficient of preference (CoP) was calculated as the ratio of individual intake to average intake of all diets. Values ≥ 1 indicated acceptability.



2.4 Proximate analysis

Proximate composition (dry matter, crude protein, ether extract, crude fibre, ash, and nitrogen-free extract) was determined using standard AOAC (2023) procedures.

2.5 Statistical Analysis

Data were analyzed using descriptive statistics and independent t-test in SAS (2003). Mean differences were considered significant where applicable.

3.0

RESULTS AND DISCUSSION

3.1 Proximate Composition of Orange and Watermelon Peel-Based Wafers

The proximate composition of orange and watermelon peel-based wafers is presented in Table 2. The results revealed clear differences in nutrient composition between the two dietary treatments, reflecting the influence of the raw materials used. Orange peel wafers recorded higher crude protein (9.85%) compared to watermelon peel wafers (4.63%), indicating a relatively superior protein profile. This difference may be attributed to the inclusion of citrus peel, which has been reported to contain higher levels of digestible nutrients and bioactive compounds compared to watermelon rind, which is generally more fibrous and lower in protein (Bampidis and Robinson, 2006). However, the crude protein levels of both diets remain below the recommended requirement (12– 16%) for growing sheep and goats (Cannas *et al.*, 2004), suggesting that protein supplementation would be necessary when these wafers are used as major components of the diet.

Dry matter content was comparable between the two treatments (94.00% and 93.00%), indicating effective drying and good storage potential. High dry matter content is desirable as it enhances shelf stability and reduces the risk of microbial spoilage (FAO, 2018). Crude fibre was slightly higher in orange peel wafers (19.16%) than in watermelon peel wafers (17.11%), suggesting adequate fibre levels to support rumen function and microbial activity (Van Soest, 2018). Ether extract (7.50% vs. 5.50%) and ash content (8.00% vs. 5.75%) were also higher in orange peel wafers, indicating better energy density and mineral content. In contrast, nitrogen-free extract (NFE) was higher in watermelon peel wafers (58.01%) than in orange peel wafers (49.49%), reflecting a greater proportion of soluble carbohydrates typical of watermelon residues (Sharma *et al.*, 2017).

Overall, these results suggest that orange peel wafers provide a more balanced nutrient profile compared to watermelon peel wafers, particularly in terms of protein and energy availability. This agrees with findings that citrus by-products can serve as valuable feed resources due to their moderate protein and energy content (Bampidis and Robinson, 2006; Makkar *et al.*, 2014).

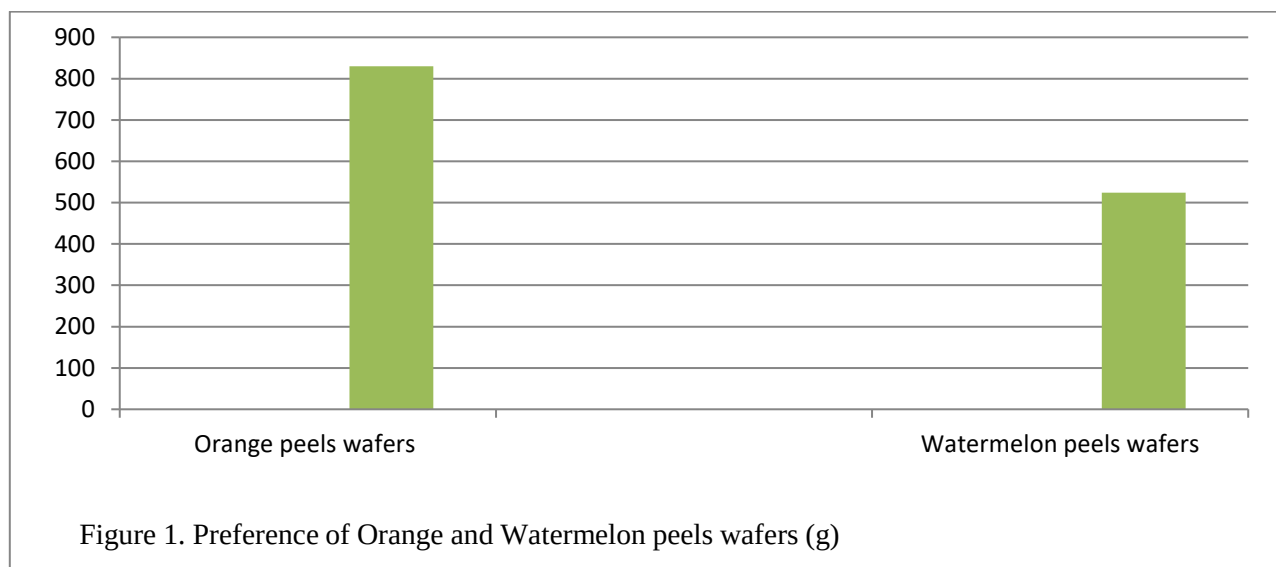
Table 2. Proximate Composition of Orange Peels Wafers and Watermelon Peels wafers

Nutrients	Mean $\pm$ Standard deviation	
	Orange peels Wafers	Watermelon peels Wafers
Dry matter	94.00 $\pm$ 0.71	93.00 $\pm$ 3.54
Crude protein	9.85 $\pm$ 0.94	4.63 $\pm$ 0.11
Crude fibre	19.16 $\pm$ 0.39	17.11 $\pm$ 0.93
Ether extract	7.50 $\pm$ 0.71	5.5 $\pm$ 0.71
Ash	8.00 $\pm$ 0.71	5.75 $\pm$ 0.35
Nitrogen-free-extract	49.49 $\pm$ 2.04	58.01 $\pm$ 1.40

3.2 Feed Preference and Intake Pattern

Feed preference results showed marked differences in voluntary intake between the two wafer types. Sheep and goats consumed significantly more orange-peel wafers (830g) than watermelon peel wafers (524g) (Figure 1), indicating higher palatability and acceptability of the former. The preference for orange peel wafers was higher than for watermelon peel wafers by 36.87%. The higher intake of orange peel wafers may be attributed to the presence of aromatic compounds and essential oils in citrus peels, which enhance feed smell and stimulate feeding behavior. Citrus by-products have been reported to improve feed intake in ruminants due to their favorable sensory characteristics and fermentable nutrient content (Marin *et al.*, 2007; Zohreh *et al.*, 2012). The lower intake observed for watermelon peel wafers may be associated with their lower crude protein content and less appealing sensory properties. Although watermelon peel contains appreciable levels of soluble carbohydrates, its relatively bland taste and lower nutrient density may have reduced its attractiveness to the animals. Feed intake in ruminants is influenced not only by nutrient composition but also by sensory attributes such as aroma, taste, and texture (Forbes, 2018). Furthermore, citrus peels contain essential oils and volatile compounds that enhance palatability and stimulate feed intake (Zhang *et al.*, 2019).

The observed preference pattern supports the concept that feed intake in ruminants is influenced by both nutritional and sensory factors. Additionally, the wafer form of the diets likely contributed to improved feed handling, reduced wastage, and more uniform intake during the feeding period (Retnani *et al.*, 2009).



3.3 Coefficient of Preference and Acceptability

The coefficient of preference (CoP) further confirmed that orange peel wafers were more acceptable to both sheep and goats compared to watermelon peel wafers. Values greater than unity for orange peel wafers indicate higher-than-average intake and stronger preference. This suggests that orange peel-based wafers have greater potential as an alternative feed resource for small ruminants. However, the lower preference observed for watermelon peel wafers does not diminish their potential value, as they can still serve as an energy source when properly supplemented or combined with other nutrient-rich feed ingredients (Makkar *et al.*, 2014).

Table 3. Coefficient of preference of Orange and Watermelon Peel-Based Wafers

Peel-based wafer	Feed intake (g)	Coefficient of preference
Orange	830	1.23
Watermelon	524	0.77

The findings of this study demonstrate that fruit peel-based wafers can serve as viable alternative feed resources in small ruminant production systems. The processing of orange and watermelon peels into wafer form improves their handling, storage stability, and ease of feeding. From a nutritional standpoint, both wafer types require protein supplementation to meet the dietary requirements of growing and lactating animals (Cannas *et al.*, 2004). Nevertheless, their inclusion in ruminant diets can reduce reliance on conventional feed ingredients and lower overall feed costs (FAO, 2018). In addition, the utilization of fruit peels contributes to environmental sustainability by reducing the accumulation of agricultural waste and promoting resource recycling within livestock production systems (Sharma *et al.*, 2017; Makkar *et al.*, 2014).



4.0

CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Orange peel-based wafers demonstrated superior nutritional quality and higher acceptability compared to watermelon peel wafers. Although both diets were accepted by sheep and goats, their low crude protein content necessitates supplementation for optimal animal performance. The utilization of fruit peel-based wafers offers a sustainable and cost-effective feeding strategy while reducing environmental waste. Future studies should evaluate long-term growth performance, digestibility, and economic viability under practical production systems.

4.2 Recommendations

It is recommended that

- i. Farmers in Nigeria should consider incorporating these orange and watermelon peels-based wafers in to the diets of their sheep and goat, especially during the period feeds scarcity or when seeking cost-effective feeds options.
- ii. Further should focus on optimizing the proportion of orange and watermelon peels.
- iii. Incorporating other locally available feeds ingredients and by-product to enhanced the nutritional profile (particularly protein and energy contents) and overall palatability of the wafers.

REFERENCES

- Aggey, M. B. (2003). Utilization of citrus pulp and other agro-industrial by-products in ruminant nutrition. *Proceedings of the Nigerian Society for Animal Production (NSAP) Conference*, 2003, 329– 331.
- Alqaisi, O. A., Ndambi, O. A., Hemme, T., & Bölling, D. (2011). Global view on feed cost and feed efficiency on dairy farms. IFCN Dairy Research Network / All About Feed.
- AOAC International. (2023). *Official Methods of Analysis* (22nd ed.). Oxford University Press.
- Bampidis, V. A., & Robinson, P. H. (2006). Citrus by-products as ruminant feeds: A review. *Animal Feed Science and Technology*, 128(3– 4), 175– 217.
- Cannas, A., Tedeschi, L. O., Fox, D. G., Pell, A. N., & Van Soest, P. J. (2004). A mechanistic model for predicting nutrient requirements of sheep. *Journal of Animal Science*, 82:149– 169.
- FAO. (2016). *Small ruminant production systems and constraints in sub-Saharan Africa*. Food and Agriculture Organization of the United Nations. Rome.
- FAO. (2018). *Feed and fodder management in livestock systems*. Food and Agriculture Organization of the United Nations.



- Forbes, J. M. (2007). Voluntary food intake and diet selection in farm animals. CAB International. 2nd Edition. Institute of Integrative and Comparative Biology, University of Leeds, Leeds LS2 9JT, UK.
- Gefu, J. O. (2002). Small ruminant production systems in Nigeria: Constraints and prospects. In R. C. Merkel, G. Abassa, & A. T. Abubakar (Eds.), The role of village poultry and small ruminants in rural livelihoods in Africa (pp. 45– 52). International Livestock Research Institute (ILRI), Nairobi, Kenya.
- KNARDA (2012). Kano Agricultural and Rural Development Authority annual agricultural report. KNARDA Press.
- Kosgey, I. S. (2004). Breeding objectives and breeding strategies for small ruminants in the tropics (PhD thesis). Wageningen University, Wageningen, Netherlands.
- Lamidi, A.A. and Ologbose, F.I. (2009). Ruminants Production and Forage Utilization Unit, Department of Animal Science, University of Port Harcourt, , Rivers state, Nigeria.
- Lawal-Adebowale, O. A. (2012). Dynamics of ruminant livestock management in the context of the Nigerian agricultural system. IntechOpen.
- Makkar, H.P.S., Tran, G., Heuzé, V. and Ankers, P. (2014). State-of-the-Art on Use of Insects as Animal Feed. *Animal Feed Science and Technology*, 197, 1-33.
- Marin, F. R., Soler-Rivas, C., Benavente-Garcia, O., Castillo, J., and Perez- Alvarez, A. J., (2007). By product from different Citrus processes as a sources of customized functional fibres, *Food Chemistry* 100 (2) 736-741.
- Muhammad, I.R. Ashiru Rabi and Abdullahi, A. Y. (2007). Implications of the slaughter of pregnant ewe and does to future stock in the semi-arid urban abattoir. *Journal of Animal and Veterinary Advances*, 6 (6): 819-822.
- Muhammad, I. R. (2019). Forage and Fodder Production in Nigeria: Its Sensitivity in Sustainable Ranching. Bayero University, Kano. Proffesorial Inaugural Lecture Series.
- Olafadehan, O.A., Olafadehan, O.O., Obun, C.O., Yusuf, A.M., Adeniji, A.A., Olayinka, O.O., and Abudulahi, B. (2009). Intake and digestibility of Red Sokoto Goats fed varying proportion of *Andropogon gayanus* and *Pterocarpus erinaceus* forage, *Proc. 14th Ann. Conf. Anim. Sci. Assoc. Nig. Ladoke Akintola University of Technology, Ogbomoso, and Nigeria*. Pp.572-574.
- Olofin, E. A. (2007). Some aspects of the physical geography of the Sudan savannah region of Nigeria. Bayero University Press.
- Oluremi, O. I. A., Andrew, I. A. and Ngi, J. (2007). Evaluation of the nutritional potential of the peels of some citrus fruits varieties of feeding stuff in livestock production. *Parkistan Journal of Nutrition*, 6(6): 653-656.
- Retnani, Y., Widiarti, W., Amiroh, I., Herawati, L., & Satoto, K. B. (2009). Storage Capacity and Palatability of Wafer Complete Ration Based on Sugar Cane Top and Bagasse on Calves. *Media Peternakan*, 32(2), 130– 136.



- SAS (2003). Statistical Analysis System. User' s Guide. Statistical Analysis Institute Inc. Cary, N.C.
- Sharma, K., Mahato, N., Cho, M. H., & Lee, Y. R. (2017). Converting citrus wastes into value-added products: Economic and environmentally friendly approaches. *Nutrition*, 34, 29– 46.
- Van Soest, P. J. (2018). Nutritional ecology of the ruminant (3rd ed.). Cornell University Press.
- Zhang, H., Wen, H., Chen, J., Peng, Z., Shi, M., Chen, M., Yuan, Z., Liu, Y., Zhang, H., & Xu, J. (2019). Volatile compounds in fruit peels as novel biomarkers for the identification of four Citrus species. *Molecules*, 24(24), 4550.
- Zohreh, P., Ali, A., Alaw, Q. and Alireza, S. (2012). Does different levels of dried Citrus sinensis peel affect on gastrointestinal microbial population? *Annals of Biological Research*, 3(9): 4474-4479.