



eISSN 2239-7132

## Italian Journal of Food Safety

<https://www.pagepressjournals.org/index.php/ijfs/index>

**Publisher's Disclaimer.** E-publishing ahead of print is increasingly important for the rapid dissemination of science. The Early Access service lets users access peer-reviewed articles well before print/regular issue publication, significantly reducing the time it takes for critical findings to reach the research community.

These articles are searchable and citable by their DOI (Digital Object Identifier).

The **Italian Journal of Food Safety** is, therefore, E-publishing PDF files of an early version of manuscripts that have undergone a regular peer review and have been accepted for publication, but have not been through the copyediting, typesetting, pagination, and proofreading processes, which may lead to differences between this version and the final one.

The final version of the manuscript will then appear in a regular issue of the journal.

The E-publishing of this PDF file has been approved by the authors.

***Please cite this article as:***

Thaha AH, Malaka R, Hatta W, Maruddin F. **Risk analysis of critical control points of *Staphylococcus aureus* in layer farms and egg chicken distributors.** *Ital J Food Saf* doi:10.4081/ijfs.2024.12409

*Submitted: 21-02-2024*

*Accepted: 03-06-2024*

 © the Author(s), 2024  
Licensee PAGEPress, Italy

Note: The publisher is not responsible for the content or functionality of any supporting information supplied by the authors. Any queries should be directed to the corresponding author for the article.

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article or claim that may be made by its manufacturer is not guaranteed or endorsed by the publisher.

## **Risk analysis of critical control points of *Staphylococcus aureus* in layer farms and egg chicken distributors**

Aminah Hajah Thaha,<sup>1,2</sup> Ratmawati Malaka,<sup>1</sup> Wahniyati Hatta,<sup>1</sup> Fatma Maruddin<sup>1</sup>

<sup>1</sup>Faculty of Animal Science, Hasanuddin University, Makassar City, South Sulawesi; <sup>2</sup>Faculty of Science and Technology, Alauddin State Islamic University, Makassar City, South Sulawesi, Indonesia

**Correspondence:** Ratmawati Malaka, Faculty Animal Husbandry, Hasanuddin University, Jalan Perintis Kemerdekaan Km. 10 Tamalanrea, Makassar City, South Sulawesi, 90245, Indonesia.

E-mail: [malaka\\_ag39@yahoo.co.id](mailto:malaka_ag39@yahoo.co.id)

**Keywords:** chicken eggs, critical control point, *Staphylococcus aureus*.

**Contributions:** all authors contributed equally.

**Contributions:** all the authors made a substantial intellectual contribution, read and approved the final version of the manuscript, and agreed to be accountable for all aspects of the work.

**Conflict of interest:** the authors declare no potential conflict of interest.

**Ethics approval and consent to participate:** not applicable.

**Funding:** No. 124/E5/PG.02.00.PL/2023 (Ministry of Education, Culture, Research, and Technology).

**Availability of data and materials:** data and materials are available from the corresponding author upon request.

**Acknowledgments:** the authors would like to thank Indonesia's Ministry of Education, Culture, Research, and Technology for providing research funding through the Phase-I doctoral dissertation scheme.

## Abstract

Microbiological criteria play a role in verifying the critical control points (CCP), which become part of the hazard analysis, and the CCP system that guarantees quality, considering possible danger points or stages in the food production chain. Studies about *Staphylococcus aureus* in chicken eggs more extensively discuss the path, source, and level of prevalence of contamination at the final distributor or consumer. Therefore, this study investigates CCP contamination of *S. aureus* in chicken eggs and their potential consumption, which could endanger human health from the layer farm until the final distributor. This study is critical in health, public health, and veterinary medicine for preventing and controlling consumers' security. This study done for CCP on the chain distribution of chicken eggs starts with preparing production and distribution process flow diagrams for livestock, agents/wholesalers, and retailers. Confirmation of operational production in the field/location study is based on the flow chart that has been arranged, identifying all potential dangers associated with each stage and analyzing potential risks considering every action for controlling identified hazards. The next step involves pinpointing the CCP to counteract the identified threat. An application tree decision defines the CCP, and the logical and final approach is the determination limit critical to the CCP. Analysis results in the determination of CCP contamination of *S. aureus*, indicating that chicken eggs, personal hands (farm workers, wholesalers, and retailers), shelf eggs, and feces are CCP on farms.

## Introduction

The demand for quality food security for livestock products continues to increase with the implementation of free trade (Owusu-Sekyere *et al.*, 2014). Therefore, it is necessary to improve the requirements of ISO 22000:2018 (ISO, 2018) through the implementation of the Hazard Analysis Critical Control Point (HACCP) system as a method to anticipate the occurrence of food poisoning and foodborne diseases due to contamination by pathogenic microbes, including viruses and bacteria, parasites, and fungi (Awuchi, 2023). HACCP is a system that internationally guarantees recognized quality based on possible hazards at various points or each production stage in the food industry. The system acknowledges, assesses, and limits significant food safety hazards to minimize the risk of food safety hazards. HACCP is used in the food industry to produce products that meet human health and safety conditions. The paramount importance of HACCP is the anticipation of hazards and the priority identification of preventive control measures rather than final food product testing. One of these food problems is related to the production of laying hens before harvest, so it must concern producers, entrepreneurs, and policymakers. *Staphylococcus aureus* contamination of eggs generally occurs because this bacterium is naturally spread. *S. aureus* produces enterotoxins, which can cause the risk of food poisoning with symptoms of headache, vomiting, diarrhea, and even death. In the egg and poultry industry, it is necessary to study the critical point of possible *S. aureus* contamination because *S. aureus* is a microbe that is always present in nature in contact with the environment. Several cases of egg-based food poisoning have been reported, and once detected, they were due to the presence of toxins produced by *S. aureus*. Therefore, the possible critical points for contamination in the egg supply chain for consumers have been explored.

A critical control point (CCP) is a point/stage/procedure in the food production system and is one of the parts of HACCP. CCP control is excellent and can prevent, eliminate, or reduce existing dangers to food security and public health (Viator *et al.*, 2016). CCP identification is necessary for managing risky food and ensuring that the public consumes product-safe food. Because of that, this system can identify potential sources, dangerous materials, and food products. CCP monitoring and control was adopted by the Codex Committee on Food Hygiene, which was later ratified to adopt regulations applicable in each country worldwide. CCP monitoring is meaningful for action prevention, monitoring control dangers to ensure effectiveness, and verifying the whole system. The presence of *S. aureus* in food is an indicator of deviation towards i) implementation of personal hygiene, ii) sanitation equipment, and iii) sanitation environment (Zeaki *et al.*, 2019; Birgen *et al.*, 2020; Pérez-Boto *et al.*, 2023), which is a CCP. Based on the results of the study, known reasons leading to

poisoning food are pathogenic microorganisms (Fernandes *et al.*, 2022) and materials chemistry (Gupta *et al.*, 2022; Thi *et al.*, 2023). One of the microorganisms that are the causative pathogen poisoning food is *S. aureus*.

*S. aureus* is a capable pathogenic bacterium that produces various toxins that cause food poisoning. This bacterium can adapt to multiple types of food, such as stand heat (68.2°C) and protease enzymes such as pepsin inside digestive tracts (Kadariya *et al.*, 2014). Gastrointestinal symptoms characterize staphylococcal foodborne intoxication (SFP) and occur after consumption of *Staphylococci Enterotoxin* (SE) in food. Not all SE can form in each food because factors such as water activity, pH, potential redox, temperature, and others can influence its formation (Bianchi *et al.*, 2014). Several outbreak reports show clinical symptoms of enterotoxin after consuming animal products, including Asao *et al.* (2003), who published that as many as 13,420 people in Kansai, Japan, were affected after consuming skim milk and yogurt contaminated with *S. Enterotoxin A* (SEA) as much as 20-100 ng per individual. Chicken egg is one of the possible sources of animal protein-contaminated *S. aureus* through two main methods, namely transovarial and trans-shell. Contamination begins on the surface shell, followed by penetration by microorganisms into albumen, but in several cases, it is directed to the yolk egg (Pondit *et al.*, 2018). Although a known path and source contamination study regarding analytical design risk CCP contamination exists, *S. aureus* starts from the layer farm and continues distributing. Bacteria still need to be considered for their outstanding contribution as a foodborne pathogen from chicken eggs compared to *Salmonella* spp.

Based on existing facts, it is necessary to identify and analyze CCP regarding the presence of *S. aureus* contamination in chicken eggs to provide safe animal protein nutrition for society and its use in food products. Then, there would be a guarantee of the security of chicken eggs, and this product would compete and be accepted in the market, and increase the farmer's economy. This study can also be done to support the application method of raising good livestock, especially in layer farms, and minimize contamination of microbes in the food chain.

## **Materials and Methods**

### ***Location***

The study was held from July until August 2023 in Regency Sidrap, Bulukumba, and Gowa, South Sulawesi Province, the biggest chicken egg supplier in this province (BPS Provinsi Sulawesi Selatan, 2021). This study comprises a population of layer farms, wholesalers, and retailers. Sample study as many as one farm with a population of 20.000-25.000 egg-laying hens, one wholesaler taking eggs from a layer farm, one retailer taking eggs from wholesalers in three districts, three agents/wholesalers from each farm, and three retail traders from each agent/wholesaler. The sampling technique used in the study is purposive sampling. The data collection techniques used in this research were observation and interviews. Data was collected through direct observation to confirm the flow chart and structured interviews with parties involved in the activities of the target location. This observation confirms chart flow production and interviews structured (Table 1) with the parties involved in the activity destination location (Figure 1)

Figure 2 shows the chart flow of the method for viewing and analyzing risks. At this point, controlling *S. aureus* cases in the egg supply chain is necessary. This matrix explains the severity and possible levels at the sample investigation level. The flow chart was made and adapted to implementation in the field during interviews with farm workers, wholesalers, and retailers. Figure 3 illustrates the examination of *S. aureus* using biochemical tests, which have been confirmed by DNA testing.

### ***Study design and determination of risk level and critical control point***

#### ***Identification and confirmation of chicken egg production process stages and distribution flow***

The study used a cross-sectional design, where the variables included factors, risks, and observed effects simultaneously. It was measured only once with a representative sample (Thiese, 2014). This study consists of three stages (Figure 4). Stage 1 is to compile a chart flow that includes all stages of the production process: layer farms, wholesale distribution processes, and retailer distribution

processes. Stage 2 confirms the operational on-site production based on the chart flow that has been arranged. Stage 3 identifies all danger potentials associated with each stage, then analyzes dangerous potentials and considers every action for controlling identified hazards (ISO, 2018). The stage analysis of potency danger is quantitatively done with a combination of opportunity (probability) and severity (severity).

The probability level consists of three indicators: the occurrence of more than one case of *S. aureus* infection in one year (value 3), the occurrence of one case of *S. aureus* in one year (value 2), and the occurrence of no cases in one year (value 1). The severity level for consumers (severity) consists of three indicators: high severity level, which means critical illness or death (value 3); medium severity level, which means illness (not a critical illness but still requires treatment) (value 2), and low severity level which means mild illness that can still carry out activities (value 1). The level of risk (significance risk) indicator is based on a combination of the effect possibility of happening risk and the level specified severity, which is a base action control that is low-risk (green), medium-risk (yellow), and high-risk (red). Stage 4 is the determination of a CCP, where control is applied to overcome the same danger. CCP is determined using a decision tree with a logical approach, referring to guidelines established in Indonesia and internationally (FAO, 2020). Stage 5 is the determination of critical limits for the CCP (Table 2) (National Standardization Agency, 2000).

## **Results**

### ***Stages 1 and 2: identification and confirmation of chicken egg production process stages and distribution flow***

Based on these results, the stages of the chicken egg production process on the farm, wholesale distribution, and distribution processes at retailers in the three districts were identified. Figure 1 explains the supply chain points, starting at the farm, wholesaler, and retailer. At the farm level, it begins with harvesting, then collecting, sorting, cleaning, grading, packaging, storage, and transportation. At the wholesaler level, it starts with collecting eggs from the farm, sorting and grading them, storing them, and transporting them to consumers. Meanwhile, retail starts with collecting either from the farm or the wholesaler, sorting and grading, and storing it for consumer transportation.

### ***Stage 3: identification and potential danger analysis***

The qualitative classification is based on observations, interviews, and an article study at layer farms, wholesalers, and retailers. It describes the severity level from the lowest to the highest and the probability that it occurs in the supply chain. The classification also discusses the possibility of *S. aureus* contamination in chicken eggs from interviews with farms, agents, wholesalers, and retail traders.

### ***Stage 4: determination of the critical control point***

In this research, stage 4 is the determination of CCP using tree decision to high-risk (red) based on matrix determination risk from People's hands, eggs, shelves, and feces are CCP in this research.

### ***Stage 5: determination limit of critical control point***

Microbial criteria play a role in verifying CCP. Based on the existing CCP, the determination mark limit critical tolerance *S. aureus* was set.

## **Discussion**

### ***Identification and confirmation of chicken egg production process and distribution channels***

Based on observation, it is known that there are differences in production processes on farms and lines of distribution to wholesalers and retailers across stages of sorting and grading. The third location sorts from separated eggs to chicken, intact and damaged, while wholesalers and retailers are in the ninth grade. Layer farms have seven stages, whereas wholesalers contain eight stages, and

retailers comprise nine stages. The average time an egg is saved on the third farm before being sold to the trader or wholesaler ranges between 24 and 96 hours. The longer the stages in each chain supply, the longer the egg is on point, so the bigger the risk of the egg being contaminated by surrounding microorganisms.

### ***Potential danger identification and analysis***

At this stage, operational production in the field is confirmed according to chart flow. The third stage identifies all danger potentials with matrix determination risk (*Supplementary Tables 1-3*). It is known that chicken eggs, hand personnel (farm workers, wholesalers, and retailers), shelf eggs, and feces risk *S. aureus* contamination. Chicken eggs are contaminated with *S. aureus* by two main methods, *i.e.*, transovarial through channel egg or transshell, which involves contamination beginning with the surface of the egg, followed by penetration next by microorganisms to albumen or, in several cases, directly to the egg yolk (Awny *et al.*, 2018; Pongit *et al.*, 2018).

Figure 3 explains the limited critical tolerance values of *S. aureus* at layer farms, wholesalers, and retailers, as quoted from several references. Egg contamination can also happen horizontally through cloaca and shell contact with dirty surfaces such as feces, which will increase the risk of penetration of microbes into the egg (Sánchez *et al.*, 2019; Damena *et al.*, 2022). Several sources of contamination include litter material, crate eggs, feces, tools for packing and storing eggs, clothes and hands, worker cages, dust, and the environment (Anosa *et al.*, 2019). Research results (Hermana *et al.*, 2021) also found that *S. aureus* isolates obtained from cloacal swabs of farm chicken broilers and layers in Bogor are resistant to tetracycline, ampicillin, oxytetracycline, erythromycin, and nalidixic acid. Corrective actions must be taken for potential hazards with high risks, while preventive actions are taken for medium and low risks.

### ***Determination of the critical control point***

Based on the analysis results to determine the CCP of *S. aureus* contamination, it is known that chicken eggs, personal hands (farm workers, wholesalers, and retailers), shelf eggs, and feces are CCP throughout the chain supply. HACCP is a system that identifies, evaluates, and controls significant food security dangers (FAO, 2020). This system ensures zero-risk or risk-free food and aims to reduce risk and danger. The HACCP system is implemented to control food's dangerous biological, chemical, and physical contamination and identify ways to improve approaches based on effectiveness and economic efficiency.

Human hands (farmers, workers, cages, and traders), eggs, shelves, and feces from poultry are considered CCP because action control is carried out to minimize contamination of *S. aureus*. Washing hands with soap and running water and applying hand sanitizer are routine planned actions for removing or reducing the contamination from *S. aureus*, thereby reducing the risk of the human hand becoming CCP on the chain supply of chicken eggs. Eggs, shelf eggs, and feces from poultry are also critical points because the amount of contamination by *S. aureus* can produce toxic and harmful consumers if it exceeds the level that can be accepted, *i.e.*,  $>10^5$  CFU/g (Salasia *et al.*, 2009). Because it is in the next stage, the required method for removing or reducing contamination is to pay attention to egg handling chicken in a way appropriate in the form of storage time, temperature storage egg, attention to hygiene sanitation shelves eggs, and improve sanitation hygiene farm.

Implementation of HACCP in the layer farm can guarantee that every chain provision starts with providing raw or processed food to the consumer. In each industry, food uses the HACCP system in a tight connection with other systems, such as good manufacturing practices, ISO, and other standards applicable in the country that are concerned with ensuring quality food (ISO, 2018).

### ***Establishing critical limits at critical control points***

Enterotoxin levels that cause enterotoxigenesis are relatively low, with insufficient doses of 1.25 g in contaminated food. The dose of toxin can be achieved if there are  $10^5$  CFU/g *S. aureus* per gram of food (Salasia *et al.*, 2009). In addition to testing samples at critical points, observations were carried

out on aspects of sanitation hygiene at farms, wholesalers, and retailers. Implementation of sanitary hygiene in laying chicken farms ranges from 42.5-52.5% (I) based on seven indicators, including the sanitary hygiene of farm workers, visitor/guest sanitation hygiene, cage sanitation, egg storage warehouses, feed warehouses, egg handling hygiene, and livestock sanitation. It is known that the implementation of sanitation hygiene at the wholesale level for eggs originating from Gowa, Bulukumba, and Sidrap Regencies ranges between 29-32% (*Supplementary Table 2*). Meanwhile, implementing sanitation and hygiene at the retailer level is 41.5-55.5% (*Supplementary Table 3*) (Health Protection Agency, 2009). This is based on nine indicators: environmental cleanliness, storage warehouses, egg sorting, handling broken or dirty eggs, egg storage and distribution/delivery, egg packaging, employee hygiene, pest control program (rodents and insects), and sanitation and waste handling.

## Conclusions

CCP of *S. aureus* contamination in egg production management on layer chicken farms is the chicken eggs, personal hands (farm workers, wholesalers, and retailers), egg racks, and feces.

The CCPs for *S. aureus* contamination in the management of egg production on laying hen farms are chicken eggs, personal hands (farm workers, wholesalers, and retailers), egg racks, and feces. The sanitation and hygiene levels at the sample locations are still between 29% and 55.5%.

## References

- Anosa GN, Ezenduka EV, Gabriel KC, Ngene A, Eze UU, 2019. Occurrence and antibiogram of *Staphylococcus aureus* and methicillin-resistant *Staphylococcus aureus* from table eggs in Nsukka, Enugu State, Nigeria. *Sokoto J Vet Sci* 17:62-71.
- Asao T, Kumeda Y, Kawai T, Shibata T, Oda H, Haruki K, Nakazawa H, Kozaki ANDS, 2003. An extensive outbreak of staphylococcal food poisoning due to low-fat milk in Japan: estimation of enterotoxin A in the incriminated milk and powdered skim milk. *Epidemiol Infect* 130:33-40.
- Awny C, Amer A, El-Makarem H, 2018. Microbial hazards associated with consumption of table eggs. *Alex J Vet Sci* 59:139-46.
- Awuchi CG, 2023. HACCP, quality, and food safety management in food and agricultural systems. *Cogent Food Agric* 9:2176280.
- Bianchi DM, Gallina S, Bellio A, Chiesa F, Civera T, Decastelli L, 2014. Enterotoxin gene profiles of *Staphylococcus aureus* isolated from milk and dairy products in Italy. *Lett Appl Microbiol* 58:190-6.
- Birgen BJ, Njue LG, Kaindi DM, Ogutu FO, Owade JO, 2020. Determinants of microbial contamination of street-vended chicken products sold in Nairobi Country, Kenya. *Int J Food Sci* 2020:2746492.
- BPS Provinsi Sulawesi Selatan, 2021. Provinsi Sulawesi Selatan dalam Angka 2021. Available from: <https://sulsel.bps.go.id/publication/2021/02/26/0747cef62696e4a91bf5224c/provinsi-sulawesi-selatan-dalam-angka-2021.html>.
- Damena A, Mikru A, Adane M, Dobo B, 2022. Microbial profile and safety of chicken eggs from a poultry farm and small-scale vendors in Hawassa, southern Ethiopia. *J Food Qual* 2022:7483253.
- Fernandes A, Ramos C, Monteiro V, Santos J, Fernandes P, 2022. Microorganisms virulence potential and antibiotic susceptibility of *S. aureus* strains isolated from food handlers. *Microorganisms* 10:2155.
- FAO, 2020. Codex Alimentarius general principles of food hygiene. Available from: <https://www.food-safety.com/articles/7483-codex-principles-of-food-hygiene-30>.
- Gupta AK, Chaudhary A, 2022. Food poisoning: causes, its effects, and control. *I TECH MAG* 4:42-8.
- Health Protection Agency, 2009. Guidelines for assessing the microbiological safety of ready-to-eat foods placed on the market. Available from:

[https://assets.publishing.service.gov.uk/media/5a7efde0e5274a2e8ab497a4/Guidelines\\_for\\_assessing\\_the\\_microbiological\\_safety\\_of\\_ready-to-eat\\_foods\\_on\\_the\\_market.pdf](https://assets.publishing.service.gov.uk/media/5a7efde0e5274a2e8ab497a4/Guidelines_for_assessing_the_microbiological_safety_of_ready-to-eat_foods_on_the_market.pdf).

- Hermana NSP, Afiff U, Safika S, Indrawati A, Pasaribu FH, 2021. Antibiotic-resistant pattern and resistant gene identification of *Staphylococcus aureus* from chicken farm in Bogor. *Jurnal Veteriner* 22:262-70.
- ISO, 2018. Food safety management systems - requirements for any organization in the food chain. ISO Norm 22000:2018. International Standardization Organization ed., Geneva, Switzerland.
- Kadariya J, Smith TC, Thapaliya D, 2014. *Staphylococcus aureus* and Staphylococcal food-borne disease: an ongoing challenge in public health. *Biomed Res Int* 2014:827965.
- National Standardization Agency, 2000. SNI No. 01-6366-2000 Batas maksimum cemaran mikroba dan batas maksimum residu dalam bahan makanan asal hewan. <https://bpmsph.ditjenpkh.pertanian.go.id/wp-content/uploads/2016/06/SNI-01-6366-2000-Batas-maksimum-cemaran-mikroba-dan-batas-maksimum-residu-dalam-bahan-makanan-asal-h.pdf> [Article in Indonesian].
- Owusu-Sekyere E, Owusu V, Jordaan H, 2014. Consumer preferences and willingness to pay for beef food safety assurance labels in the Kumasi Metropolis and Sunyani Municipality of Ghana. *Food Control* 46:152-9.
- Pérez-Boto D, D'arrigo M, García-Lafuente A, Bravo D, Pérez-Baltar A, Gaya P, Medina M, Arqués JL, 2023. *Staphylococcus aureus* in the processing environment of cured meat products. *Foods* 12:2161.
- Pondit A, Haque ZF, Sabuj AAM, Khan MSR, Saha S, 2018. Characterization of *Staphylococcus aureus* isolated from chicken and quail eggshell. *J Adv Vet Anim Res* 5:466-71.
- Salasia SIO, Sugiyono K, 2009. Distribusi gen enterotoksin *Staphylococcus aureus* dari susu segar dan pangan asal hewan. *Jurnal Veteriner* 10:111-7. [Article in Indonesian].
- Sánchez M, Neira C, Laca A, Laca A, Díaz M, 2019. Survival and development of *Staphylococcus* in egg products. *LWT* 101:685-93.
- Thi HV, Nguyen ML, Thao Tran L, Ngo AD, Nguyen KH, Thi TMN, Chu DT, 2023. Food poisoning: a case study in Vietnam. *CSCEE* 7:100295.
- These MS, 2014. Observational and interventional study design types; an overview. *Biochemia Med* 24:199-210.
- Viator CL, Cates SC, Karns SA, Muth MK, Noyes G, 2016. Food safety practices in the egg products industry. *J Food Prot* 79:1210-5.
- Zeaki N, Johler S, Skandamis PN, Schelin J, 2019. The role of regulatory mechanisms and environmental parameters in staphylococcal food poisoning and resulting challenges to risk assessment. *Front Microbiol* 10:1307.

Online supplementary material:

Supplementary Table 1. Implementation of sanitation hygiene in laying chicken farms.

Supplementary Table 2. Implementation of sanitation hygiene at wholesalers of laying chickens.

Supplementary Table 3. Implementation of sanitation hygiene at retailer level.



**Table 1. Operational Definition of critical control points in layer farm, wholesome, and retailer.**

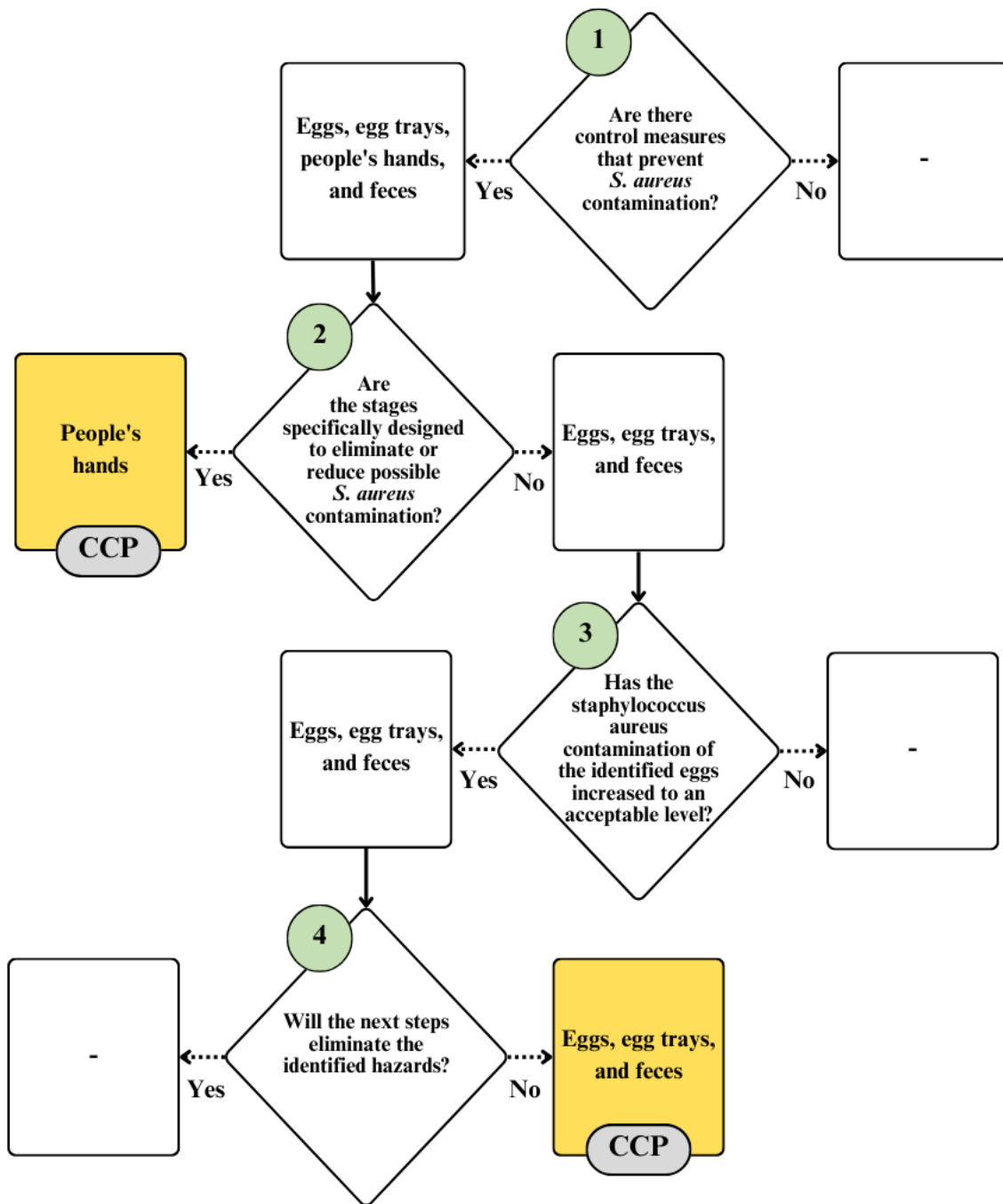
Variables	Operational definition	How to measure	Measurement scale	Category
Critical Control Point (X)	Point/stage/procedure in a food production system	Interviews by questionnaires; observation	Intervals	Yes = 1 No = 0
Laying chicken farming (Y1)	Farms that carry out laying hen cultivation activities to produce chicken eggs for consumption	Interviews by questionnaire; observation	Intervals	Yes = 1 No = 0
Wholesaler (Y2)	Traders who collect chicken eggs for consumption from distributors or breeders to distribute to retail traders	Interviews by questionnaires; observation	Intervals	Yes = 1 No = 0
Retailers (Y3)	Traders who collect consumption chicken eggs from agents/wholesalers to sell directly to consumers	Interviews by questionnaire; observation	Intervals	Yes = 1 No = 0

**Table 2. Staphylococcus aureus has limited critical tolerance values in layer farms, wholesalers, and retailers.**

No	Critical control point	Contamination limits	Reference
1	Fresh eggs	$<1 \times 10^2$ CFU/g	National Standardization Agency, 2000
2	People's Hands	$20 - \leq 10^4$ CFU/g	Health Protection Agency, 2009
3	Shelves Egg	$20 - \leq 10^4$ CFU/g	Health Protection Agency, 2009
4	Feces	$20 - \leq 10^4$ CFU/g	Health Protection Agency, 2009



**Figure 1. Retail research locations sourced from Sidrap (A), Bulukumba (B), and Gowa (C) Regencies**



**Figure 2. Determination of critical control points (CCP) based on the highest risk of contamination.**

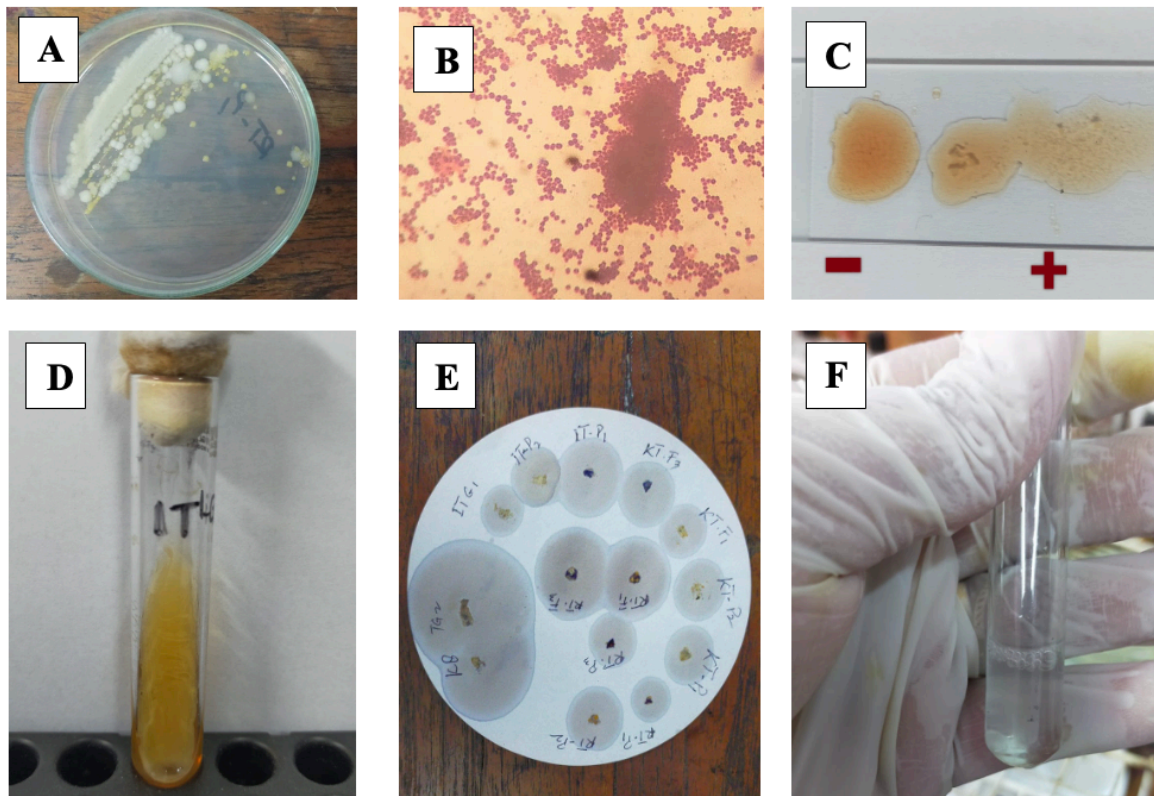


Figure 3. Positive results of testing for *Staphylococcus aureus* bacteria on nutrient agar media (A), gram staining (B), coagulase test (C), mannitol salt agar media (D), oxidase test (E), and catalase test (F).

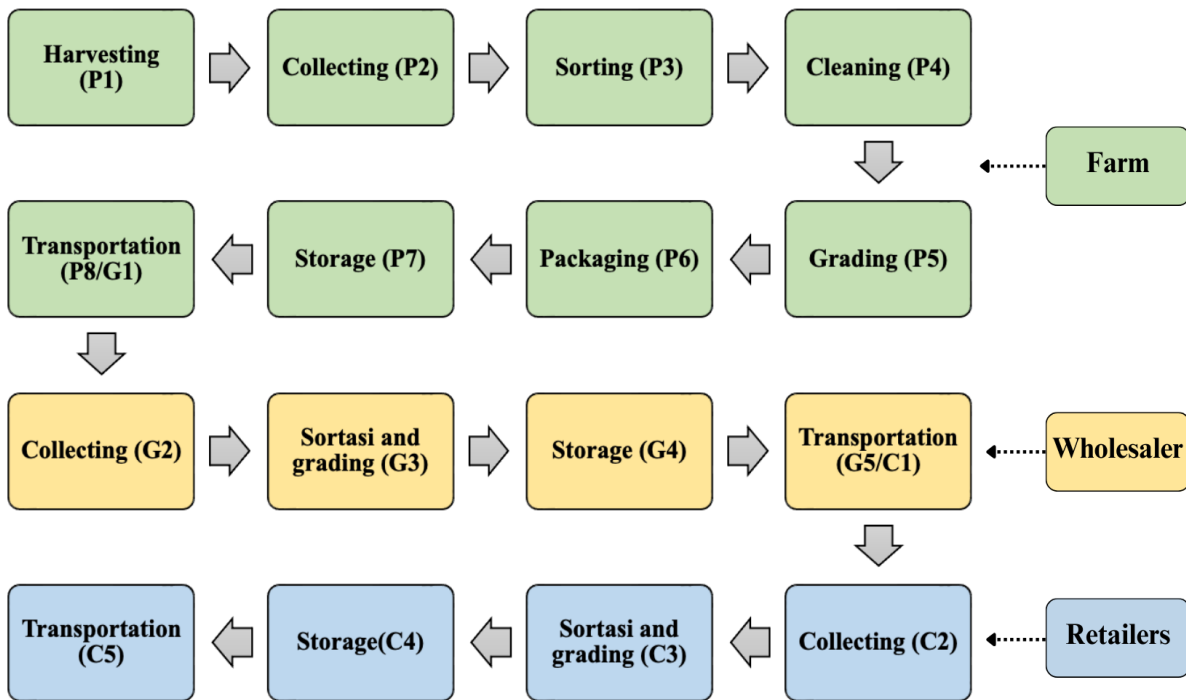


Figure 4. Stages of producing chicken eggs at layer farms, wholesalers, and retailers.