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Comparison Performance and Carcass Characteristics of Native Chicken Breeds under Free-Range and Intensive Rearing System: A Meta-Analysis

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ABSTRACT

Poultry-rearing systems generally consist of intensive, semi-intensive, or free-range systems. Currently, free-range is a system that guarantees healthy poultry products. This meta-analysis aims to assess the effects of intensive and free-range rearing systems on live weight (LW), feed intake (FI), feed conversion ratio (FCR), body weight gain (BWG), carcass weight (CW), breast meat weight (BM), water holding capacity (WHC), shear force (SF), flavor (Flav), tenderness (Tend), juiciness (Juic), thigh meat (TM), meat water content (MW), protein content (Prot), color (Col), and mortality (Mort) in native chickens. Literature search served as the data source using searches in platforms such as Elsevier, Google Scholar, Springer, Wiley, and Oxford University Press. Twenty-seven (27) articles were identified, covering seven parameters related to the growth performance and carcass characteristics of 30 free-range chickens. The influence of the maintenance system significantly affects the live weight (g) parameter (SMD=-1.21; C.I. 95%=-1.73 to -0.687) (P<0.001) and the carcass weight (g) parameter (SMD=-3.02; C.I. 95%=-4.59 to -1.45) (P<0.001). Regarding breast meat quality parameters, there is a significant influence on part b* (SMD=3.048; C.I. 95%=1.31 to 4.79) (P<0.001). The meta-analysis results concluded that performance and carcass characteristics are better in the intensive system. At the same time, the breast meat quality parameter is better in the free-range system.

Key words: Carcass, Meta-analysis, Native chicken, Performance

INTRODUCTION

Organic and natural foods are currently prevalent food sources and the main target for consumers worldwide (Wang et al. 2009). Poultry products such as meat and eggs are also important food sources. Currently, poultry-rearing systems are receiving much attention due to the demand for food products, including poultry products that are free from chemical residues, antibiotics, and other synthetic materials. There is a growing number of consumers interested in poultry products, particularly those raised in free-range systems (Miao et al. 2005; Wang et al. 2009). Free-range rearing systems are becoming increasingly popular because they affect the welfare of livestock, production efficiency, and the health of poultry products (Chen et al. 2013; Tong et al. 2014). Research by Yamak et al. (2016) shows that free-range rearing positively affects the welfare and quality of wild chicken meat. Consumers are interested in buying and even willing to pay more for free-range raised animal products because they believe the resulting products have better sensory quality and taste (Mcfadden et al. 2017; Zhang et al. 2018).

The demand for animal products produced from free-range rearing is believed to expand globally as people become more aware of consuming animal products raised with animal welfare principles (Tong et al. 2014). The issue of animal products raised with consideration for welfare has been ongoing for a long time. Since the 1990s, countries such as the United States, Australia, and Europe have initiated and promoted animal welfare, focusing on eliminating complete confinement systems for animals, especially those intended for meat and egg consumption

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(Hansen and Østerås 2019; Jin et al. 2019). One form of animal husbandry that upholds animal welfare is the free-range system. Free-range rearing allows animals to exhibit natural behaviors, move freely, receive natural sunlight, and consume natural feed (Pettersson et al. 2018; Fitra et al. 2021). Since this issue has been raised, market segmentation for animal products produced from free-range rearing has increased in these countries (Scrinis et al. 2017).

Poultry products from free-range rearing are generally healthier than those from intensive rearing systems (Rehman et al. 2016; Scrinis et al. 2017). Free-range chickens have better meat quality, composition, and flavor (Yamak et al. 2016). Free-range chickens exhibit better growth performance, meat quality, carcass characteristics, and immune function than cage-raised chickens (Stadig et al. 2016; Tong et al. 2014). Free-range chickens without confinement have better carcass quality and meat flavor (Fanatico et al. 2007; Lewis et al. 1997). On the other hand, poultry raised in confinement systems tend to be more stressed, resulting in physiological responses and behaviors that deviate from their natural tendencies and poorer growth performance (Marin et al. 2001).

Previous studies have discussed the effects of free-range and intensive rearing systems on the growth performance and meat quality of native chickens. However, the results vary, so a meta-analysis study is needed to review and obtain valid conclusions from various studies comprehensively. Therefore, this research aims to compare the growth performance and carcass characteristics of thigh and breast parts of native chickens raised in two rearing systems, namely free-range and intensive-rearing systems, using the meta-analysis method.

MATERIALS AND METHODS

Metadata

The articles were obtained from various electronic databases such as Elsevier, Google Scholar, Springer, Wiley, and Oxford University Press. The keywords used are “chicken,” “native,” “free-range and “rearing systems.” The search results on the database and the selection process, from identification to inclusion (Fig. 1), are used to complete the grammatical qualifications. Articles that have been collected from several web publishers were then coded. Fill in the coding in the form of the author's name, year of publication, publisher, article title, free-range chicken breed, free-range chicken sex, cage size, number of samples, research parameters, and research results (intensive rearing as control and free-range rearing as treatment). Articles that have been coded were then checked by all authors for double checking. The results of the minutes of the study search and selection process can be seen in Table 1. After completing the checking process, it continued to the inclusion and exclusion evaluation selection stage.

Selection criteria

The selection process applies an inclusion and exclusion evaluation of the articles that have been collected. Inclusion criteria were the general characteristics of research subjects from a target study to be researched, such as studies of free-range rearing systems of native chickens; studies compared intensive and free-range rearing systems of native chickens; studies measuring growth performance and carcass characteristics, quality of breast, and thigh meat; the results of statistical analysis were in the form of average values and SD (if the statistical results are in the form of SEM, they were converted to SD for uniformity of data); and published in English with the Digital Object Identifier (DOI) and indexed by Scopus. Meanwhile, exclusion criteria included removing research subjects from a target study that were researched because they did not meet the inclusion criteria of the study, such as studies of free-range rearing systems other than native chickens (such as laying hens and broiler chickens); studies that only examine intensive or semi-intensive or free-range rearing systems for native chickens; and the results of the statistical analysis did not have mean values and SD or SEM.

Meta-Analysis approach

The meta-analysis approach used is a cumulative meta-analysis approach to see changes in the cumulative effect size observed for each parameter. Meta-analysis was conducted using OpenMEE (Makmur et al. 2022; Ariyanti et al. 2023). All analyses on each parameter were carried out with the same method; the author has marked as the Study ID column, and the number of samples, in the control category (intensive) and in the treatment category (free-range), has been converted into count format. Meanwhile, the average value and SD (Standard Deviation) for the control category (intensive) and treatment category (free-range) were changed to a continuous format. Next, the differences in all the data collected in a calculated effect size wizard were measured with data types in the form of means and SD and effect size Hedges' d (Palupi et al. 2012). Hedges effect size method was calculated using Eq.

$$d = \frac{(\bar{X}^T - \bar{X}^C}{S} J \qquad (1)$$

Where $\bar{X}^T$ is the average value of the treatment category group (free-range), $\bar{X}^C$ is the average value of the control category group (intensive), S is the combined standard deviation, and J is the correction factor for sample size calculated using Eq. (2) and (3):

$$S = \sqrt{\frac{(N^T-1)(s^T)^2 + (N^C-1)(s^C)^2}{(N^T + N^C - 2)}} \qquad (2)$$

$$J = 1 - \frac{3}{(4(N^C + N^T - 2) - 1)} \qquad (3)$$

Where N^T is the number of samples from the treatment category group (free-range), N^C is the number of samples from the control category group (intensive), s^T is the standard deviation of the treatment category group (free-range), and s^C is the standard deviation of the control category group (intensive). Then, the inverse variance of fixed effect method for estimating effect size C.I. 95% use Eq. (4). This range is the confidence interval (CI) which is estimated on the basis of a desired confidence level:

$$CI = \theta \pm Z \, . SE \qquad (4)$$

Where CI is the Confidence Interval, θ is the value of the combined effect estimate from the meta-analysis (the weighted average of the effects of the analyzed studies),

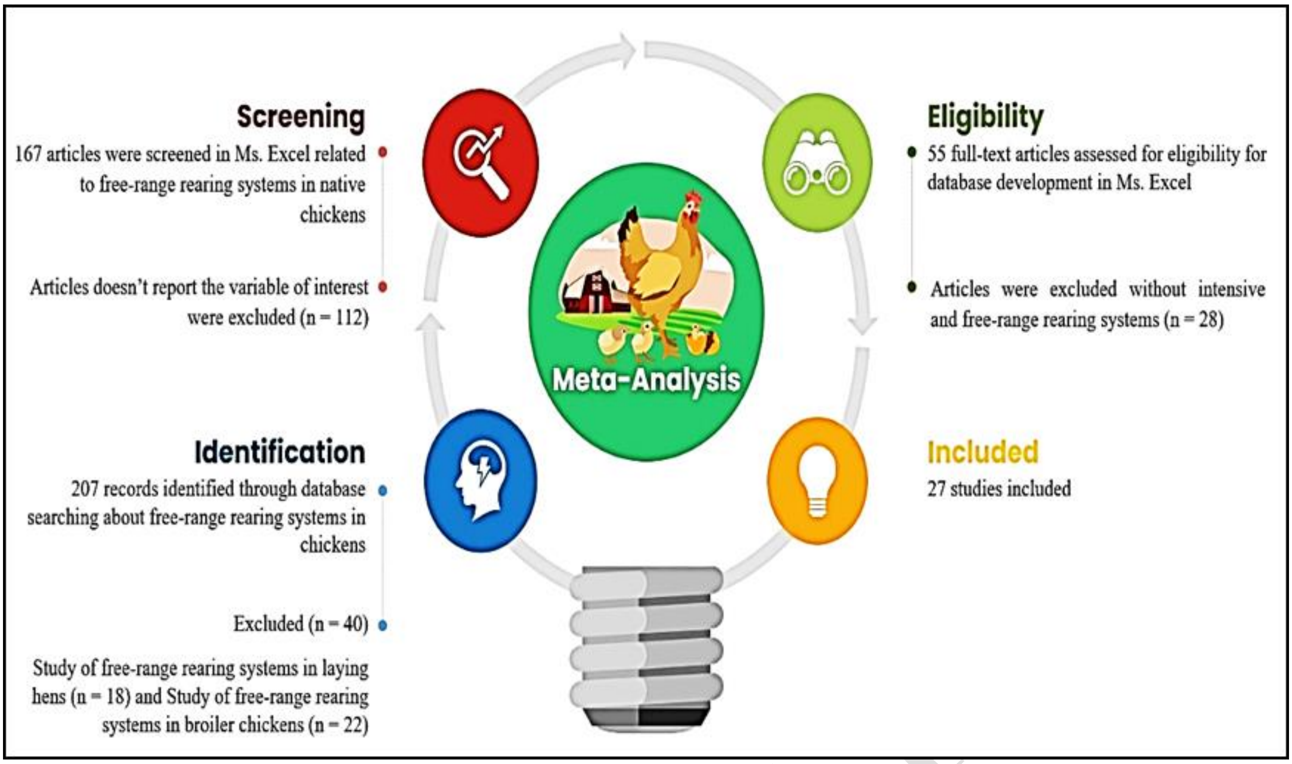

Fig. 1: Flow of the article search and selection process

Z is the z score corresponding to the 95% confidence level (usually around 1.96 to 95% confidence) and SE is the Standard Error of the combined effect estimate, where this SE measures the extent to which the average effect estimate can vary.

In the OpenMEE software, control group and treatment group categories are filled in based on the mean (x), SD (sd), and sample size (n) codes. Subgroup Meta-Analysis is seen based on the variables sex and cage area. The random-effects method uses DL (DerSimonian-Liard) and a Confidence level of 95%. Standard Meta-Analysis analyzes df and effect size C.I. 95% (SMD, lower, upper, SE, and p-value). Furthermore, the standard tool for checking publication bias uses a funnel plot based on data exploration. The article search and selection process flow is presented in Fig. 1, and the studies included in the meta-analysis are presented in Table 1.

RESULTS

Growth performance and carcass characteristics

A total of 27 articles with seven parameters related to growth performance and carcass characteristics of 30 native chickens and 49 studies that cover eligibility rules are to be accepted in the meta-analysis. In this case, we are measuring intensive rearing systems with free-range rearing systems in native chickens on performance growth and carcass characteristics. Table 2 shows that native chickens have evidence of an effect on the rearing system on live weight parameters (SMD=-1.21; C.I. 95%=-1.73 to -0.687) and carcass weight in grams (SMD=-3.02; C.I. 95%=-4.59 to -1.45). Meanwhile, the parameters that were not proven to show a significant difference in the rearing system were the weight gain parameters (SMD=-0.355; C.I. 95%=-0.701 to -1.-10), carcass weight in percent (SMD=-0.362; C.I. 95%=- 0.946 to 0.221), feed consumption (SMD=-4.19; 95% C.I.=-8.38 to 0.007), FCR (SMD=-0.798; 95% C.I.=-1.68 to 0.08), and mortality (SMD=4.7; 95% C.I.=1.3 to 8.13).

Quality of breast meat

Table 3 shows the meta-analysis of breast meat quality between free-range and intensive-rearing systems. The results obtained on free-range chickens have evidence of the effect of the rearing system on meat quality parameters for b* (SMD=3.048; C.I. 95%=1.31 to 4.79). Meanwhile, parameters that have no evidence of an effect on the rearing system are breast weight parameters in percent (SMD=0.682; C.I. 95%=0.072 to 1.29), meat quality for L* (SMD=1.37; C.I. 95%=0.129 to 2.61), a * (SMD=1.49; C.I. 95%=0.492 to 2.49), pH (SMD=-0.281; C.I. 95%=-1.11 to 0.547), shear force (SMD=-0.469; C.I. 95%=-2.04 to 1.11), WHC (SMD=-0.262; 95% C.I.=-0.758 to 0.234), meat water (SMD=0.808; 95% C.I.=0.128 to 1.487), as well as chemical composition for protein (SMD=0.642; C.I. 95%=-0.105 to 1.39) and fat (SMD=-1.66; C.I. 95%=-3.03 to -0.299), as well as on sensory for aroma (SMD=0.957; C.I. 95%=-1.52 to 3.44), taste (SMD=-0.144; C.I. 95 %=-0.53 to 0.243), juiciness (SMD=-0.517; C.I. 95%=-1.45 to 0.414), and tenderness (SMD=-0.026; C.I. 95%=-0.411 to 0.359).

Quality of thigh meat

Table 4 shows the thigh meat quality meta-analysis results between free-range and intensive-rearing systems. The parameters that were not proven to show a significant difference in the rearing system were the thigh weight parameters (SMD=0.228; C.I. 95%=-0.304 to 0.761), meat quality for L* (SMD=1.19; C.I. 95%=0.109 to 2.27), a* (SMD = 0.842; C.I. 95%=-0.092 to 1.78), b*

Table 1: Studies included in the meta-analysis

Study	Reference	Breed	Sex	Cage Area (m^2/head)	Rearing Systems	Parameters
1	Martínez-Pérez et al. (2023)	Rhode Island Red	Ma	0.1667	FR and IN	LW, FI, FCR and BWG
2	Ahmad et al. (2019)	Rhode Island Red x Naked Neck, Black Australorp x Naked Neck, Naked Neck	Mix	0.2300	FR and IN	LW
3	Rehman et al. (2016)	Lakha, Mushki, Peshawari, Sindhi	Fe	0.3528	FR and IN	LW and BWG
4	Cheng et al. (2008)	Taiwan Black	Fe	0.1300	FR and IN	CW, LW, BM (We, WHC, SF, pH, Flav, Tend, Juic), and TM (We, WHC, SF, Ph, Flav, Tend, Juic)
5	(Dou et al., 2009)	Gushi	Fe	0.1429	FR and IN	LW, BWG, MW, BM (We, Prot, Fat, WHC, SF, pH) and TM (We)
6	Li et al. (2016)	Lingnanhuang	Fe	0.1250	FR and IN	CW, LW, BM (We, WHC, SF, pH) and TM (We)
7	Mikulski et al. (2011)	Hybrid	Ma	0.1300	FR and IN	CW, LW, FCR, BM (We, Prot, Fat, WHC, pH, Col, Flav, Tend, Juic) and TM (We, WHC, pH, Col)
8	Wang et al. (2009)	Gushi	Fe	0.1429	FR and IN	CW, MW, LW, BWG, BM (We, Prot, Fat, WHC, SF, pH) and TM (We)
9	Bosco et al. (2014)	Native chicken	Ma	0.1000	IN	LW, FI, FCR, BWG, and Mort
10	Jiang et al. (2011)	Chinese Local Chicken (Local x Broiler)	Ma	0.3800	FR and IN	CW, LW, FI, FCR, BWG, BM (We, SF, pH, Col) and TM (We)
11	Niranjan et al. (2008)	C1 cross, C2 cross, Vanaraja 234, Gramapriya 212	Ma	-	FR	LW
12	Jin et al. (2019)	Yellow chicken (wannan)	Ma	0.6667	FR	CW, LW, FI, FCR, BWG, Mort, BM (We, SF, pH, Col) and TM (We)
13	Sogunle et al. (2012)	Harco black, Novogen	Ma	0.2500	FR and IN	LW, FI, FCR, BWG, Mort
14	Evaris et al. (2020)	Rhode Island Red	Fe	2.9400	FR and IN	CW, LW, and BM (We, Fat)
15	Rehman et al. (2022)	Aseel	Ma	1.1577	FR and IN	CW, LW, BWG, BM (We), and TM (We)
16	Ahmad et al. (2019)	Rhode Island Red x Naked Neck, Black Australorp x Naked Neck, Naked Neck	Ma	0.2300	FR and IN	CW and LW
17	Duran (2004)	Azul	Ma	2.7174	IN	CW, LW, BM (We, Flav, Tend, Juic) and TM (We)
18	Lin et al. (2014)	Taiwan	Fe	1.2500	FR and IN	BM (Flav, Tend, Juic) and TM (Flav, Tend, Juic)
19	Volk et al. (2011)	Slovenian hybrid Prelux-G	Ma	8.0000	FR	CW, BM (Ph and Col), and TM (pH and Col)
20	Calik (2017)	Yellowleg Partridge breed (Z-33)	Ma	1.0000	IN	LW, BM (We, WHC, pH, Col, Flaf, Tend, Juic) and TM (We, WHC, pH, Col, Flav, Tend, Juic)
21	Cerolini et al. (2019)	Milanino	Fe and Ma	2.0000 and 10.0000	IN	CW, and LW
22	Miguel et al. (2008)	Castellana Negra	Ma	1.0000	IN	CW, LW, BM (pH, Col, Flav, Tend, Juic), and TM (pH, and Col)
23	Mosca et al. (2018)	Milanino	Fe and Ma	8.0000	FR	CW, LW, BM (WHC, pH, Col), and TM (WHC, pH, Col)
24	Tong et al. (2014)	Suqin yellow	Ma	2.4000	FR	CW, LW, FI, FCR, BWG, Mort, BM (We, WHC, SF, pH, Col), and TM (We)
25	Yamak et al. (2016)	Alectoris chukar	Fe and Ma	3.5000	FR and IN	CW, LW, BM (We, pH, Col) and TM (We, pH, Col)
26	Olaniyi et al. (2012)	Harco black, Novogen	-	0.2500	FR and IN	LW, FI, FCR, and Mort
27	Sosnówka-Czajka et al. (2017)	Yellowleg Partridge (Z-33), Rhode Island Red (R-11)	Mix	1.0000	FR and IN	LW, BM (WHC, pH, Col), and TM (WHC, pH, Col)

Ma=male; Fe=female; Mix=mix; FR=free-range; IN=intensive; LW=live weight; FI=feed intake; FCR=feed conversion ratio; BWG=body weight gain; CW=carcass weight; BM=breast meat; We=weight; WHC=water holding capacity; SF=shear force; Flav=flavor; Tend=Tenderness; Juic=Juiciness; TM=thigh meat; MW=meat water; Prot=protein; Col=colour; Mort=mortality

(SMD=0.391; C.I. 95%=-0.712 to 1.5), pH (SMD=-1.01; C.I. 95%=-2.24 to 0.217), WHC (SMD=0.011; C.I. 95%=-0.433 to 0.456), sensory for flavor (SMD=0.179; C.I. 95%=-0.24 to 0.598), juiciness (SMD=0.117; C.I. 95%=-0.301 to 0.536), and tenderness (SMD=0.18; C.I. 95%=-0.239 to 0.599).

DISCUSSION

The meta-analysis results showed a significant influence between the rearing system for native chickens on live weight and carcass weight in grams but not significantly on the parameters of body weight gain, carcass weight in percent, feed intake, FCR, and mortality. This situation is caused by the different types or breeds of native chickens and other types of feed in each study. Studies have shown that chicken breeds vary in various regions, so the phenotype and genotype can differ depending on the breed. For example, Saudi native chickens have different morphological appearances and colors and feather patterns (black, black striped, dark brown, light brown, and grey), where the black breed has a lighter body weight than other breeds of the Saudi native chicken (Fathi et al. 2017).

According to research by Wang et al. (2023), ten local chicken breeds native to China show genetic and performance variations related to body weight and different body sizes (small, medium and large). The same can also be seen in the growth curves for four local Italian chicken breeds and two crosses showing different performances

Table 2: Comparison of growth performance and carcass characteristics between free-range and intensive system

Parameters	Specification		*df*	Effect Size (C.I. 95%)				
				SMD (lower; upper)			SE	P Value
Live weight (g)	General		30	-1.21	-1.73	-0.687	0.266	<0.001
	Cage area (m^2/h)	0.125		-8.53	-9.34	-7.73	0.41	NA
		0.13		-0.057	-0.358	0.244	0.154	0.712
		0.143		-1.48	-2.22	-0.742	0.376	<0.001
		0.167		-0.088	-0.446	0.27	0.183	NA
		0.23		-0.767	-1.56	0.021	0.402	0.056
		0.25		-1.47	-1.65	-1.29	0.091	<0.001
		0.353		-0.173	-0.756	0.41	0.297	0.56
		0.38		0.085	-1.16	1.33	0.633	NA
		1		0.627	0.446	0.808	0.092	<0.001
		1.16		-0.288	-0.62	0.04	0.168	NA
		2.94		-0.677	-1.12	-0.237	0.224	NA
		3.5		-3.62	-5.07	-2.161	0.743	<0.001
Body weight gain (g/h/d)	General		10	-0.355	-0.701	-0.010	0.176	0.044
	Sex	Ma		-0.412	-0.733	-0.092	0.164	0.012
		Fe		-0.44	-1.33	0.445	0.451	0.33
	Cage area (m^2/h)	0.143		-2.3	-3.14	-1.45	0.43	<0.001
		0.167		-0.009	-0.367	0.349	0.183	NA
		0.25		-0.72	-0.885	-0.555	0.084	<0.001
		0.353		0.221	-0.152	0.595	0.19	0.245
		0.38		0.053	-1.19	1.29	0.633	NA
		11.6		-0.215	-0.543	0.112	0.167	NA
Carcass weight (%)	General		7	-0.362	-0.946	0.221	0.298	0.224
	Sex	Ma		-0.295	-1.24	0.647	0.481	0.539
		Fe		-0.449	-0.702	-0.195	0.129	<0.001
	Cage area (m^2/h)	0.125		-0.46	-0.716	-0.204	0.131	NA
		0.13		-0.028	-1.01	0.952	0.5	NA
		0.143		-0.01	-1.61	1.59	0.817	NA
		0.23		0.167	-0.773	1.11	0.48	0.728
		0.38		0.14	-0.738	1.02	0.448	NA
		1.16		-1.87	-2.55	-1.2	0.346	NA
Carcass weight (g)	General		7	-3.02	-4.59	-1.45	0.8	<0.001
	Sex	Ma		-4.3	-6.04	-2.59	0.881	<0.001
		Fe		-2.07	-3.7	-0.449	0.829	0.012
	Cage area (m^2/h)	0.13		-0.31	-0.933	0.314	0.318	NA
		2.94		0.622	0.184	1.06	0.223	NA
		3.5		-4.27	-5.61	-2.9	0.683	<0.001
Feed intake (g)	General		5	-4.19	-8.38	0.007	2.14	0.05
	Cage area (m^2/h)	0.167		-0.025	-0.382	0.333	0.183	NA
		0.25		-6.56	-9.1	-4.03	1.29	<0.001
		0.38		0.145	-1.1	1.39	0.633	NA
FCR (%)	General		6	-0.798	-1.68	0.08	0.448	0.075
	Cage area (m^2/h)	0.13		0.213	-0.132	0.558	0.176	NA
		0.167		-0.367	-0.728	-0.006	0.184	NA
		0.25		-1.54	-2.44	-0.632	0.461	<0.001
		0.38		0.19	-1.05	1.432	0.634	NA
Mortality (%)	General		3	4.7	1.3	8.13	1.74	0.007
	Cage area (m^2/h)	0.25		4.7	1.3	8.13	1.74	0.007

Ma=male; Fe=female; C.I.=confidence interval; *df*=degrees of freedom, equal to n (number of observation) – 1; SE=standard error; SMD=standardized mean difference.

Table 3: The quality of breast meat in native chicken between free-range and intensive

Parameter	Specification		*df*	Effect Size (C.I. 95%)				
				SMD (lower; upper)			SE	*p* Value
Breast weight (%)	General		13	0.682	0.072	1.29	0.311	0.028
	Sex	Ma		0.168	-0.489	0.826	0.336	0.616
		Fe		1.02	0.078	1.97	0.483	0.034
	Cage area (m^2/h)	0.125		-0.573	-0.831	-0.315	0.132	NA
		0.13		0.342	-2.02	2.7	1.2	0.776
		0.143		1.2	0.489	1.91	0.362	<0.001
		0.38		-0.183	-1.06	0.695	0.448	NA
		1.16		0.191	-0.376	0.758	0.289	NA
		2.94		1.61	1.11	2.1	0.251	NA
		3.5		0.979	0.166	1.79	0.415	0.018
Meat Quality								
L*	General		9	1.37	0.129	2.61	0.633	0.03
	Sex	Ma		2.21	0.023	4.39	1.11	0.048
		Fe		4.02	-1.93	9.97	3.04	0.186
		Mi		-0.507	-1.51	0.499	0.513	0.323
	Cage area (m^2/h)	0.13		-0.434	-1.43	0.557	0.506	NA
		0.38		0.043	-0.834	0.919	0.447	NA
		1		-0.507	-1.51	0.499	0.513	0.323
		3.5		5.25	1.58	8.93	1.88	0.005
a*	General		9	1.49	0.492	2.49	0.51	0.003
	Sex	Ma		1.84	-0.023	3.7	0.95	0.053
		Fe		3.41	0.164	6.65	1.66	0.039

		Mi		0.36	-0.804	1.53	0.594	0.544
	Cage area (m^2/h)	0.13		0.81	-0.209	1.83	0.52	NA
		0.38		0.099	-0.778	0.976	0.447	NA
		1		0.36	-0.804	1.53	0.594	0.544
		3.5		3.54	1.05	6.03	1.27	0.005
b*	General		9	3.048	1.31	4.79	0.887	<0.001
	Sex	Ma		1.86	-0.308	4.03	1.11	0.093
		Fe		4.95	-1.6	11.5	3.34	0.139
		Mi		3.8	1.01	6.59	1.4	0.008
	Cage area (m^2/h)	0.13		0.572	-0.428	1.57	0.51	NA
		0.38		-0.387	-1.27	0.497	0.451	NA
		1		3.8	1.01	6.59	1.42	0.008
		3.5		4.37	0.809	7.92	1.81	0.016
pH	General		13	-0.281	-1.11	0.547	0.422	0.506
	Sex	Ma		-1.28	-4.15	1.58	1.46	0.38
		Fe		-0.369	-1.64	0.901	0.648	0.569
		Mi		0.074	-0.664	0.813	0.377	0.843
	Cage area (m^2/h)	0.125		0.854	0.59	1.12	0.135	NA
		0.13		0.643	-0.162	1.45	0.411	0.117
		0.143		-0.803	-1.48	-0.123	0.347	0.021
		0.38		0.208	-0.671	1.09	0.448	NA
		1		0.074	-0.664	0.813	0.377	0.843
		3.5		-3.5	-9.09	2.1	2.86	0.221
Shear force (Kg)	General		4	-0.469	-2.04	1.11	0.803	0.559
	Sex	Ma		-0.657	-1.56	0.243	0.459	NA
		Fe		-0.418	-2.37	1.53	0.994	0.674
	Cage area (m^2/h)	0.125		-2.2	-2.53	-1.89	0.164	NA
		0.13		1.56	0.85	2.27	0.361	NA
		0.143		-0.518	-1.18	0.146	0.339	0.126
		0.38		-0.657	-1.56	0.243	0.459	NA
WHC (%)	General		6	-0.262	-0.758	0.234	0.253	0.301
	Sex	Ma		-1.33	-2.41	-0.244	0.552	NA
		Fe		0.201	-0.02	0.423	0.113	0.075
		Mi		-0.602	-1.8	0.593	0.61	0.323
	Cage area (m^2/h)	0.125		0.272	0.017	0.526	0.13	NA
		0.13		-0.71	-1.706	0.285	0.508	0.162
		0.143		0.281	-0.376	0.937	0.335	0.402
		1		-0.602	-1.797	0.593	0.61	0.323
Meat water (%)	General		1	0.808	0.128	1.487	0.347	0.02
	Sex	Fe		0.808	0.128	1.487	0.347	0.02
	Cage area (m^2/h)	0.143		0.808	0.128	1.487	0.347	0.02
Chemical Composition								
Protein (%)	General		2	0.642	-0.105	1.39	0.381	0.092
	Sex	Ma		1.42	0.322	2.52	0.559	NA
		Fe		0.293	-0.364	0.949	0.335	0.383
	Cage area (m^2/h)	0.13		1.42	0.322	2.51	0.559	NA
		0.143		0.293	-0.364	0.949	0.335	0.383
Fat (%)	General		3	-1.66	-3.03	-0.299	0.696	0.017
	Sex	Ma		-0.189	1.17	0.793	0.501	NA
		Fe		-2.2	-3.535	-0.867	0.681	0.001
	Cage area (m^2/h)	0.13		-0.189	-1.17	0.793	0.501	NA
		0.143		-2.17	-5.1	0.763	1.5	0.147
		2.94		-2.1	-2.63	-1.56	0.272	NA
Sensory								
Aroma	General		1	0.957	-1.52	3.44	1.27	0.449
	Sex	Ma		2.28	1.03	3.54	0.643	NA
		Fe		-0.248	-0.87	0.374	0.317	NA
	Cage area (m^2/h)	0.13		0.957	-1.52	3.44	1.27	0.449
Flavor	General		2	-0.144	-0.53	0.243	0.197	0.466
	Sex	Ma		-0.709	-1.72	0.301	0.515	NA
		Fe		-0.047	-0.465	0.371	0.213	0.827
	Cage area (m^2/h)	0.13		-0.278	-0.806	0.251	0.27	0.303
		1.25		0.01	-0.556	0.576	0.289	NA
Juiciness	General		2	-0.517	-1.45	0.414	0.475	0.277
	Sex	Ma		-1.996	-3.195	-0.796	0.612	NA
		Fe		-0.01	-0.428	0.408	0.213	0.964
	Cage area (m^2/h)	0.13		-0.956	-2.85	0.938	0.966	0.323
		1.25		0.03	-0.535	0.596	0.289	NA
Tenderness	General		2	-0.026	-0.411	0.359	0.197	0.896
	Sex	Ma		-0.473	-1.47	0.521	0.507	NA
		Fe		0.053	-0.365	0.471	0.213	0.803
	Cage area (m^2/h)	0.13		-0.101	-0.627	0.425	0.268	0.706
		1.25		0.061	-0.505	0.627	0.289	NA

L*=(Lightness) represents the lightness or darkness of meat; a*=(Redness-Greenness) represents the position of meat color on the red-green axis; b*=(Yellowness-Blueness) represents the position of meat color on the yellow-blue axis; Ma=male; Fe=female; Mi=Mix; WHC=water holding capacity; C.I.=confidence interval; *df*=degrees of freedom, equal to n (number of observation) – 1; SE=standard error; SMD=standardized mean difference.

(Mancinelli et al. 2023). Furthermore, research by Chaiwang et al. (2023) reported that four different chicken breeds kept in the same conditions and with the same commercial feed also showed other growth performance in terms of growth performance (body weight, feed intake, body weight gain, feed conversion ratio), carcass trait (live weight, carcass percentage, carcass weight), meat quality traits, amino acid content, rancidity of chicken meat, and nucleotide content and derivatives. However, if the feed is given with different metabolic energy (ME) and crude protein (CP) contents, it will affect feed intake and mortality rates (Chang et al. 2023). Apart from that, the effect size value generally shows that the treatment is lower than the control, which means that the intensive maintenance system has better performance and carcass characteristics than the free-range maintenance system; one example of this is the higher amount of intramuscular fat in intensive raised chicken as opposed to free-range chickens (Yang et al. 2009; Yang et al. 2014). This is because controlled management is the primary factor that promotes improved chicken production in the intensive system. A review of indigenous chickens in East Africa with intensive, semi-intensive, and free-range rearing systems shows that they correlate with different performance and the highest body weight in intensive rearing systems (Mujyambere et al. 2022).

The results show a significant influence between the rearing system on native chickens only on the meat quality parameter for b*. Meanwhile, other parameters did not substantially affect the rearing system for native chickens. The meat quality in the research literature, especially the breast meat part, is more dominant in yellowness. According to (Mikulski et al. 2011), the feed consumed by the chicken causes the yellow breast meat in poultry. On the other side, access in and out of the cage led to greater amounts of polyunsaturated fat in the muscles of chickens (Sokołowicz et al. 2016). This is supported by several previous studies regarding yellowish meat color (Freitas et al. 2015; Chai and Sheen 2021). Meat color in poultry is essential to consumer interest (Kim et al. 2020).

Intensive rearing and free-range rearing systems for native chickens have no evidence of an effect on thigh meat quality. These results were driven by reference studies using different native chicken breeds. According to Chaiwang et al. (2023), performance, carcass, meat quality traits, chemical content, nucleotides, and derivatives are different for each chicken breed (commercial broilers, Mae Hong Son Thai native chickens, Pradu Hang Dam Thai native chickens, and male layer chickens) in the section tight.

Several research results related to thigh meat have also been carried out for research objects on native chickens (Mahuang and Tuer) and commercial broilers (Deng et al. 2022); mixed-sex Thai indigenous crossbred chickens (Hang et al. 2018); Korean native chickens (Jayasena et al. 2015); Korat hybrid chickens (Katemala et al. 2021); crossbred native chickens, namely LBC chickens (Layer-Broiler crossed with Chee), LSC chickens (Layer-Shanghai crossed with Chee), and LSRBC chickens (Layer-Shanghai Road Bar crossed with Chee) (Promket et al. 2016); two Chinese native chickens, namely Wuding chicken and Yanji silky fowl chicken (Xiao et al. 2021); and local Chinese chicken breeds, namely Beijing-you chickens (Zheng et al. 2019). Besides breed factors, meat quality is also influenced by genetic configuration, environment, feed, and stress (Chaiwang et al. 2023). The general effect size values obtained show that the treatment is higher than the control, where the free-range maintenance system has a better quality of thigh meat than the intensive maintenance system. According to Yamak et al. (2016), the quality of thigh meat with a free-range rearing system is better than that of an intensive rearing system. Various chicken species may cause performance variations in research studies, feeds, and rearing systems (Zheng et al. 2019). The free-range rearing system benefits animal welfare compared to other rearing systems (Stefanetti et al. 2023).

Table 4: The quality of thigh meat in native chicken between free-range and intensive

Parameter	Specification		*df*	Effect Size (C.I. 95%)				
				SMD (lower; upper)			SE	*p* Value
Thigh weight (%)	General		12	0.228	-0.304	0.761	0.272	0.4
	Sex	Ma		0.07	-0.868	1.01	0.479	0.883
		Fe		0.392	-0.232	1.02	0.318	0.218
	Cage area (m^2/h)	0.125		0.406	0.15	0.661	0.13	NA
		0.13		0.071	-0.454	0.595	0.268	0.791
		0.143		1.05	0.357	1.75	0.356	0.003
		0.38		0	-0.877	0.877	0.447	NA
		1.16		-1.53	-2.17	-0.882	0.328	NA
		3.5		0.535	-0.658	1.73	0.609	0.379
Meat Quality								
L*	General		8	1.19	0.109	2.27	0.551	0.031
	Sex	Ma		1.23	-1.2	3.65	1.24	0.321
		Fe		3.23	0.768	5.68	1.25	0.01
		Mi		0.128	-0.312	0.568	0.224	0.569
	Cage area (m^2/h)	0.13		-1.54	-2.65	-0.42	0.569	NA
		1		0.128	-0.312	0.568	0.224	0.569
		3.5		2.85	0.914	4.79	0.987	0.004
a*	General		8	0.842	-0.092	1.78	0.477	0.077
	Sex	Ma		1.47	-1.62	4.57	1.58	0.351
		Fe		0.758	-0.691	2.21	0.739	0.305
		Mi		0.68	0.229	1.13	0.23	0.003
	Cage area (m^2/h)	0.13		-0.356	-1.34	0.632	0.504	NA
		1		0.68	0.229	1.13	0.23	0.003

		3.5		1.38	-0.581	3.34	1	0.168
b*	General		8	0.391	-0.712	1.5	0.563	0.487
	Sex	Ma		0.129	-2.38	2.63	1.28	0.919
		Fe		0.871	-1.87	3.61	1.4	0.533
		Mi		0.795	0.021	1.57	0.395	0.044
	Cage area (m^2/h)	0.13		-0.889	-1.92	0.138	0.524	NA
		1		0.795	0.021	1.57	0.395	0.044
		3.5		0.744	-1.42	2.9	1.11	0.501
pH	General		9	-1.01	-2.24	0.217	0.626	0.107
WHC (%)	General		3	0.011	-0.433	0.456	0.227	0.96
	Sex	Ma		-0.328	-1.39	0.738	0.544	NA
		Fe		0.057	-0.563	0.677	0.316	NA
		Mi		0.071	-0.857	1	0.474	0.88
	Cage area (m^2/h)	0.13		-0.04	-0.576	0.495	0.273	0.882
		1		0.071	-0.857	1	0.474	0.88
Sensory								
Flavor	General		1	0.179	-0.24	0.598	0.214	0.403
	Sex	Fe		0.179	-0.24	0.598	0.214	0.403
	Cage area (m^2/h)	0.13		0.292	-0.331	0.915	0.318	NA
		1.25		0.086	-0.48	0.652	0.289	NA
Juiciness	General		1	0.117	-0.301	0.536	0.213	0.583
	Sex	Fee		0.117	-0.301	0.536	0.213	0.583
	Cage area (m^2/h)	0.13		0.173	-0.448	0.794	0.317	NA
		1.25		0.071	-0.495	0.637	0.289	NA
Tenderness	General		1	0.18	-0.239	0.599	0.214	0.399
	Sex	Fe		0.18	-0.239	0.599	0.214	0.399
	Cage area (m^2/h)	0.13		0.295	-0.329	0.918	0.318	NA
		1.25		0.086	-0.48	0.652	0.289	NA

L*=(Lightness) represents the lightness or darkness of meat; a*=(Redness-Greenness) represents the position of meat color on the red-green axis; b*=(Yellowness-Blueness) represents the position of meat color on the yellow-blue axis; Ma=male; Fe=female; Mi=Mix; WHC=water holding capacity; C.I.=confidence interval; *df*=degrees of freedom, equal to n (number of observation) – 1; SE=standard error; SMD=standardized mean difference.

Conclusion

This meta-analysis provides critical scientific insights into the effects of rearing systems for native chickens in many regions on their growth performance and carcass characteristics. The conclusion is that the performance and carcass characteristics are better in the intensive system. Meanwhile, the better breast meat quality parameter is in the free-range system. Future research should concentrate on modern free-range rearing systems to evaluate the impact on chicken growth performance and meat quality in various regions.

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Author's Contribution

JAL, S, and MMS: conceptualization, formal analysis, investigation, methodology, computing resources, validation, data curation, writing-original draft, writing, and editing. JAL, RA, ZW, SE, TS, CS, S, SYH, and MMS: investigation, data curation, formal analysis, validation, writing-review, and editing.

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