HARRAN ÜNİVERSİTESİ VETERİNER FAKÜLTESİ DERGİSİ

The Effect of Season on the Performance, Health, and Welfare of Broilers*

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Abstract: The research was carried out on 80 broiler flocks (Ross 308) raised during the winter, spring, summer, and autumn seasons in commercial enterprises in Uşak City Center and its districts engaged in contract farming. Broiler flocks were examined weekly during the 0-42 day growth period for body weight, weight gain, feed consumption, feed conversion ratio, mortality and EPEF. The 42-day-old broiler was scored for FPD and HB. The season significantly impacted the broiler flock's performance and the birds' prevalence with FPD and HB under commercial conditions. Spring and autumn flocks showed higher performance than winter and summer flocks. The prevalence of birds with foot pad burn and hock burn was highest in winter flocks and lowest in summer flocks. These findings indicate that seasons can significantly impact broiler farms' economic performance and bird welfare. As a result, obtaining further information about the positive and negative effects of seasons on broilers can promote production and provide critical data to encourage innovative strategies for sustainable flock management and improve broiler industry compliance with animal welfare standards.

Keywords: *Broiler, Performance, Season, Welfare.*

Mevsimin Broiler Piliç Performansı ve Refahı Üzerine Etkisi

Özet: Araştırma, Uşak İl Merkezi ve ilçelerinde sözleşmeli üretim yapan ticari işletmelerde kış, ilkbahar, yaz ve sonbahar mevsimlerinde yetiştirilen 80 adet broiler piliç sürüsünde (Ross 308) yürütülmüştür. Broiler piliç sürüleri canlı ağırlık, canlı ağırlık artışı, yem tüketimi, yemden yararlanma oranı, ölüm oranı ve EPEF yönünden 0-42 günlük büyüme döneminde haftalık olarak incelenmiştir. Kırk iki günlük piliçler FPD ve HB yönünden skorlanmıştır. Mevsim ticari koşullardaki broiler sürülerin performansı ile FPD ve HB görülen piliç prevelansını önemli ölçüde etkilemiştir. İlkbahar ve Sonbahar sürüleri, Kış ve Yaz sürülerine göre daha yüksek performans göstermiştir. Ayak tabanı yanığı ve diz yanığı tespit edilen broiler piliçlerin prevalansının Kış sürülerinde en yüksek ve Yaz sürülerinde en düşük olduğu belirlenmiştir. Bu bulgular, mevsimlerin broiler işletmelerinin ekonomik performansı ile piliçlerin refahını önemli ölçüde etkileyebileceğini göstermektedir. Sonuç olarak, mevsimlerin broiler piliçlerin üzerindeki olumlu ve olumsuz etkileri hakkında daha fazla bilgi edinmenin, üretimi teşvik edebileceği ve sürdürülebilir sürü yönetimi için yenilikçi stratejileri teşvik etmek ve broiler endüstrisinin hayvan refahı standartlarına uyumunu geliştirmek için önemli veriler sağlayabileceği sonucuna varılmıştır.

Anahtar Kelimeler*: Broiler, Mevsim, Performans, Refah*

Introduction

Broiler hybrids, which have been subjected to high levels of selection for high productivity and rapid growth, have also become highly sensitive to environmental factors (Beg et al., 2011; Musilová et al., 2013). Therefore, optimizing the indoor conditions in poultry houses is crucial for maximum efficiency (Beg et al., 2011; De Jong et al., 2014; Federici et al., 2016). However, outdoor environmental conditions can make maintaining optimal conditions inside poultry houses challenging. Adverse indoor conditions have been shown to reduce broiler performance and threaten broiler health and welfare (De Jong et al., 2012; Guo et al., 2023).

Closed housing systems and indoor climate control systems have been introduced to optimize indoor conditions in poultry houses. However, they increase production costs and need to provide long-term and definitive solutions (Marcu et al., 2013; Nawaz et al., 2021). Additionally, the accelerating pace of global climate change highlights the importance of new insights that shed light on the present and near-future seasonal effects (Aksoy et al., 2021; De Jong et al., 2012). Further research is required to examine the effects of seasons on commercial broiler houses and broilers' performance and welfare, using actual field samples that cover the entire year. (Jones et al., 2005; Nawaz et al., 2021). This study investigates the effects of the year's seasons on the performance and welfare of broilers reared on commercial poultry farms.

Materials and Methods

Experimental Design, Flock Management and Production Performance

This study was conducted in commercial broiler farms in Uşak City Center and its districts engaged in contract farming. A total of 80 broiler flocks were used and raised during winter (December, January, February), spring (March, April, May), summer (June, July, August), and autumn (September, October, November) seasons in 2021 and 2022. The study utilized a cross-sectional sampling approach, randomly selecting 20 broiler farms (four flocks were used from each farm, reared in four different seasons) and poultry houses, focusing on the hybrid broiler type (Ross 308), poultry house and equipment characteristics, feeding program, and slaughter age (El-Tahawy et al., 2017; Federici et al., 2016; Kittelsen et al., 2017; Meluzzi et al., 2008).

All flocks were raised in littered houses equipped with automatic ventilation, heating, drinkers, and feeders for 0-42 days. The broiler management, feeding, vaccination, and health protection practices followed the Ross 308 management guide (Aviagen, 2020). The birds were provided with three different diets *ad libitum*: starter (23% CP and 3000 kcal ME/kg) from 1-10 days, grower (22% CP and 3100 kcal ME/kg) from 11-21 days, and finisher (20.5% CP and 3200 kcal ME/kg) from 21-42 days of age. On August 24, 2021, with reference number AKUHADYEK-88-21, this study was approved by the Local Animal Ethics Committee of Afyon Kocatepe University.

Litter and drinking water temperatures were measured using an infrared thermometer when chicks were placed in the house, and the number of chicks was recorded. A total of 50 chicks, randomly selected from five locations in the poultry house, were individually weighed using a digital precision scale precision 1g to determine average body weight (ABW) at one day of age (De Jong et al., 2012; Marcu et al., 2013). Using the same sampling method, the selected birds were individually weighed on days 7, 14, 21, 28, 35, and 42, and the average weekly body weights (ABW) for the groups were calculated. On the days the animals were weighed, the amount of feed remaining in the silos and troughs was subtracted from the total feed intake for the week to calculate the average weekly feed intake. On farms with silo weighing systems, the remaining feed was determined directly by weighing the silo. On the other farms, silo residues were collected, loaded onto lorries, and weighed. Weekly feed consumption was determined by subtracting the remaining feed at the end of the week from the total feed given that week. Average weekly feed intake per bird was calculated by dividing weekly feed intake by the number of birds per week. Mortality rate, total feed intake (TFI), and total weight gain (TWG= final body weight (g) - day one body weight (g)) were calculated on a weekly cumulative basis. Feed conversion ratio (FCR= cumulative feed intake (kg) /total weight gain (kg)) and livability (100 - mortality rate) were calculated weekly (Kryeziu et al., 2018; Kubiś et al., 2022; Meluzzi et al., 2008; Teyssier et al., 2022). The European Production Efficiency Factor was used to evaluate the broiler growth performance. It was calculated according to the formula proposed by Marcu et al. (2013) and Aviagen (2020) (EPEF= viability (%) x BW (kg)/age (d) x FCR (kg feed/kg gain) x100).

Data Collection and Lesion Scoring

In each flock, the number of dead birds was recorded daily using farm records. The mortality rates were calculated by dividing the cumulative number of dead birds each week by the initial chick numbers. The stocking density was calculated as m^2/bird (total number of chicks placed on the first day / total house area) and m^2/kg live weight (total live weight of flock's birds (the birds harvested on day 42 + the birds removed from the flock through thinning on days 33-36) / total house area).

Assessments of footpad and hock burn (FPD and HB) were carried out on broilers from 5 flocks in each season group when the broilers were 42 days old, taking into account the geographical distribution of broiler flocks and time constraints (only at 42 days of age). A total of 100 broilers were randomly selected, 25 birds each from 4 different areas along the length of the house, and both feet and knees of these birds were examined. According to the Welfare Quality® Poultry Welfare Assessment Protocol (Welfare Quality, 2009), each bird's foot pads and hock joint areas were observed and palpated for skin burns (contact dermatitis). The type, extent, and severity of the lesions were scored. Scoring was performed in five categories for the footpad and hock joint lesions of birds: no lesion (score:

0), superficial staining in an area less than 10% (score: 1), superficial staining in an area greater than 10% (score: 2), deep lesions and ulceration up to 50% (score: 3), and deep lesions and ulceration in an area greater than 50% (score: 4) (Freeman et al., 2020).

Statistical analysis: Statistical analysis was performed using a one-way analysis of variance to evaluate the differences in ABW, mortality rate, TWG, TFI, and FCR. The significance of differences between the seasonal groups was tested using the Duncan test. (Ural and Kılıç, 2013). Prevalences of FPD and HB scores were presented for each seasonal group. The statistical analyses for the studied parameters were performed using the SPSS 21 software package. The significance level was set at 0.05.

Results

The season significantly (P<0.05, P<0.001) influenced the ABW of broilers at 4, 5, and 6 weeks of age (Table 1).

Table 1. The average body weights and total weight gain of broilers in the season groups.

Weeks	Winter	Spring	Summer	Autumn	Total	P
ABW (g/bird)						
0	43.70 ± 0.76	44.45 ± 0.56	42.40 ± 0.94	44.15 ± 0.53	43.68±0.36	0.201-
1	180.25 ±1.91	181.60 ±1.65	180.70 ±1.87	182.20 ±1.34	181.19 ±0.84	0.851-
2	468.50 ± 6.96	476.25 ± 7.99	457.50 ± 7.03	466.15 ± 6.85	467.10±3.62	0.337-
3	904.75 ± 10.13	918.75 ± 10.78	890.75 ± 11.56	915.95 ± 11.65	907.55±5.56	0.272-
4	1475.00 ± 13.74^{a}	1476.00 ± 12.51^{a}	1404.00 ± 34.65^{b}	1479.75 ± 10.71^{a}	1458.69±10.61	0.028*
5	2021.80 ± 22.66^{bc}	2072.45 ± 23.51^{ab}	2003.05 ± 19.03^{c}	2085.80 ± 14.83^{a}	2045.78±10.68	0.013*
6	2602.60 ±24.18^{bc}	2660.70 ±31.24^{ab}	2535.65 ±29.53^{c}	2722.75 ±31.02^{a}	2630.43±16.27	0.000***
TWG (g/bird)						
1	136.55±1.65	137.15±1.70	138.30±1.97	138.05±1.33	137.51±.83	0.874-
2	424.80±6.56	431.80±7.86	415.10±6.77	422.00±6.78	423.43±3.50	0.410-
3	861.05±9.86	874.30±10.78	848.35±11.38	871.80±11.63	863.88±5.48	0.326-
4	1431.30±13.54^{a}	1431.55±12.45^{a}	1361.60±34.25^{b}	1435.60±10.60^{a}	1415.01±10.47	0.030*
5	1978.10±22.37^{cb}	2028.00±23.54^{ab}	1960.65±18.83^{c}	2041.65±14.70^{a}	2002.10±10.59	0.015*
6	2558.90±23.77^{cb}	2616.25±31.20^{ab}	2493.25±29.22^{c}	2678.60±30.78^{a}	2586.75±16.14	0.000***

*:P<0.05, ***:P<0.00, -: Non significant, ^{a,b,c} :Means of groups followed by different letters differ significantly at p<0.05, **ABW : A**verage Body Weight**, TWG:** Total Weight Gain

The highest ABW were observed during the winter, spring, and autumn seasons at four weeks, while at 5 and 6 weeks of age, the highest values were recorded in the spring and autumn seasons. The season had no significant effect on TWG, TFI, and FCR before 21 days. However, it significantly impacted TWG between 28-45 days (P<0.05, P<0.001), TFI between 35 and 42 days (P<0.001), and FCR in the 42 days (P<0.01) (Table 2).

Table 2. Total feed intake and feed conversion rate results by season in broilers,

Weeks	Winter	Spring	Summer	Autumn	Total	P
TFI (g/ bird)						
1	164.95 ±1.70	164.05±1.83	165.35±1.59	165.15±1.38	164.88±0.80	0.946-
2	528.30±7.33	545.00±10.62	529.75±12.50	541.15±8.56	536.05±4.95	0.559-
3	1202.50±17.26	1172.85±16.62	1146.95±14.06	1169.50±12.87	1172.95±7.83	0.093-
4	2122.50±22.66	2103.75±16.88	2055.70±37.28	2087.75±19.94	2092.43±12.77	0.301-
5	3193.00±38.40^{a}	3249.25±29.44^{a}	3068.20±32.44^{b}	3202.50±20.56^{a}	3178.24±16.92	0.001***
6	4322.24±53.62^{a}	4469.17±39.65^{a}	4114.89±66.49^{b}	4351.00±53.44^{a}	4314.33±30.18	0.000***
FCR (kg feed/kg gain)						
1	1.21±0.01	1.20±0.02	1.20±0.02	1.20±0.01	1.20±0.01	0.909-
2	1.25±0.02	1.26±0.02	1.28±0.03	1.29±0.03	1.27±0.01	0.649-
3	1.33±001	1.28±0.01	1.29±0.02	1.28±0.02	1.29±0.01	0.082-
4	1.44±0.02	1.43±0.01	1.48±0.04	1.41±0.01	1.44±0.01	0.173-
5	1.58±0.02	1.57±0.02	1.53±0.01	1.54±0.01	1.56±0.01	0.063-
6	1.66±0.02^{ab}	1.68±0.02^{a}	1.62±0.02^{bc}	1.60±0.02^{c}	1.64±0.01	0.019**

:P<0.01, ***:P<0.001, -: Non significant, ^{a,b,c}:Means of groups followed by different letters differ significantly at p<0.05, TFI**:Total Feed Intake, **FCR**: Feed Conversion Rate.

The highest TWG values were detected in Spring and Autumn. The winter, spring, and summer seasons showed the highest TFIs, while the winter and spring seasons exhibited the highest FCRs. Seasonal variation did not significantly affect the mortality rates of broiler flocks in the periods 0-42 days (Table 3). The differences in EPEF values between the seasonal groups were insignificant during the first five weeks. However, by week 6, the autumn flocks had significantly higher EPEF values (P<0.01) (Table 3).

Table 3. Mortality rates and EPEF by season in broilers.

Weeks	Winter	Spring	Summer	Autumn	Total	P
Mortality rate (%)						
1	1.47±0.12	1.07±0.13	1.49±0.13	1.34±0.15	1.34±0.07	0.124-
2	2.15±0.18	1.73±0.16	2.10±0.14	1.92±0.16	1.97±0.08	0.246-
3	2.69±0.20	2.31±0.18	2.52±0.15	2.55±0.20	2.52±0.09	0.536-
4	3.30±0.20	3.20±0.22	3.27±0.18	3.21±0.28	3.24±0.11	0.988-
5	4.42±0.22	4.32±0.24	4.01±0.19	4.26±0.38	4.25±0.13	0.741-
6	6.14±0.34	6.17±0.31	5.31±0.30	5.84±0.61	5.87±0.20	0.422-
EPEF						
1	210.26±3.46	215.01±3.91	213.20±4.73	214.88±2.93	213.34±1.88	0.799-
2	264.73±7.60	266.00±7.09	252.44±6.61	256.61±8.34	259.95±3.71	0.518-
3	315.99±4.81	335.64±6.21	322.37±8.22	334.01±7.79	327.00±3.50	0.142-
4	354.81±6.19	358.24±4.29	334.00±13.07	362.79±3.49	352.46±3.99	0.051-
5	350.33±6.26	362.01±7.04	358.98±4.72	372.07±5.45	360.85±3.04	0.085-
6	350.98±5.88^b	355.09±8.26^b	353.21±6.27^b	383.38±8.56^a	360.67±3.89	0.007**

:P<0.01, -: Non significant, a,b:Means of groups followed by different letters differ significantly at p<0.05, **EPEF: European Production Efficiency Factor

The effect of season on litter temperature was significant (P<0.05), with the highest litter temperatures observed in the summer flocks and the lowest in the spring and autumn flocks. Season significantly influenced the drinking water temperature on the first day (P<0.01), with the highest temperatures observed in the summer, autumn, and spring. Stocking density was not significantly affected by season (Table 4). Regardless of the season, the percentages of broilers with FPD severity scores of 0, 1, 2, 3, and 4 were 64.35, 15.65, 11.20, 5.75, and 3.05 %, respectively (Table 4). Summer flocks had the highest proportion (73.80 %) of broilers with healthy footpads (score 0). The highest ratios of broilers scored as scores 1 and 2 were observed in winter and Spring flocks, while the highest rate of broilers scored 3 was in the winter and autumn seasons. The most severe FPD (score 4) was observed in the winter and spring. As was the case for FPD, the prevalence of broilers with HB also varied from one season to the next. Overall, the proportions with HB severities 0, 1, 2, 3, and 4 were 62.60, 19.50, 14.95, 1.70 and 1.25% respectively. While the highest prevalence of broilers with HB 1 and 2 scores was observed in the winter and autumn, the highest rates of broilers with 3 scores were observed in the winter. The proportion of birds with an HB severity score of 4 was higher in winter and spring.

Table 4. The results on litter and drinking water temperatures, stocking density, and PFD and HB prevalence in seasons.

Traits	Score	Winter	Spring	Summer	Autumn	Total	P
Fist-day litter temperature (ºC)		31.93± 0.24^{ab}	31.59 ±0.13^b	32.44±0.14^a	31.77±0.21^b	31.93±0.10	0.013*
Fist-day water temperature (ºC)		25.05±0.38^b	25.88±0.20^a	26.25±0.13^a	25.94±0.23^a	25.78±0.13	0.009**
Stocking density (m²/bird)		17.52±0.22	17.90±0.28	17.55±0.22	18.05±0.28	17.75±0.13	0.373-
Stocking density (m²/kg)		41.17±0.79	41.38±0.86	39.72±055	42.00±0.98	41.06±0.41	0.239-
FPD (%)	0	55.60	62.40	73.80	65.60	64.35	
	1	19.00	16.00	12.80	14.80	15.65	
	2	14.40	11.40	9.00	10.00	11.20	
	3	7.20	5.80	3.40	6.60	5.75	
	4	3.80	4.40	1.00	3.00	3.05	
HB (%)	0	52.20	65.20	70.40	62.60	62.60	
	1	23.20	18.20	17.40	19.20	19.50	
	2	19.60	13.60	10.40	16.20	14.95	
	3	3.00	1.60	1.20	1.00	1.70	
	4	2.00	1.40	0.60	1.00	1.25	

*:P<0.05, **:P<0.01, -: Non significant, a,b:Means of groups followed by different letters differ significantly at p<0.05, **FPD**: Food pad dermatitis; **HB**: hock burn.

Discussion and Conclusion

The season significantly influenced the ABW, TWG, TFI, and FCR. Moreover, summer flocks, in particular, exhibited the lowest TFI and TWG, likely due to the adverse impact of high ambient temperatures. The hot weather might have led the broilers to reduce TFI for thermoregulation purposes. The study found that litter and drinking water temperatures on the first day were notably higher in summer compared to other seasons. The lower TFI in summer could be attributed to increased ventilation and the cold air flow from the cooling pads used in the poultry house. The birds seemed to stay still and reluctant to move towards the feeders when the cool fresh air circulated inside the houses, possibly contributing to reduced TFI. These results indicated that the ventilation and cooling systems effectively maintained a suitable environment in the summer houses, ensuring good indoor air and litter quality. The research was carried out in poultry houses equipped with well-functioning ventilation systems and cooling pads, leading to the understanding that proper ventilation effectively prevents unfavourable conditions caused by high seasonal temperatures in the broiler house. This indoor air and litter quality maintenance likely contributed to the observation that disease score, FPD, and HB incidences were lowest in the summer flocks

(Musilová et al., 2013). Interestingly, despite slightly lower flock performance, the welfare of the broilers appeared to be better in summer, as indicated by the lower FPD and HB incidences. The low percentages of the broilers with FPD and HB indicated improved broiler welfare (De Jong et al., 2012; Youssef et al., 2021). These factors play a crucial role in determining the economic performance of the flocks (Kittelsen et al., 2017). Although no statistically significant difference was found between seasons, the fact that total mortality in summer flocks was slightly lower than in other seasons supports this interpretation (Table 2).

Winter flocks had high TFI; however, this did not result in a correspondingly high ABW. The winter conditions, characterized by high humidity and increased manure-origin gas emissions due to limited ventilation, might have created unfavorable indoor environments for the broilers, thus negatively impacting their health and welfare, ultimately leading to reduced flock performance (David et al., 2015). Shepherd and Fairchild (2010) and David et al. (2015) emphasized that low airflow rates during cold seasons contribute to elevated ammonia levels in the broiler house, leading to respiratory issues and decreased production performance.

The slightly higher mortality rate in winter flocks (6.14%) and the more frequent observation of respiratory and digestive diseases were thought to be responsible for this result. Moreover, the immune system responses of broilers raised in such conditions may have been compromised (Guo et al., 2023). Oakley et al. (2018) reported that the gastrointestinal microbiota of broilers varies with the season. Contrary to the findings of Petracci et al. (2006), although mortality was not significantly affected by the season, slightly higher mortality rates were observed in winter and spring flocks. The lower values for TWG and FCR in winter flocks may also be attributed to poor broiler welfare. De Jong et al. (2014) reported that housing broilers with poor litter quality decreased TWG and TFI, increased FCR, impaired bird performance, and increased hock burn, chest burns, and lameness resulting from higher litter moisture. Thus, our study observed the highest percentage of broilers with FPD and HB in winter flocks. Spring and autumn flocks exhibited higher TFI, TWG and EPEF compared to winter and summer flocks. This suggests that commercial broiler flocks achieve higher body weights by consuming more feed in these seasons, which do not experience extreme weather conditions (Youssef et al., 2021).

Moreover, the broiler ratios with FPD and HB were lower in spring and autumn flocks. This finding is expected since high ambient temperatures and adverse climatic conditions are less common in spring and autumn than in winter and summer (Aksoy et al., 2021). Surprisingly, however, the FCR was highest in the spring herds. This result contradicts the study's findings on spring mortality and animal welfare. It is challenging to explain this outcome, but it is possible that higher TFI (average 118 g) and mortality (0.33%), along with lower TWG (average 62.35 g) in spring flocks, may have influenced the FCR.

Consistent with previous research, the incidence of FPD and HB among broilers varied between seasons (De Jong et al., 2012; Shepherd and Fairchild, 2010). Winter flocks had the highest percentage of broilers with FPD and HB, possibly due to poor litter quality in the houses during that season. The litter quality was observed to deteriorate more rapidly in winter houses compared to other seasons, and certain areas, particularly in the latter part of the production period, had extremely compacted and hard litter. The study revealed that FPD and HB incidences were lower in the spring and autumn, which are a few months after or before winter, with the lowest occurrence of lesions observed during the summer. These findings may explain better foot and leg health during the spring and autumn, as litter quality tends to improve during these seasons, just like Meluzzi et al. (2008) reported significant positive correlations between litter moisture and FPD and HB incidences (r=0.87 and 0.75). While litter quality is essential, it is not the sole determinant of broiler foot health, as reported by reports like Kaukonen et al. (2016). There are many factors, such as litter type, ventilation, temperature, feed characteristics, water flowing from drinkers onto a litter, and intestinal disease, resulting in diarrhoea that can cause litter to become wet and compacted hard (De Jong et al., 2012; Musilová et al., 2013; Shepherd and Fairchild, 2010). FPD and HB in this study could be linked to respiratory and digestive system diseases in winter flocks, which are more vulnerable to diseases, leading to compromised foot and leg health due to reduced activity (De Jong et al., 2012). The percentages of birds with FPD and HB in this study (26.2-44.4% and 29.6-47.8%) were lower than those reported in other studies (Kaukonen et al., 2016; Musilová et al., 2013), possibly due to antibiotic treatment in winter flocks. The proportion of broilers with FPD and HB in winter, spring, and autumn flocks was higher than in summer flocks. Stocking density may also have played a role; stocking density in summer flocks was slightly lower than in other seasons (1.45-2.28 %). However, the prevalence of FPD and HB was lower in spring and autumn compared to winter, suggesting that foot pad and huck lesions are also influenced by environmental factors other than housing density (Jones et al., 2005; Meluzzi et al., 2008; Sans et al., 2021).

The study demonstrated that each season had varying effects on commercial broiler flocks' performance and welfare. The research findings conclude that the observed results can provide valuable guidance and contribute to developing innovative strategies for improving flock management and meeting animal welfare standards, considering different seasons' negative and positive effects.

Conflict of Interests

The authors have declerated that they have no real, potential, or perceived conflicts of interest for this article.

Ethics Committee Approval

Ethics committee approval was received for this study from the ethics committee of Afyon Kocatepe University (Reference no: AKUHADYEK-88-21). Additionally, the authors declared that they comply with the Research and Publication Ethics.

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Critical Review: ZB

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