Wassachiè chicken farming systems characterization of the Southern and Western agroecological zones of Mali

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Running title : Wassachiè chicken production system

Abstract

The characterization of production systems is essential for improving local poultry. A study was conducted on the production systems of Wassachiè chickens in the southern and western agroecological zones of Mali. The survey, carried out with 84 poultry farmers across 30 villages, collected data on the farmers, the origin, and management of the flock. The results show that raising Wassachiè chickens is predominantly a male activity (94.04%), practiced by young farmers (50%) with no formal education (53.57%). Furthermore, in spite of receiving any training in poultry farming (73.80%), the artificial incubation (89.28%) in a common practice. The flocks generally consist of fewer than 50 chicks, fed with locally produced feed. Multiple correspondence analysis revealed three groups of poultry farmers. The first group consists of crop farmers (37.04%) and livestock farmers (24.07%) without formal education, who started with a small number of chicks, often purchased. The second group is composed of artisans (56.25%) who manage animal health themselves and produce exclusively for sale (100%). The third group, made up of civil servants (66.67%), entrusts veterinary care to a specialist (75%) and also focuses their production for sale. The current production systems in these two zones require technical support to improve the production of eggs, chicks, and Wassachiè chickens.

Keywords: Breeding system, agroecological zone, Wassachiè chicken, typology.

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Caractérisation des systèmes d'élevage de poulets Wassachiè dans les zones agroécologiques Sud et Ouest du Mali

Titre courant : Système d'élevage des poulets Wassachiè

Résumé

La caractérisation des systèmes de production est essentielle pour améliorer la volaille locale. Une étude a été réalisée sur les systèmes de production des poulets Wassachiè dans les zones agroécologiques Sud et Ouest du Mali. L'enquête, menée auprès de 84 aviculteurs dans 30 villages, a permis de recueillir des données sur les éleveurs, l'origine et la gestion du troupeau. Les résultats montrent que l'élevage de poulets Wassachiè est majoritairement une activité masculine (94,04%), pratiquée par des jeunes (50%) sans niveau d'instruction formelle (53,57%). Bien qu'ils n'aient reçu aucune formation en aviculture (73,80 %), l'incubation artificielle (89,28%) est courante. Les troupeaux comptent généralement moins de 50 poussins, nourris avec des aliments produits localement. L'analyse des correspondances multiples a révélé trois groupes d'aviculteurs. Le premier groupe est constitué d'agriculteurs (37,04%) et d'éleveurs (24,07%) sans instruction, qui ont démarré avec un petit nombre de poussins, souvent achetés. Le deuxième groupe est formé d'artisans (56,25%) qui assurent eux-mêmes le suivi sanitaire des animaux et produisent exclusivement pour la vente (100%). Le troisième groupe, composé de fonctionnaires (66,67%), confie le suivi vétérinaire à un spécialiste (75%) et oriente également leur production vers la vente. Les systèmes de production actuels dans ces deux zones nécessitent un accompagnement technique pour améliorer la production d'œufs, de poussins et de poulets Wassachiè.

Mots-clés : Système d'élevage, zone agroécologique, poulet Wassachiè, typologie.

Introduction

Facing the global population explosion, the production of short-cycle animal species represents an interesting approach to address the deficit in animal protein and meet the changing dietary preferences (NANTOUMÉ, 2011, OROUNLADJI *et al.*, 2021). This farming type contributes to income generation through the sale of eggs and poultry, improves food security conditions, and consequently plays a role in reducing rural household poverty (OROUNLADJI *et al*., 2022). Despite constituting 13% of the world's population, Africa only supplies 4% of poultry products globally (HUART, 2004). In many sub-Saharan African countries, the consumption of poultry products remains a luxury, despite the significant need for animal proteins (ISSA, 2012). This can be partly explained by the dominance

of traditional poultry farming practiced by small rural farms due to its lower input constraints (CHRISTY, 1989).

In Mali, traditional poultry farming represents nearly 54,703,373 birds, accounting for 86.35% of the poultry sector (DNPIA, 2021). Indeed, the local hen lays an average of 40 to 50 eggs per year, with 3 incubations and a hatching rate of 50-60%. At hatching, the weight of the chicks varies between 15 g and 26 g with a mortality rate of approximately 80% (CRRA, 2012). Considered a significant activity in the livestock sub-sector in Mali, the development of traditional poultry farming has become a key element in socio-economic development strategy and an effective means to fight against rural poverty (DNPIA, 2021). Its growth significantly contributes to ensuring food security and promoting rural women (TRAORÉ, 1999).

In the interest of improving zootechnical performance, a local chicken breed (indigenous) called Kokochiè (KKC) was crossed with an exotic breed, the Rhode Island Red (RIR). This crossbreeding gave rise to Wassachiè chickens. These Wassachiè chickens were expected to exhibit relatively homogeneous mixed production (meat and eggs) from a phenotypic perspective. Wassachiè is a stabilized and homogeneous chicken breed. The plumage color is red, the comb is simple in hens and well-developed in cocks. It is well-adapted to different agro-climate zones in Mali, with a good level of productivity and hardiness. The mortality rate is around 3% during the production period (chick to growth) and 2% during the production period (laying) (CRRA, 2012). The Wassachiè hen is more precocious compared to the local hen, starting to lay eggs at 18 weeks with a production of 173-210 eggs/year with an average weight of 45 g. The weight of the female at 6 months varies between 1,400 g and 1,600 g, while the cock weighs between 2,000 g and 2,500 g (CRRA, 2012).

Due to its performance, the Wassachiè chicken has been introduced to rural areas to improve local production. Several studies have been conducted on the zootechnical and reproductive performance of these Wassachiè chickens. However, a breed is characterized by a set of phenotypic, morphological, and genotypic characteristics (SAVARY *et al.*, 1997).

MTILENI *et al.* (2009) and DANDA *et al.* (2010) have expressed that the characterization of production systems should be the first step towards conducting a study that can identify threats and opportunities for the improvement of local poultry. OKENO *et al.* (2011) have

addressed these steps as they help understand the production and management practices of poultry farmers as well as crucial factors associated with the development of improved strategies. PEDERSEN (2002) suggested in these studies that characterization should be carried out in farm situations by collecting basic data rather than experimental station studies.

The characterization of farming systems explores the "how" and "why" in monitoring all stages, from housing, feeding, and healthcare to establishing production data. That’s why, the objective of this study is to characterize the poultry production systems of Wassachiè chicken in the Southern and Western agroecological zones of Mali.

The characterization of Wassachiè chicken farming systems in the southern and western agroecological zones of Mali reveals significant diversity based on environmental conditions, farming practices, available resources, and local traditions. These factors influence the productivity, sustainability, and resilience of these farming systems.

Improving farming practices, ensuring adequate chicken nutrition, effective health management, farmer training and awareness, integrating crop and livestock systems, market access, and the use of appropriate technologies are factors that could not only enhance the productivity of these farming systems but also make them more sustainable and resilient in the face of economic and environmental challenges.

I. Materials and methods

I.1. Study area

The study was conducted in two agroecological zones of Mali: the Southern zone (Sudanian) and the Western zone (Sudano-Guinean) (Figure 1). The Southern zone is characterized by an average rainfall ranging from 600 to 1000 mm/year and extending over 4 months (June, July, August, and September). It covers the regions of Kayes, Koulikoro, and the Bamako district. On the other hand, the Western zone only covers the Sikasso region and is characterized by rainfall exceeding 1200 mm/year, extending over 6 months (May, June, July, August, September, and October)

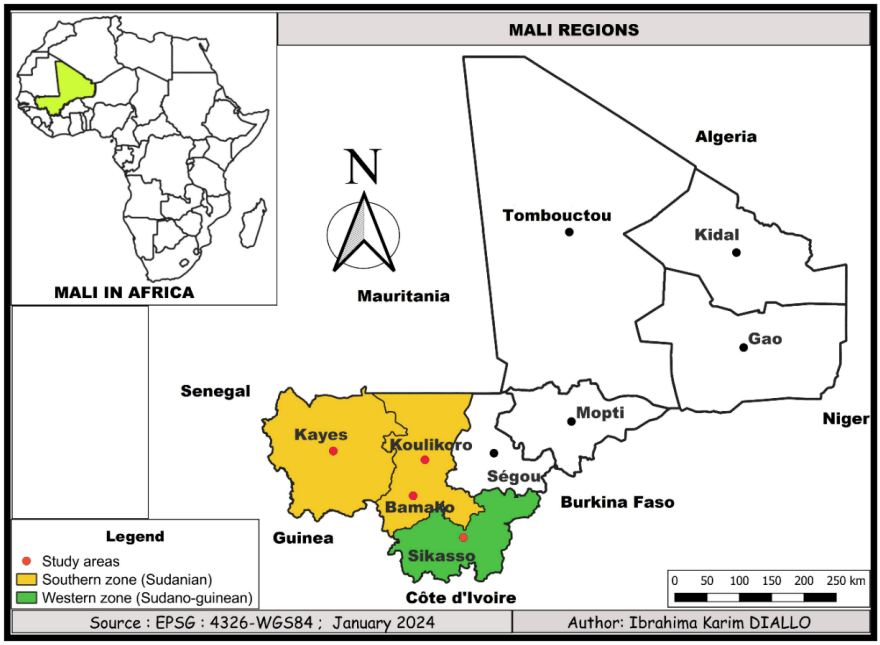

Figure 1. Mapping of the study area

I.2. Data collection

The surveys were conducted in 14 villages across the Sikasso, Bougouni, Koutiala, Koulikoro, Kolokani, and Bamako districts for the Southern zone, and 16 villages in the Kita, Keniéba, Mahina, and Kayes districts for the Western zone, making a total of 30 villages from 8 districts and the Bamako district.

In total, 84 poultry farmers were selected, with 36 poultry farmers in the Southern zone and 48 in the Western zone. The selection of villages and poultry farmers for the survey was based on:

- A directory of Wassachiè farmers available at the Poultry Program of the Regional Center for Agronomic Research (CRRA) in Sotuba (the research structure responsible for the production and sale of day-old Wassachiè chicks),
- The level of cooperatives for Wassachiè chicken production in the respective zones, in consultation with the agents of the state technical services.

The criteria for selecting villages and poultry farmers are outlined in Table I.

During data collection, a questionnaire was developed and administered. The information collected includes:

- Description of the poultry farmers: age, gender, level of education, profession, poultry farming training, motivations for raising Wassachiè chickens, age of the farm.
- Origin of the herd: number of animals at the creation of the farm, method of acquiring Wassachiè chickens.
- Herd management: farming method, poultry quantity, feeding system, reproduction method, production goal, health monitoring.

Table I: Criteria for the selection of villages and poultry farmers

Choices	Selection criteria
Village selection	• Significance of Wassachiè chicken farming among the population's activities. • Adequate distance between farms within a village to prevent animal exchange, with at least 10 km between villages.
Poultry farmer selection	• Willingness to participate in the survey. • Ownership of an adult Wassachiè chicken farm (over six months old) with a minimum of 10 birds.

I.3. Data analysis

The statistical software IBM SPSS 21.0 and R 3.4.3 were used for the analysis of qualitative and quantitative data. Frequencies of qualitative variables related to the identification of the poultry farmer, farm, herd management (farming practices), and the use of farming products were calculated. Descriptive statistics were applied to quantitative variables (farm age), followed by the t-test. Multiple Correspondence Analysis (MCA) was used to highlight existing relationships between qualitative variables and to outline a typology of production systems. The variables used are described in Table II.

Table II: variables and modalities used in multiple correspondence analysis

Variables	Modalities
Age	Young (≤ 39 years old) Adults (40 and 59 years old) Elderly (≥ 60 years old)
Gender	Man Woman
Educational level	None Primary Secondary
Occupation	Poultry farmer Farmer Official Trader Craftman
Poultry training	Yes No
Starting squad	Small (≤ 50 chicks) Medium (51 - 100 chicks) Large (≥ 101 chicks)
Acquisition mode	Purchase Gift
Objective	Object1 = Sale Object2 = Sale + consumption
Mode of reproduction	Repro1 = Natural Repro2 = Incubation
Feed	Almt1 = Purchase Almt2 = Self-manufacturing
Health monitoring	None Poultry farmer Veterinarian
Agroecological zones	South West
Ethnic groups	Bambara Peulh Malinké Dafing Dogon Forgeron Sarakole Senoufo Others: Bobo, Kakolo, Samoko.

II. Results

II.1. Socioprofessional characteristics of the respondents

In the Western and Southern zones of Mali, Wassachiè chicken is predominantly raised by men, accounting for 97.22% of the respondents (Table III). Poultry farmers with no formal education were predominant, constituting an average of 53.57% in both zones. There were also those with secondary education (29.76%) and a low representation of those with primary education, accounting for 16.67% of the respondents.

Table III: Socio-professional characteristics of respondents

Parameters	Agroecological zones		Overall (X=84)
	Southern zone (X= 36)	Western zone (X=48)	
Gender (%)			
Men	97.22	91.66	94.04
Women	2.78	8.34	5.96
Educational level (%)			
None	55.55	52.08	53.57
Primary	13.88	18.75	16.66
Secondary	30.55	29.16	29.76
Occupation (%)			
Poultry farmers	16.66	20.83	19.04
Farmers	19.44	31.25	26.19
Public officer	19.44	22.91	21.42
Trader	8.33	8.33	8.33
Craftsmen	36.11	16.66	25.00
Poultry training (%)			
Trained	16.66	33.33	26.19
Untrained	83.33	66.66	73.80
Age of respondent (%)			
Young (≤ 39 years old)	41.67	56.25	50
Adult (40 and 59 years old)	55.56	43.75	48.81
Elderly (≥ 60 years)	2.78	-	1.19

In addition to the low level of education, 73.80% of the respondents had not received any poultry farming training. Wassachiè chicken farming is dominated by craftsmen in the Southern zone (36.11%)

and by farmers in the Western zone (31.25%). Overall, in both zones, the respondents were mostly young (50%), but the proportions varied between the zones. Poultry farmers in the Southern zone were predominantly adults (55.56%), while they were mostly young (56.25%) in the Western zone (Table III).

II.2. Establishment of farms

The visited farms were of similar ages, with an average farm age of 6.74 ± 0.37 years (Table IV). The histories of farm creation were diverse, ranging from simple gifts to purchasing chicks to build a herd. With a proportion of 80.95% of the total respondents in both zones, acquiring chickens through purchase was the primary mode of acquisition, followed by acquisition through donations (19.04%). The initial herd size mostly consisted of small numbers (≤ 50 chicks), accounting for 77.78% of cases in the South and 91.67% of cases in the West.

Table IV: Characteristics of farms' size

Parameters	Agroecological zones		**Overall** (X=84)
	Southern zone (X= 36)	**Western zone** (X= 48)	
Herd size (%)			
Small (≤ 50 chicks)	77.78	91.67	84.52
Medium (51 - 100 chicks)	5.56	4.17	5.95
Large (≥ 101 chicks)	16.67	4.17	9.52
Acquisition mode (%)			
Purchase	83.33	79.17	80.95
Gift	16.67	20.83	19.04
Farm age (mean ± SEM)	6.94 ± 0.73	6.58 ± 0.36	6.74 ± 0.37

SEM: standard error of the mean.

II.3. Herd management

Table V presents the herd management of Wassachiè chickens in the Western and Southern zones. It is evident from this table that Wassachiè chickens are raised in confinement at 78.57%, and 21.42% are free-range in both study zones. Additionally, artificial incubation was the most commonly used reproductive method, accounting for 89.28%, compared to 10.71% for natural brooding.

The feed source varied between the zones. In the Southern zone, breeders predominantly purchased the feed, while in the Western zone, they preferred to produce it themselves.

Regardless of the zones, the proportion of breeders with the production objective of both selling and self-consumption (69.05%) and those personally handling health monitoring (71.42%) were higher than other modalities. The sex ratio is 1:6 in the Southern zone and 1:5 in the Western zone.

Table V: Herd management in agroecological zones.

Characteristics	Agroecological zones		Overall (%) (X=84)
	Southern zone (X=36)	Western zone (X=48)	
Breeding method (%)			
Confinement	80.55	77.08	78.57
Free-range	19.44	22.91	21.42
Reproduction mode (%)			
Artificial incubation	86.11	91.66	89.28
Natural brooding	13.88	8.33	10.71
Sex ratio	1/6	1/5	1/6
Feeding source (%)			
Feed purchase	52.77	41.66	46.42
Self-making	47.22	58.33	53.57
Number of chickens (mean ± SEM)	41.37 ± 7.62	27.69 ± 7.22	33.34 ± 3.23
Production targets (%)			
Repay	16.67	10.42	13.10
Sale	25	12.50	17.86
Sale + self-consumption	58.33	77.08	69.05
Health monitoring (%)			
Poultry farmer	72.22	70.83	71.42
None	2.78	-	1.19
Veterinarian	25	29.17	27.38

SEM: standard error of the mean

II.4. Typology of farms

Multiple Correspondence Analysis (MCA) was conducted on 13 variables, including 12 active variables characterizing farms, the origin, and herd management. An additional variable, the age of farms, was associated with the active variables. All these variables contributed to representing individuals in a two-dimensional space

(Figure 2). The first two dimensions (axes) allowed for the discrimination of poultry farmers and explained 53.85% of the total variation.

MCA grouped the respondents into 3 clusters (Group 1 in black, Group 2 in red, and Group 3 in green). Based on the production objective and the health management approach of the three groups, a nomenclature was established to designate the poultry farmers in each group. The percentage distribution of parameters is presented in Table VI.

Group 1: Traditional farmers with mixed objectives

Group 1 consists solely of men, predominantly crop farmers (37.04%) or livestock farmers (24.07%). They have no formal education and started their farming with a small number of chicks (≤ 50 chicks) acquired through purchase. Artificial incubation is practiced in 98.15% of cases, and breeders in this group produce their own feed (59.26%). They are motivated by both selling and consumption.

Group 2: Market-oriented traditional farmers

Group 2 exists in both the South (62.50%) and the West (37.50%). It comprises craftmen (56.25%) who acquired their initial herd through donation (68.75%). They personally monitor the health of animals (93.75%) and produce exclusively for sale (100%).

Group 3: Market-oriented modern farmers

This group consists of government employees (66.67%), mostly with secondary education (58.33%). 75% of these breeders are adults, with a gender proportion of 66.67% male and 33.33% female. Although they have a small herd size (≤ 50 chickens), they practice artificial incubation (66.67%), and the animals are monitored by a veterinarian (75%). The primary production objective for breeders in this group is sales.

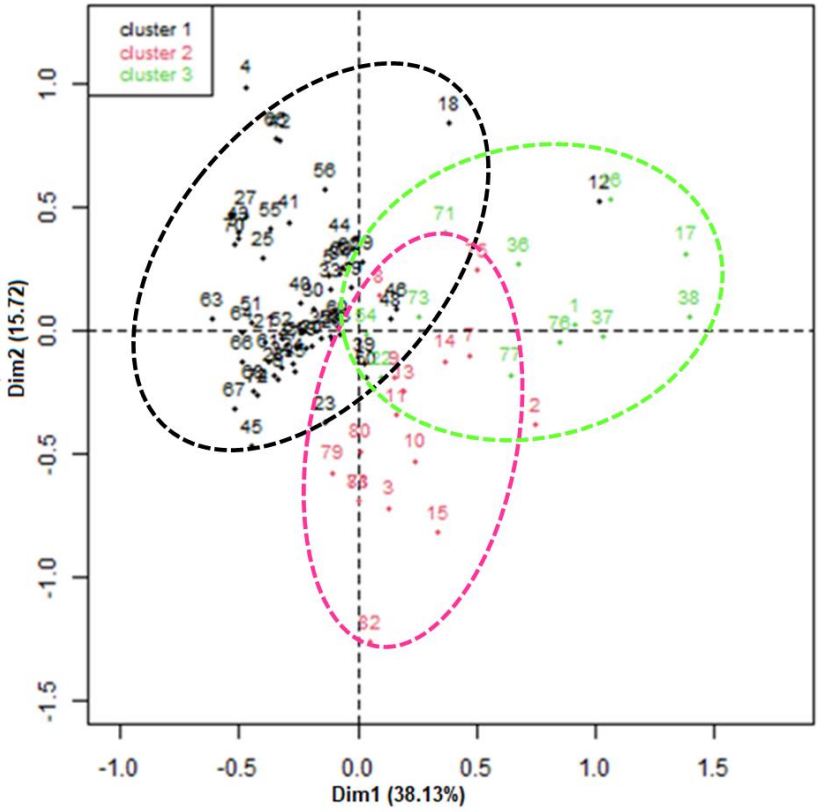

Figure 2: A graphical representation of the groups characterizing the farming systems.

Table VI: Distribution of socio-economic parameters by type of breeder depending on the significance of the modality.

Variables	Modalities	Group 1	Group 2	Group 3
Agroecological zones	South	-	62.50	-
	West	-	37.50	-
Occupation	Public officer	12.96	-	66.67
	Farmer	37.04	-	00
	Poultry farmers	24.07	-	00
	Craftmen	16.67	56.25	
Acquisition mode	Purchase	92.59	31.25	-
	Gift	7.41	68.75	-
Educational level	Secondary	14.81	-	58.33
	Fundamental	-	-	00
	No level	61.11	-	25
Age	Young	-	-	25
	Adult	-	-	75
Mode of reproduction	Repro1	1.85	-	33.33
	Repro2	98.15	-	66.67
Starting squad	Little	88.89	-	66.67
	Big	00	-	33.33
Objective	Object2	98.15	0.00	33.33
	Object1	1.85	100.00	58.33
Gender	Woman	00	-	33.33
	Man	100	-	66.67
Ethnic group	Senufo	00	-	33.33
Feed	Almt2	59.26	-	-
Health monitoring	Veterinarian	-	6.25	75
	Poultry farmer	-	93.75	25

III. Discussion

This study has shown that Wassachiè chicken farming is predominantly carried out by men in the Southern and Western zones of Mali. This trend aligns with the findings of LOUKOU (2013), DAO (2015), and PINDE *et al.* (2020), in Ivory Coast, Togo, and Burkina Faso respectively. However, FOTSA *et al.* (2007) observed the opposite, stating that poultry farming is traditionally a female activity practiced by 80% of women and disadvantaged youth in most developing countries. In rural areas, the patriarchal management of families in Mali could account for the high percentage of men in the poultry sector. Nevertheless, men's involvement in poultry sales decision-making is already known in Africa, driven by socio-cultural

considerations that grant men the right to be responsible for family management, often at the expense of women (GUEYE, 1998).

The study revealed a high proportion of livestock farmers involved in primary sector activities (crop production, animal production, craftsmanship, etc.). These findings could be linked to the low level of education among respondents in both zones and perfectly reflects the low literacy rate in the Malian population, which is 38% (INSTAT MALI, 2016). Additionally, the proportions of 16.66% in the South and 20.83% in the West indicate that Wassachiè chicken farming is practiced as a secondary activity, parallel to other activities such as agriculture, trade, and craftsmanship.

Despite the low level of poultry farming training, breeders in the Southern and Western zones produce for both sale and self-consumption. These results align with those of LOUKOU (2013), who stated that poultry farming serves as a means of livelihood during the lean season, with products directly consumed during the rainy season.

The study highlighted that the majority of breeders formed their herds through chick purchases. This observation aligns with LOUKOU (2013) and FOSTA *et al.* (2007), who respectively showed in Ivory Coast and Cameroon that rural poultry herds are mainly formed through purchases, followed by other methods such as donation, entrustment, inheritance, and barter.

It was observed that breeders starting with a small number of chicks are more successful in sustaining the herd over the years. This observation may result from ancestral knowledge based on animal management techniques and cultural practices passed down through generations (LOBRY, 2003). This also justifies veterinary care practices by the breeders themselves, as well as occasional self-medication with non-conventional pharmaceutical products (such as ampicillin commonly known as "toupaille," paracetamol, or chloroquine) or traditional treatments based on barks, leaves, and fruits of medicinal plants used by people in rural areas (LOUKOU, 2013; OROUNLADJI *et al.*, 2022). However, these practices have limitations with medium and large herds. These constraints are factors contributing to the loss of genetic diversity, leading to genetic erosion by eliminating genes specifically carried by individuals that disappear.

MCA allowed the classification of breeders into three groups. Groups 1 (Traditional farmers with mixed objectives) and 2 (Market-oriented

traditional farmers) correspond to the commercial production system described by DANG (2009). In this type of system, the herd consists of animals obtained through purchases. For breeders in this system, Wassachiè chicken farming is a source of income. Although artificial incubation is a common practice in these farms, the level of biosafety practice is low due to a low level of knowledge and skills in poultry health monitoring. Group 3 (Market-oriented modern farmers) corresponds to the category described by YUSUF *et al.* (2014). Breeders in this type of farming have a secondary education level, justifying the high proportion of government employees. These authors found that a person's level of education contributes to their rate of adoption of new technologies. OCHIENG *et al.* (2012) confirmed in their conclusions on the adoption of management interventions in local chicken production in Kenya that farmers' education level had a positive marginal effect on the adoption of supplementary feeding and vaccination.

Conclusion

This study successfully characterized the Wassachiè chicken farming systems in the Southern and Western agroecological zones of Mali, achieving its objective by identifying key factors shaping these systems. The findings revealed that poultry farming in these areas is predominantly carried out by men, influenced by patriarchal structures, unlike other regions in sub-Saharan Africa where women are more involved.

Education was identified as a critical factor, with higher levels correlating with better adoption of innovative practices like vaccination and supplementary feeding. However, low literacy rates among most farmers highlight the need for targeted training to improve knowledge and skills. The reliance on traditional remedies and self-medication points to gaps in veterinary care, particularly for medium and large herds, where access to modern health services is essential to boost productivity and preserve genetic diversity.

Market-oriented farmers benefit from income generation, but low biosafety awareness remains a challenge, necessitating investments in training and infrastructure to mitigate risks and improve sustainability. Strengthening local breeding programs could further enhance the availability of high-quality chicks, reducing dependence on external sources.

The study confirmed its hypothesis by demonstrating the influence of socio-economic and agroecological factors on farming systems. It provided a comprehensive understanding of Wassachiè chicken production, offering a foundation for targeted interventions to enhance productivity and resilience in these regions.

Conflict of Interest

The authors reported no conflict of interest regarding the publication of this article.

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