



Special Issue (UniSZA), Malaysia:

ICAFT 2023: 3rd International Conference on Agriculture, Animal Sciences & Food Technology

The Effect of Organic Wheatgrass Fodders (*Triticum aestivum*) on Growth Performance, Meat Quality of Japanese Quail (*Coturnix japonica*)

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Abstract | A 30-day feeding trial on 45 quails aged 12 days was conducted to evaluate the effects of organic wheatgrass (*Triticum aestivum*) fodders on growth performance and meat quality of Japanese quail (*Coturnix japonica*). This research aims to determine nutrient compositions in organic wheatgrass fodder (OWF) and to evaluate the effect of organic wheatgrass on the growth performance and meat quality of quail. Wheatgrass fodder was grown using organic fertilizer which is goat dung. Then, proximate analysis was done on OWF and commercial feed. Five dietary treatments consisting different percentages (%) such as Control (0% OWF+ 100% Commercial Feed), Treatment 1 (5% OWF+ 95% Commercial Feed), Treatment 2 (10% OWF+ 90% Commercial Feed), Treatment 3 (15% OWF+ 85% Commercial Feed), Treatment 4 (20% OWF+ 80% Commercial Feed) were given for feeding experiment in triplicates. Body Weight Gain (BWG), Average Daily Weight Gain (ADWG), Daily Feed Intake (DFI), Feed Conversion Ratio (FCR), survival rates were recorded and calculated. 15 quails aged 42 days were slaughtered on day-30 for carcass yield, pH, color, WHC, shear force and proximate analysis were conducted. Results showed that nutrient composition of OWF for crude protein (CP), crude fibre (CF), Crude Lipid (CL), moisture, nitrogen-free extract (NFE), ash content were 26.80%, 7.09%, 2.49%, 9.89%, 45.35%, 4.30% respectively. In conclusion, Treatment 3 (15% OWF+ 85% Commercial Feed) showed the overall best performance among quails.

Received | February 22, 2024; **Accepted** | August 30, 2024; **Published** | November 01, 2024

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Citation | Sathiaganeshan, S., N.A.N. Yusoff, S.J. Zuraimi, R.O. Folarin, S.N.R. Ramasamy, A. Kari, E.D. Kusumawati, I.W. Karyasa and C.F. Komilus. 2024. The effect of organic wheatgrass fodders (*Triticum aestivum*) on growth performance, meat quality of Japanese quail (*Coturnix japonica*). *Sarhad Journal of Agriculture*, 40(Special issue 1): 186-194.

DOI | <https://dx.doi.org/10.17582/journal.sja/2024/40/s1.186.194>

Keywords | Wheatgrass, Quail, Organic fertiliser, Growth performance, Meat quality, Animal



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Introduction

Wheatgrass (*Triticum aestivum*) is a good option for cultivated crops as food and fodder for humans and livestock. It is a tender, small plant grown from wheat seed. It has antioxidant molecules and acts as an antimicrobial agent. Its increased growth rate, the number of harvests taken from a single crop input, and its nutritive quality made wheatgrass worthwhile (Linsha *et al.*, 2018). Quails are small, ground-nesting birds. Depending on the species, they can reach up to 5–10 ounces in weight and 6–12 inches in length. Quail serves as protein source and achieves the self-sufficiency level of white meat in Malaysia. The Japanese quail (*Coturnix japonica*) was domesticated for its eggs (layer) and meat (broiler) (Mat *et al.*, 2021). The taste and texture of it have led to increasing demand for animal and food output. Quails are fed twice daily and consume varieties like seeds, berries, insects, and leaves. Young quail mainly feed on insects and shaft to grains as they become adults (Mohd, 2018).

About 70–80% of the total production cost is for feed costs for quail because of insufficient, expensive sources of protein and high expenses for importation (Komilus *et al.*, 2021). Besides, the quail feed is expensive, which burdens small-scale farmers as their profit will be low (Rahman *et al.*, 2022). Therefore, farmers need to find cheaper, better-nutritive-value, and more sustainable sources of quail feed. The price of fodder seeds ranges from RM6–15 per kg depending on species, and 1kg will yield up to 6 kg of fodder (RM1.00–RM2.50 per kg), while the commercial feed is approximately RM136 for 50 kg (RM2.72 per kg). Other than that, it is challenging to own land and maintain it. Among the different urban agricultural systems, the evolution brings the method of tray cultivation, which is widely chosen now (Shamshiri *et al.*, 2019). However, Malaysia has yet to explore fodder cultivation on a large scale, although the Agriculture Department has tried to cultivate fodder at the experimental stage (Taffesse and Tsakok, 2019).

Materials and Methods

House preparation for quails

Cage setup was done and saw dust was used as bedding. On the day of collecting the chicks, quails were kept in boxes with holes for breathing 45 tails, unsexed 4-days old quails, weighing an average of

29.8g were purchased from a commercial hatchery. Throughout the brooding process (4 to 11-day old), lightbulbs were used to provide constant lighting and heat for chicks. After brooding, for 30 days, quails were randomly placed according to treatment groups with 3 replicate cages each and 3 birds per cage in a safe, enclosed rearing facility.

Germination of wheatgrass fodder

Wheatgrass fodders were grown using tray cultivation method (Linsha *et al.*, 2018). The sprouted seeds of wheatgrass fodder were placed in the trays uniformly. Every day, 4 trays were sown with the rate of 120g/tray. Irrigation was performed manually by filling water underneath the tray where the roots will absorb it. Fertilizer was diluted in ratio of 100g goat dung: 300ml of water. Goat dung was mixed in the water, ratio of 150ml of goat dung: 600ml of water.

Experimental diets

Five treatments were formulated with some modifications to meet all nutritional requirements of a starter diet for quails. The feed will be supplied ad libitum while clean and fresh water will be provided at free access.

Diets will be prepared based on 5 different treatments consisting of:

Control = 0% Organic Wheatgrass fodder (OWF)+ 100% Commercial feed

Treatment 1 = 5% OWF+ 95% Commercial feed

Treatment 2 = 10% OWF+ 90% Commercial feed

Treatment 3 = 15% OWF+ 85% Commercial feed

Treatment 4 = 20% OWF+ 80% Commercial feed

Feeding trial

The feeding trial started after growing wheatgrass fodder for 7 days and fed the one harvested on the eighth day. The quails were fed experimental diets based on 5% of the bird's body weight. The quails were under feeding trials for 30 days. The experimental diet was given twice daily at 8-9 am and 5-6 pm.

Data collection on parameters for quail growth performance

Data were collected on initial to final weight, amount of feed given and the leftover weekly (Komilus *et al.*, 2021).

The body weight gain (BWG) = Final weight - Initial weight

Average daily weight gain (ADWG) = $\frac{\text{Final weight} - \text{initial weight}}{\text{Total time (days)}}$

Feed intake = Initial weight feed amount(g) - Remaining weight of feed

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Total Feed Intake}}{\text{Amount of weight gain}}$$

$$\text{Survival rate} = \frac{\text{Live quail}}{\text{Total quail}} \times 100\%$$

Data collection on parameters for meat quality

Three quails from each treatment were chosen for slaughter when the feeding trial had reached 30 days, according to the Malaysian Protocol for Halal Meat and Poultry Production MS 1500: 2009. Quails were fasted for four hours. After exsanguination, quails were allowed to bleed out for 2 minutes. Quails were plunged into hot water (50 – 55 °C) in the scalding tank and de-feathered (Komilus *et al.*, 2021).

Carcass yield: Post-mortem was done on the slaughtered quails. All parts and organs such as carcass, wing, breast, drumstick, thigh, feet, head, neck, heart, crop, spleen, gizzard, empty gizzard, liver, diaphragm, small intestine, large intestine, duodenum are separated, weighed and recorded.

pH: Breast muscle's pH were evaluated at 45 minutes and 24 hours after death using a digital pH meter (pH 45min and pH 24h) according to (Ilavarasan *et al.*, 2016).

Colour: Three replications of the meat colour of breast muscle were determined using a chromameter (Konica Minolta CR-400 Chromameter). Colour values were presented as L* (lightness), a* (redness), and b* (yellowness) based on the CIE-LAB system at 45 minutes and 24 hours (Purnama *et al.*, 2021).

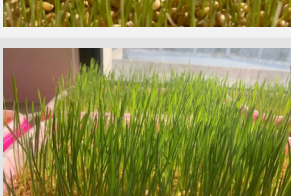
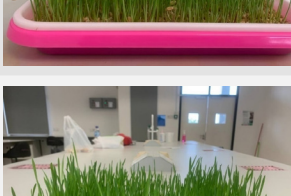
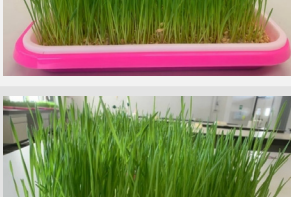
Water holding capacity (WHC): WHC values were measured in triplicate, followed by 24-hour post-mortem period as described by (Komilus *et al.*, 2021; Ilavarasan *et al.*, 2016). Quail breast muscles were cut into 5 g cubes and placed between two Whatman No. 1 filter papers and two glass plates for 10 minutes with a 5 kg weight on top of the glass plate.

$$\text{WHC \%} = 100 - \frac{\text{Initial weight of the sample (g)} - \text{Final weight of the sample (g)}}{\text{Initial weight of the sample (g)}} \times 100$$

Cooking loss: At 24 h post-mortem, approximately 10 g of breast muscles were kept in plastic bags, cooked in a water bath at 75°C for 20 min and cooled at room temperature (Komilus *et al.*, 2021).

$$\text{CL} = \frac{\text{Weight of sample before cooked} - \text{weight of sample after cooked}}{\text{Weight of sample before cooked}} \times 100$$

Table 1: Observation of wheatgrass growth.

Sprouting time	Observation	Description
24 hours		Wheat seeds was sown
48 hours		Wheat seed starts to germinate
72 hours		More wheat seeds start to germinate
96 hours		The leaves and roots are more visible
120 hours		All seeds were germinated uniformly
144 hours		The leaves start getting darker green color
168 hours		The leaves continue to grow taller
192 hours		The wheatgrass has reached its maximum height and is ready for harvest

Shear force: According to minor modifications, shear force analysis was carried out by [Omar et al. \(2018\)](#). Cooked breast muscle was cut into two adjacent muscular strips measuring 1 cm in width and 3 cm in length in the direction of muscle fibre before being sheared once. Muscle strips were put in a texture analyser with the fibres directions perpendicular to the Warner Bratzler blade and a downstroke distance of 20.0 mm to determine shear force.

Proximate composition of quail's breast meat: Breast meat samples were kept in the freezer before being transferred into the containers of a freeze dryer and freeze-dried for 24 hours. Samples were then ground into powder form. Crude protein, crude lipid, ash and moisture contents were measured according to ([AOAC, 2006](#)).

Statistical analysis

Data was evaluated using one way analysis (ANOVA) to evaluate the significance differences ($p < 0.05$) among treatment groups in this study via SPSS version 27.0 ([Komilus et al., 2021](#)). Tests were done on post hoc, Tukey, Games-Howell and homogeneity of variance tests with a 95% confidence interval.

Results and Discussion

Observation of wheatgrass growth

Proximate composition in wheatgrass

Wheatgrass fodders were grown using tray cultivation method and fertilized with goat dung with ratio of 150ml of goat dung: 600ml of water.

Growth parameters of quails

The BWG results revealed significantly ($P \leq 0.05$) higher body weight gain in T3 (158.70 g) group compared to the control (77.40 g), T1 (98.65 g), T2 (101.75 g), T4 (115.48 g) group. ADWG was highest in T3 (31.74 g/d), while others were significantly

different and lower. The control showed lower weight gain than other treatments supplemented with OWF. The weight gain was mainly caused by increasing protein level in the diet with the inclusion of wheatgrass. T4 (20% OWF) can be considered as the level beyond the optimum amount, which is T3 (15% OWF). The result obtained is further supported by the findings of [Ekbal et al. \(2021\)](#), where the final gained body weight was increased in treated groups of rats.; [Barbacariu et al. \(2021\)](#), wherein common carp fed with 2% wheatgrass juice, final weight increased by up to 39% and body length increased by up to 7%. Other than that, [Asaduzzaman et al. \(2017\)](#) found that hydroponic wheatgrass has positive effects at up to 15% of OWF but showed negative effects at 20% of OWF on weight gain of turkeys; also found that wheatgrass can improve the performance of animals by up to 8%.

Table 2: Proximate composition in wheatgrass.

Nutrients	% in wheatgrass
CP	26.80 ± 0.99
Lipid	2.49 ± 0.42
CF	7.09 ± 0.30
Moisture	9.89 ± 0.08
Ash	4.30 ± 0.19
NFE	45.35 ± 0.64

Proximate composition in commercial feed

Table 3: Proximate composition in commercial feed.

Nutrients	% in commercial feed
CP	21.0
Lipid	4.5
CF	5.0
Moisture	13.0
Ash	8.0
NFE	61.5
Calcium	0.8
Phosphorus	0.4

Table 4: Growth parameters of quails.

Parameter	Control	T1	T2	T3	T4	p-value
BWG (g)	77.40 ^a ±4.49	98.65 ^b ±2.94	101.75 ^b ±0.93	158.70 ^d ±5.76	115.48 ^c ±2.39	<0.001
ADWG (g/d)	15.48 ^a ±0.90	29.78 ^b ±1.77	20.35 ^b ±0.19	31.74 ^d ±1.16	23.09 ^c ±0.48	0.151
DFI (g)	9.59 ^b ±0.20	9.84 ^c ±0	9.84 ^c ±0	9.10 ^c ±0.02	9.84 ^c ±0	<0.001
FCR	3.19 ^d	2.53 ^c	2.44 ^c	1.50 ^a	2.16 ^b	<0.001
Survival rate	100%	100%	100%	100%	66.67%	-

Control=100% commercial feed, T1=5% OWF+ 95% Commercial feed, T2=10% OWF+ 90% Commercial feed, T3=15% OWF+ 85% Commercial feed, T4=20% OWF+ 80% Commercial feed. The presence of subsets on the same row indicates a significant difference between the diets ($p < 0.05$).

Daily feed intake was highest in T1, T2, and T4 and lowest in birds that consumed 15% of OWF. Lower FI is preferred as it can save feed costs and have a good impact with a minimal amount of feed, like in T3. As per (Ekbali et al., 2021), a significant decrease in feed intake was also observed in rats who consumed wheatgrass.

FCR is a useful measure for evaluating feeds since it calculates the quantity of feed required per unit of somatic growth (Rana et al., 2020). Lower FCR is preferable in animal diets, where less feed intake provides a higher impact on body weight (Komilus et al., 2021). In this study, the lowest FCR was 1.50 found in T3, which was significantly lower ($P < 0.05$) than the highest FCR in control (3.19). The presence of diverse bioactive components in OWF that may have a role in increased nutrition utilisation in supplemented birds could explain the higher body weight and reduced FCR in this study. The better FCR can be attributed to improved nutrient absorption and digestibility from gut. Salam et al. (2020) mentioned that adding OWF is cost-effective for feed formulation. The photogenic property may

lead to the reduction of FCR, as demonstrated by, Mocanu et al. (2019), who reduced FCR from 1.6 -1.2% by utilising plant extracts like garlic and sea buckthorn in a 4% proportion.

The survival rate of all the groups was recorded as 100% except for T4 (66.67%). The mortality percentage observed in this investigation is not normal, as one quail from each replicate dies due to high percentages of OWF. The percent values of survival rate indicate that OWF beyond optimum level (>15%) affects perniciously on health of Japanese quail.

Carcass yield

Japanese quails didn't produce much butchery yield. In this study, the crop had a significant difference ($P < 0.05$) where T2 was markedly highest, followed by T1, T3, and T4 and control was the lowest. Without significant difference, carcass yield was slightly higher with the inclusion of OWF for wing, neck, heart, and small intestine. Overall, there's no significant difference between treatments for carcass yield.

Table 5: Carcass yield of Japanese quails after bleeding.

	Control	T1	T2	T3	T4	p-value
After Bleeding	203.5±4.70	173.57±3.98	170.32±1.32	197.33±7.95	190.53±3.02	0.204
Carcass	180.70±3.35	163.73±4.16	153.62±9.81	173.65±1.61	177.19±4.00	0.363
Wing	18.03±0.40	20.48±1.27	22.92±5.77	20.72±4.12	23.34±5.11	0.512
Breast	75.02±14.30	69.76±6.07	79.53±17.82	83.02±9.78	86.19±2.73	0.471
Drumstick	20.38±2.27	19.30±2.85	19.57±3.54	19.89±1.11	21.20±1.22	0.757
Thigh	30.14±6.40	29.62±3.00	26.71±5.62	31.03±3.72	34.34±2.35	0.400
Feet	6.98±0.10	6.60±0.04	6.84±0.25	6.52±1.14	7.50±0.39	0.282
Head	14.14±1.96	12.69±0.47	15.24±4.03	13.35±0.62	16.61±1.71	0.264
Neck	8.04±2.25	8.62±1.39	9.15±1.96	8.61±0.81	8.29±2.32	0.957
Heart	2.16±0.21	2.67±0.59	2.98±0.58	2.87±0.19	2.90±0.16	0.157
Crop	1.17 ^a ±0.03	1.25 ^{ab} ±0.05	1.78 ^b ±0.40	1.42 ^{ab} ±0.08	1.50 ^{ab} ±0.28	0.049
Spleen	0.28±0.09	0.20±0.09	0.35±0.25	0.24±0.08	0.30±0.03	0.705
Gizzard	5.93±0.28	5.08±0.85	5.74±0.64	7.14±1.50	6.89±1.16	0.134
Empty Gizzard	5.40±0.12	4.91±0.91	5.41±0.64	6.39±1.25	6.14±1.50	0.421
Liver	7.22±1.15	6.11±1.05	8.57±1.68	7.78±0.83	9.21±1.31	0.082
Diaphragm	18.08±6.18	17.35±3.68	22.05±4.05	17.19±4.55	16.11±4.15	0.585
Small intestine	4.22±0.84	4.21±0.83	4.92±2.67	4.33±1.02	4.96±1.25	0.935
Large intestine	4.40±0.67	3.84±0.98	4.59±1.28	4.33±0.87	3.60±0.77	0.681
Duodenum	4.81±0.84	3.85±0.49	5.76±1.25	3.22±1.56	5.05±1.81	0.196

Control=100% commercial feed, T1=5% OWF+ 95% Commercial feed, T2=10% OWF+ 90% Commercial feed, T3=15% OWF+ 85% Commercial feed, T4=20% OWF+ 80% Commercial feed. The presence of subsets on the same row indicates a significant difference between the diets ($p < 0.05$).

Table 6: *pH of breast muscle.*

	Control	T1	T2	T3	T4	p-value
pH 45 min	6.86±1.57	6.46±0.39	6.52±0.16	6.82±0.31	7.93±0.19	0.186
pH 24 hr	6.62±0.29	6.33±0.14	6.52±0.37	6.91±0.14	6.61±0.34	0.213

Control=100% commercial feed, T1=5% OWF+ 95% Commercial feed, T2=10% OWF+ 90% Commercial feed, T3=15% OWF+ 85% Commercial feed, T4=20% OWF+ 80% Commercial feed.

Table 7: *Colour of Japanese quails.*

	Control	T1	T2	T3	T4	p-value
L* 45min	51.82 ^b ±3.22	54.26 ^b ±3.19	52.39 ^b ±2.17	48.08 ^{ab} ±0.87	44.77 ^a ±1.25	0.004
a* 45min	12.00±5.00	9.53±4.50	11.60±5.43	10.45±1.97	8.35±1.47	0.793
b* 45min	7.64±0.98	8.06±1.74	9.26±1.42	7.96±2.86	6.09±0.30	0.314
L* 24hr	54.56±6.51	54.58±1.65	52.37±4.73	49.90±3.17	46.92±5.70	0.284
a* 24hr	12.04±5.06	12.44±4.06	13.62±6.83	10.87±2.09	13.59±3.42	0.938
b* 24hr	9.03±2.93	12.49±0.89	10.55±2.72	7.33±3.61	9.26±3.95	0.363

Control=100% commercial feed, T1= 5% OWF+ 95% Commercial feed, T2=10% OWF+ 90% Commercial feed, T3=15% OWF+ 85% Commercial feed, T4=20% OWF+ 80% Commercial feed. The presence of subsets on the same row indicates a significant difference between the diets ($p < 0.05$).

pH

In this study, breast meat of quail showed no significant differences ($p < 0.05$) among control and all treatments in pH45min and pH24h values. Age, sex, husbandry practices, feed additives, pre-slaughtering stress, muscle conformation, and glycogen content are all factors that influence pH levels. As for the chicken meat, pH drops 7 to 5.5 after death due to accumulation of lactic acid in the muscle (Warner, 2017). A few studies examined the correlation between the nutritional value and meat quality features of Nandanam Quail-III that were slaughtered at different ages. The findings were pH value of 6.65 for 5-week old quail as per Ilavarasan *et al.* (2016) and 5.94 according to (Komilus *et al.*, 2021). Unlike turkey and chicken, Japanese quails have dark muscle fibers that are made up of oxidative type. This type of muscle is known to contribute to higher pH values in their meat (El-Tahawy, 2022). In this study, pH value after 24 hours post-mortem falls within 6.33 to 6.91 (good pH for quail).

However, pH 45min value for all treatments was in the normal range except T4, which was higher (7.93). According to Boubekour *et al.* (2021), higher pH values could indicate reduced glycogen levels in quail birds before slaughter. Excessive starvation or malnutrition has been linked with increased pH levels in animals after death. This study found no evidence of low pH. Low pH values (<5.4) in poultry meat have been related to decreased water-holding ability,

which leads to greater thawing and cooking losses (Masenya *et al.*, 2021). In addition, low pH influences meat storability.

The pH at 24hr was better than 45min. The variations in pH for 45 min and 24 hrs could potentially have been caused by the way the quail muscles were stored. According to Damaziak *et al.* (2016), who noted a favorable influence of cold storage duration on pH value in chicken meat quality, where an extended storage period within 24 hrs after slaughter may cause the pH to fall within the normal range.

Colour

L* indicates lightness (0=black, 100=diffuse white). a* indicates redness (negative values=green, whereas positive values=red). b* indicates yellowness (negative values=blue, positive values=yellow) (Zhuang and Savage, 2013). Lightness is an indicator of meat freshness and has a direct impact on consumers' final buying decisions (Masenya *et al.*, 2021).

The results of colour for the breast meat of quail showed there were significant differences ($p < 0.05$) in L*45min only. In broiler chickens, the standard L* value falls between 46 and 53. Meat with below 46 is Dark Firm Dry (DFD), which has a high water holding capacity and short shelf life. For L* 45min, control, T2, T3, and T4 were in the ideal range showing the best lightness on the meat except T1 (54.26).

Results for L* 24hr were in the range for T2, T3, and T4, while control (54.56) and T1 (54.58) values indicate PSE (Pale Soft Exudative). PSE meat is defined as meat having a lightness value greater than 53 (Purnama *et al.*, 2021). Protein denaturation in muscle and post-mortem pH has an impact on PSE meat. No DFD meat was observed. The results also have a pattern of decreasing lightness as the percentages of OWF increase but still in range. No significant difference in a* 45 min, b* 45 min, L* 24 hr, a* 24 hr, b* 24 hr. The redox reactions of myoglobin, haemoglobin, and heme pigment determine the redness (a*) of meat (Calnan *et al.*, 2016). Genetics, carotenoid pigments in feed, liver biochemistry and meat preparation influence the yellowness (b*) of meat (Purnama *et al.*, 2021).

Water holding capacity (WHC), cooking loss and shear force

The result of water holding capacity for breast meat of quail showed significant different ($p>0.05$) among control and treated quails. When the muscle's pH falls after death, some of the muscle's capacity to store water is lost (Warner, 2017). The best WHC was in T3.

The result for breast meat of quail showed that there was no significant difference among all treatments in cooking loss value, but T2 showed the highest percentage of cooking loss, and T3 was the lowest. The moisture, juiciness in meat can be retained even after cooking in all treatments.

Shear force didn't differ statistically among treatments. Shear force (toughness) was the force needed to cut off the meat sample. Lower values indicated the most tender meat (Bowker and Zhuang, 2019). The shear force range of all treatments falls within 2.15 to 3.15. T3 recorded the least value, 2.15, indicating it as the most tender meat among treatments. This result can be supported by the findings in cooking loss.

Proximate composition of breast meat

Proximate analysis of the breast meat of quail showed that there were significant differences among treatments in crude protein, ether extract, ash and moisture contents. For crude protein, control has the lowest value and treatments with the inclusion of OWF have a higher value. The findings didn't exhibit any trend with the inclusion of wheatgrass and similar to findings of (Barbacariu *et al.*, 2021; Islam *et al.*, 2017), where the result did not have a trend with the inclusion of OWF but higher than control. For lipids, the value drops as the level of OWF increases. This result was parallel to a previous study (Barbacariu *et al.*, 2021; Rana *et al.*, 2020; Islam *et al.*, 2017), where lipid content dropped in carp as the level of OWF increased. For ash, control has the highest value, followed by T1, T3, T4, and T2, showing decreasing pattern with the inclusion of OWF. For moisture, the result showed T3 significantly has the highest moisture and value scattered among control and treatment, which shows the inclusion of wheatgrass didn't affect much moisture, similar to Islam *et al.* (2017) result on stinging catfish fry fed on OWF.

Table 8: *Water holding capacity (WHC), cooking loss and shear force of Japanese quails.*

	Control	T1	T2	T3	T4	p-value
WHC	77.74 ^{ab} ±2.77	77.13 ^a ±7.09	83.73 ^{ab} ±1.97	88.48 ^b ±4.58	80.08 ^{ab} ±2.35	0.040
CL	25.72±4.43	27.57±2.88	27.96±2.93	23.52±1.03	24.28±2.52	0.023
SF	2.80±0.58	3.15±1.00	2.64±0.91	2.15±0.18	2.46±0.39	0.507

Control=100% commercial feed, T1=5% OWF+ 95% Commercial feed, T2=10% OWF+ 90% Commercial feed, T3=15% OWF+ 85% Commercial feed, T4=20% OWF+ 80% Commercial feed. The presence of subsets on the same row indicates a significant difference between the diets ($p<0.05$).

Table 9: *Proximate composition of quails' breast meat.*

	Control	T1	T2	T3	T4	p-value
CP	57.09±0.47 ^a	61.12±1.58 ^b	62.26±0.06 ^b	59.64±0.17 ^{ab}	60.15±0.21 ^b	<0.001
Lipid	4.08±0.05 ^c	4.00±0.07 ^c	3.45±0.07 ^b	3.18±0.04 ^a	2.99±0.01 ^a	<0.001
Ash	5.21±0.04 ^c	4.92±0.12 ^b	4.57±0.02 ^a	4.68±0.02 ^a	4.59±0.01 ^a	<0.001
Moisture	71.48±0.01 ^b	71.95±0.01 ^d	70.26±0.01 ^a	72.33±0.02 ^c	71.79±0.01 ^c	<0.001

Control=100% commercial feed, T1=5% OWF+ 95% Commercial feed, T2=10% OWF+ 90% Commercial feed, T3=15% OWF+ 85% Commercial feed, T4=20% OWF+ 80% Commercial feed. The presence of subsets on the same row indicates a significant difference between the diets ($p<0.05$).

Conclusions and Recommendations

In conclusion, Treatment 3 (15% OWF+ 85% Commercial Feed) showed overall best performance among treatments. The study suggests that inclusion of OWF up to 15% dietary levels can be a growth and performance enhancer for Japanese quail without detrimental impact. As a recommendation, the wheatgrass seed can be treated first during soaking process to avoid fungus and reduce risk of diseases. For organic production, apple cider vinegar and for chemical, sodium chloride or hydrogen peroxide can be used.

Acknowledgements

Acknowledgements to the top management of the Faculty of Bioresources and Food Industry for granting permission to conduct the research. The authors are also thankful to the faculty staff who assisted the team during the research.

Novelty Statement

The study presents wheatgrass as the potential feed substitute that can reduce farmers feed expenses and dependability on commercial feeds for Japanese Quail (*Coturnix japonica*).

Author's Contribution

All authors contributed to the conceptualisation, methodology, data collection and analysis, interpretation of results and writing of the original draft.

Ethical approval

The study was conducted at Lab Agrostology and poultry house, Universiti Sultan Zainal Abidin (UniSZA) Kampus Besut, Tembila, 22200, Besut, Terengganu. Application for ethical approval was applied to Universiti Sultan Zainal Abidin Animal and Plant Research Ethics Committee (UAPREC) under UAPREC/07/013 before the feeding trial commences.

Conflicts of interest

The authors have declared no conflict of interest.

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