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Nutritional composition and thai consumer buying behavior of dead fertilized and incubated chicken eggs in the northeastern region of Thailand

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ABSTRACT

This study examined consumer purchasing behavior toward dead fertilized and incubated chicken eggs (balut) in the upper northeastern region of Thailand, alongside their nutritional composition. Two trials were conducted. In Trial 1, data were collected from 400 respondents through a structured questionnaire to assess factors influencing purchase decisions. Results indicated a stronger preference for dead fertilized egg over incubated eggs. Participants favored consuming the yolk and white separately in dead fertilized eggs, citing superior taste, texture, and overalleating experience. Trial 2 analyzed the nutrient profiles of different egg types. Whole boiled chicken eggs contained the highest moisture content ($P<0.05$), dead fertilized eggs showed the greatest fat levels ($P<0.05$), and incubated eggs exhibited the highest protein and vitamin A content ($P<0.05$). Overall, odor was identified as the primary factor influencing consumer choice, with dead fertilized eggs generally preferred. Nutritionally, dead fertilized eggs offer notable fatcontent, while incubated eggs provide high protein and vitamin A, highlighting their for value-added egg product develpoment.

Introduction

Unfertilized eggs and those containing dead embryos are significant factors influencing the success of incubation procedures in commercial hatcheries (Wang *et al*., 2024). Balut refers to fertilized duck eggs that are consumed alter a period of incubation but before hatching. As noted by food writer Doreen Fernandez, "The person who first discovered balut observed that food's quality (taste, texture) changes as it matures and changes" (Arthur, 2013). Although widely associated with Filipino cuisine, the practice of consuming fertilized duck eggs has been documented across several Asian countries (Baruth, 2022). This delicacy is widely enjoyed among numerous Asian diaspora communities, such as Vietnamese, Cambodians, Laotians, Thais, Malays, Indonesians, and Chinese groups (Jong and Clark, 2000; Claudio *et al*., 2021). Historical accounts suggest that the tradition originated in China as a method to prolong the shelf life of eggs before refrigeration technology was available (Arthur, 2013). In China, these—known as maodan, meaning "feathered" or hairy egg"— were named for the visible feathers oresent after cooking. Similar preparations can be found in other parts of Asia, including hot vit lon in Vietnam and phog tea khon in Cambodia, with the primary difference among these regional varieties being the length of incubation (Sanceda *et al*., 2007).

In the Philippines, balut is a famous delicacy made from duck eggs that are incubated for about 18 days, during which the embryo develops partially and is surrounded by a whitish membrane (Fernandez, 2002; Alejandria, *et al*., 2019). In local terms, this is known as balut sa puti, which translates to "wrapped in white (Alejandria, *et al*., 2019). In Vietnamese the preferred incubation period is a slightly longer—about 19 to 21 days—allowing the embryo to develop a firmer texture when cooked (Sanceda *et al*., 2007), while in Combodia, eggs are typically incubated for 18 to 20 days. This cuisine is popular across numerous countries in East and Southeast Asia, such as Laos and Thailand (Magat, 2002). Before eating, balut is boiled for 20–30 minutes, and the edible protions include the embryo, yolk, and amniotic fluid. Many consumers prefer live embryos, describing the flavor of the liquid ("soup") as sweeter and more appealing (Jong and Clark, 2000). Traditionally served hot, balut is enjoyed with condiments such as salt, vinegar, or chilu sauce. Commonly recommended preparation involves tapping the wider and of the egg, creating a small opening to sip the hot broth—likened to concentrated chicken soup—before peeling and eating the yolk, embryo, and, if desired, the albumen. The albumen, or hardened white, is sometimes discarded due to its tough, rubbery texture; however, some individuals chew it into smaller pieces before swallowing, while others consume it whole (Lisa, 2003). Depending on how long the embryo has been dead, eggs containing embryos that perished before cooking typically have a blander or slightly bitter flavor (Jong and Clark, 2000). Culture beliefs hold the balut consumption provides strength, rerves as an aphrodisiac for men, and offers nourishment and energy for women (Alejandria *et al*., 2019). In many cases, dinner reserve the chick embryo for the final bite. Notably, due to its dense and irregular texture, the hardened albumen has occasionally caused esophageal obstruction (Claudio *et al*., 2021). The preparation and consumption of incubated mallard duck (Anas platyrynchos) is a long-standing culinary in Asia, with previous research exmineing their composition, fatty acid profile, and nutritional indices (Bondoc *et al*., 2023a).

Eggs are an affordable and widely accessible source of high-quality protein essential for human health. Beyond the commonly consumed table eggs, certain cultural traditions—particularly in Thailand—also include the consumption of fertilized eggs, both with partially developed chick embryos and those that have not yet hatched. Although dead fertilized chicken eggs and incubated chicken eggs (balut) both originate from standard chicken eggs, variations in their developmental stages lead to distinct nutritional profiles and value. Given the regional interest in these products, gathering information on consumer preferences and purchasing behavior can help guide local resource management, enhance product value, and promote culinary heritage through the effective use of locally available ingredients.

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This study addressed the need for clearer information on the characteristics and nutritional composition of dead fertilized and incubated chicken eggs, providing insights into their respective benefits and considerations for consumption. Current literature on the nutrient content and consumer demand for these egg types in Thailand remains scarce. Accordingly, this research aimed to: (1) investigate Thai consumer purchasing behavior related to dead fertilized and incubated chicken eggs (balut) in the upper northeastern region of Thailand; and (2) analyze the nutrient composition of these two egg varieties.

Materials and methods

Ethics Statement

This study, conducted in 2024, focused on Thai consumers. The target population was residents of five villages known for high consumption of dead fertilized chicken eggs and incubated chicken eggs (balut). Yamane's (1973) formula was used to determine the sample size, which was based on the 144,700 residents of Nakhon Phanom Province:

$n = (N/1 + Ne^2)$

where e2 is the margin of error, n is the sample size, and N is the population size. Value substitution in the formula:

$n = 144{,}700 / (1 + 144{,}700 \times 0.05^2)$ yields a result of 398.86.

Accordingly, 400 respondents were included in the study.

Participants were randomly selected from Mueang District, Nakhon Phanom Province, in the upper northeastern region of Thailand. This province serves as a key border crossing to the Lao People's Democratic Republic. The five surveyed villages were Nong Saeng, Kham Thao, Ban Klang, Ban Naat, and Nai Mueang. Three sections made up the questionnaire: (1) demographic information; (2) consumer buying behavior regarding dead fertilized chicken eggs and incubated chicken eggs (balut); and (3) additional comments and suggestions. The research procedure conformed with the Kasetsart University Human Care and Use Committee's Guidelines for Experimental Human Research (permission number KUREC-CSC68-014).

Nutritional composition

Egg samples were collected from six retail outlets selling each egg type. The sampling included: 60 whole boiled chicken eggs (unfertilized), 60 whole boiled dead fertilized chicken eggs (fertilized but non-viable), and 60 whole boiled incubated chicken eggs (balut). Every sample was ground to fit through a 1 mm screen (Polymix® PX-MFC 90D, Kinematica, Switzerland) after being dried in a hot air oven. Chemical analyses for moisture, protein, and fat content followed AOAC (2012) procedures. Vitamin A and vitamin D contents were determined using high-performance liquid chromatography (Horwitz and Latimer, 2005).

Data Analysis

Statistical software was used to process the 400 questionnaire responses. Data on customer behavior was compared using one-way analysis of variance (ANOVA), together with descriptive statistics (percentages) and inferential statistics. A completely randomized design was used to evaluate nutritional composition data using the GLM algorithm in the SAS software program (version 9.0; SAS Institute Inc., Cary, NC, USA). The threshold for statistical significance was set at $P<0.05$.

Results

Respondent information

Among respondents for dead fertilized chicken eggs, most households had 4–5 members (38.89%) and the majority were female (42.70%). Buddhism was the predominant religion (77.39%), with the largest age group being over 47 years (30.68%), and 20.25% having attained a bachelor's degree. For incubated chicken egg respondents, 4–5 member households accounted for 26.45%, most were female (29.04%), Buddhism was the main religion (53.63%), those over 47 years comprised the largest age group (20.86%), and 13.77% held a bachelor's degree (Table 1).

Table 1. Respondent information by number of household members, gender, religion, age, and educational level.

Parameter	Dead fertilized chicken eggs respondents (%)	Incubated chicken eggs respondents (%)
Number of household members		
1–3	33.37	24.24
4–5	38.89	26.45
6–7	3.2	2.46
>7	0.19	0.13
Gender		
Male	35.65	24.24
Female	42.7	29.04
Religion		
Buddhism	77.39	52.63
Christianity	0.96	0.65
Age (years)		
<18	3.05	2.07
18–23	6.1	4.15
24–29	7.25	4.93
30–35	11.44	7.78
36–41	10.11	6.87
42–47	9.72	6.61
48–53	12.77	8.68
54–60	10.11	6.87
>60	7.8	5.31
Educational level		
Primary education	15.48	10.53
Junior high school	15.1	10.27
High school/Vocational certificate	17.39	11.83
Vocational certificate/ associate degree	10.13	6.89
Bachelor's degree	20.25	13.77

Regarding occupation, most dead fertilized egg consumers were farmers (13.73%), with 75.11% reporting no secondary occupation. Their primary monthly income was below THB 5,000 (21.73%). For incubated egg consumers, farming was also the main occupation (9.33%), with 51.07% having no secondary occupation, and 14.78% earning under THB 5,000 per month (Table 2). Differences in household size, religion, and monthly income were found to influence consumption patterns for both egg types (Table 3).

Thai consumer buying behavior

As shown in Table 4, purchases of dead fertilized and incubated chicken eggs were primarily for personal and family consumption (51.24% and 37.99%, respectively). For dead fertilized eggs, most respondents (76.70%) consumed yolk and albumen separately, while 23.30% mixed them. Selection criteria for incubated eggs included visible blood vessels, albumen, and yolk (71.23%), visible feathers (16.59%), albumen drawn into the abdominal cavity with only yolk visible (8.63%), and visible chick embryo (3.55%).

Table 2. Respondent information by primary occupation, secondary occupation, and average monthly income.

Parameter	Dead fertilized chicken eggs respondents (%)	Incubated chicken eggs respondents (%)
Primary occupation		
Student	4.96	3.37
Hired worker	10.68	7.26
Farmer	13.73	9.33
Owner of business/trading company	13.53	9.2
Private company employee	8.77	5.96
Butler/Housekeeper	8.96	6.1
Government service	9.34	6.35
State enterprise employee	3.82	2.59
Student	4.19	2.85
Monk	0.2	0.13
Unemployed	0.18	0.12
Secondary occupation		
Have an additional career	3.24	2.21
No extra career	75.11	51.07
Average monthly income		
<5,000 THB	21.73	14.78
5,001–9,000 THB	8.93	5.71
9,001–13,000 THB	15.82	8.91
13,001–17,000 THB	13.15	8.95
17,001–21,000 THB	12.58	8.56
21,001–25,000 THB	19.04	1.29
>25,000 THB	4.76	3.23

Weekly purchases were more common for dead fertilized eggs (44.41%) than for incubated eggs (30.59%). Most respondents bought 3–4 eggs per purchase (52.85% for dead fertilized; 38.81% for incubated). The most common price per egg was THB 6 for dead fertilized (47.33%) and THB 8 for incubated (48.84%). Dead fertilized eggs were mainly bought at fresh markets (51.55%), while incubated eggs were most often purchased at flea markets (68.95%). Many consumers did not know the source of the eggs (59.49% for dead fertilized; 71.69% for incubated). Religious or faith-healing beliefs had little influence (98.11% and 100.00% unaffected, respectively). Nutritional beliefs influenced 10.24% of dead fertilized egg consumers but none of the incubated egg consumers.

Taste was the primary factor driving satisfaction (51.87% for dead fertilized; 34.34% for incubated). Dead fertilized eggs were most often purchased monthly (43.17%), while incubated egg purchases peaked in April and June (37.90%). Overall, 78.35% consumed dead fertilized eggs, while 21.65% did not. For incubated eggs, 53.28% were satisfied with their purchase, compared to 46.72% who were dissatisfied (Table 4).

Consumer opinion and nutrional composition

Most respondents preferred dead fertilized eggs due to the stronger smell and taste of incubated eggs, which some found unpleasant. Visible signs of embryo development, such as feather growth, reduced appeal, as did concerns about appearance, cleanliness, and perceived safety.

As shown in Table 5, whole boiled chicken eggs had the highest moisture content ($P<0.05$), while whole boiled incubated chicken eggs had the highest protein levels ($P<0.05$). Whole boiled dead fertilized chicken eggs contained the most fat ($P<0.05$). Vitamin A content was higher in incubated eggs than in chicken eggs ($P<0.05$). Vitamin D was not detected in any sample.

Discussion

The respondent profile showed that most consumers lived in households with 4–5 members, were female, practiced Buddhism, and were over 47 years of age, with a bachelor's degree being the most common education level (Table 1). Farming was the primary occupation, and most did not engage in secondary work, with a monthly income below THB 5,000 (Table 2). Differences in household size, religion, and income were positively associated with consumption patterns for both dead fertilized and incubated chicken eggs (Table 3). These findings align with Sukhawatthanakun (2022), who noted that the upper northeastern region of Thailand is largely agricultural, with rice farming concentrated in the rainy season (July–December). This seasonal production means many farmers have little to no income between August and December while waiting for harvest. In the present study, the low average income among respondents may have influenced their preference for affordable protein sources such as dead fertilized and incubated chicken eggs.

An excellent source of animal protein, eggs provide vital nutrients and are simple to prepare. (Chang *et al*., 2018). Consumption patterns vary by country (Chen *et al*., 2023). In this study, dead fertilized chicken eggs were most often purchased from fresh markets (51.55%), whereas incubated chicken eggs were mainly bought at flea markets (68.95%) (Table 4). This contrasts with China, where shell eggs are predominantly purchased in supermarkets (58.77%), and the United States, where grocery stores are the main source (89.50%) (Kosa *et al*., 2015). Balut is frequently sold by street vendors in the Philippines, especially during the evenings. (Fernandez, 2002), and is often consumed as a snack alongside alcoholic beverages (Alejandria *et al*., 2019). Vergara *et al*. (2020) emphasized that economic, nutritional, and cultural factors shape the consumption of such street foods, which may explain the diversity of purchase locations in Thailand.

In terms of preparation preferences, 76.70% of respondents consumed dead fertilized chicken eggs without mixing the yolk and albumen, while 71.23% selected incubated chicken eggs with visible blood vessels, albumen, and yolk, corresponding to around 7 days of incubation (Table 4). Only 8.63% consumed eggs incubated for 16–18 days, a figure similar to that in the Philippines (Alejandria *et al*., 2019). Unlike in the Philippines, where such eggs are sometimes valued for their aphrodisiac qualities in men and as an energy source for women, Thai respondents reported no influence from faith-healing beliefs on their purchases.

Taste was the leading reason for buying both egg types, influencing 51.87% of dead fertilized egg buyers and 34.34% of incubated egg buyers (Table 4). Approximately one-quarter more respondents preferred dead fertilized eggs over incubated eggs, with the former being purchased throughout the year and the latter mainly between April and June. Factors such as consistent supply and odor perception should be considered when promoting each product type.

Nutrient analysis revealed significant differences among the egg types (Table 5). Whole boiled chicken eggs had the highest moisture

Table 3. The test results of different personal factors resulted in different preferences on the consumption needs associated with dead fertilized chicken eggs and incubated chicken eggs.

Parameter	Number of household members	Gender	Religion	Age	Educational level	Primary occupation	Secondary occupation	Average monthly income
Dead fertilized chicken eggs	0.007*	0.95	0.018*	0.41	0.13	0.13	0.00	0.001*
Incubated chicken eggs	0.005*	0.74	0.013*	0.42	0.21	0.22	0.00	0.001*

*Different superscripts on the same row differences in each treatment ($P<0.05$)

Table 4. Respondent information regarding expected consumer, patterns in purchasing, number of eggs purchased each time, price, place, source of purchase, reason for consumption, month of choice, and not consuming.

Parameter	Dead fertilized chicken egg (%)	Incubated chicken egg (%)
Who did you buy for		
Yourself	28.57	36.53
Your family members	11.18	16.44
You and your family members	51.24	37.99
Someone else	9.01	9.04
Patterns in purchasing		
Yolk and albumen not mixed	32	0
Yolk and albumen mixed	23.3	0
Both yolk and albumen	44.7	0
Visible blood vessels, albumen, and yolk (7 days)	0	71.23
Visible feathers, albumen, and yolk (8-15 days)	0	16.59
Egg white sucked into the abdominal cavity and only yolk visible (16-18 days)	0	8.63
Yolk sucked into abdominal cavity and visible chick embryo (19-21 days)	0	3.55
Consume egg in one period		
Daily	7.14	2.28
Once a week	44.41	30.59
Once every 2 weeks	19.88	13.7
Every 2 weeks	8.7	14.61
Every 3 weeks	5.23	6.85
Every month	7.45	16.44
2+ months	7.19	15.53
Number of eggs purchased each time		
1–2 egg	17.39	28.77
3–4 egg	52.85	38.81
5–6 egg	19.57	21.92
>7 egg	10.19	10.5
Price		
3 THB per egg	2.8	1.37
5 THB per egg	41.12	14.16
6 THB per egg	47.33	0
7 THB per egg	5.59	5.94
8 THB per egg	3.16	48.84
10 THB per egg	0	23.74
15 THB per egg	0	3.65
20 THB per egg	0	2.3
Place of purchase		
Fresh market	51.55	14.16
Flea market	41.3	68.95
Online market	6.21	16.89
Other	0.94	0
Source of dead fertilized chicken eggs		
Received from within the province	16.29	28.31
Received from other provinces	23.29	0
Source unknown	59.49	71.69
Processed at home from incubated chicken egg	0.93	0
Belief in consumption		
Have faith	1.89	0
No faith	98.11	100
Belief in nutrient		
Have faith	10.24	0
No faith	89.76	100
Reason for consumption		
Taste	51.87	34.34
Smell	13.67	7.56
Nutritional value	15.54	13.39
Novelty	11.24	23.33
Tricky	7.3	20.52
Other	0.38	0.86
Month of choice		
Buy every month	43.17	26.94
January-March	12.73	15.98
April-June	28.57	37.9
July-September	9.63	10.5
October-December	5.9	8.68
Egg consumption		
Consume eggs	78.35	53.28
Do not consume eggs	21.65	46.72

content, consistent with Farron-Wilson (2012) and Tanjor *et al.* (2015), who reported 75.40% and 76.60% moisture, respectively. Boiling generally reduces nutrient levels compared to raw eggs (Roe *et al.*, 2012). The current findings match Tanjor *et al.* (2015), who recorded 76.60% moisture, 13.00% protein, and 8.60% fat in boiled chicken eggs, as well as Réhault-Godbert *et al.* (2019), who found 76.10% water, 12.60% protein, and 9.50% fat in raw eggs. Frances *et al.* (2023) reported 25.80% moisture, 21.52% protein, and 5.70% fat in whole boiled chicken eggs. Lower moisture content, as observed in dead fertilized and incubated eggs, can limit microbial growth and extend shelf life (Fillion and Henry, 2018).

Among the three types, dead fertilized eggs had the lowest protein but the highest fat content, whereas incubated eggs were richer in protein and vitamin A. The high fat content of balut yolks, which includes important fatty acids like oleic, palmitic, and linoleic acids, is in line with

Table 5. Nutrient composition of whole boiled chicken eggs, whole boiled dead fertilized chicken eggs, and whole boiled incubated chicken eggs.

Parameter	Whole boiled chicken egg	Whole boiled dead fertilized chicken egg	Whole boiled incubated chicken egg	P-value
Moisture, %	76.71±2.00^{a}	66.49±2.06^{b}	68.48±2.03^{b}	0.01
Protein, %	51.02±1.05^{ab}	46.74±0.09^{b}	51.87±0.12^{a}	0.03
Fat, %	33.97±0.25^{b}	41.12±0.58^{a}	35.17±0.58^{b}	0.01
Vitamin A, µg/100 g	65.63±0.71^{b}	51.57±0.23^{b}	159.68±1.02^{a}	0.03
Vitamin D, µg/100 g	ND	ND	ND	-

$^{a-b}$ Different superscripts on the same row differences in each treatment (P<0.05); ND=Not detected

Bondoc *et al*. (2023a). Eggs from a variety of chicken species continue to be a staple food around the world (Bondoc *et al*., 2023b). In this study, vitamin A content in whole boiled incubated chicken eggs exceeded that of both chicken and dead fertilized eggs, a finding consistent with Tanjor *et al*. (2015). The reason for this elevated vitamin A remains unclear. Boiling was associated with an overall reduction in vitamin A content compared to raw eggs (Roe *et al*., 2012). Vitamin D was not detected in any samples.

Given the availability of dead fertilized and incubated chicken eggs in laying hen production, these products represent a potential local food resource. Promoting their consumption could support local food culture, generate marketing opportunities, and increase product value, particularly in Nakhon Phanom Province. Additionally, the nutritional profile of these eggs may vary depending on the embryo's developmental stage, an aspect that warrants further study.

Conclusion

According to the study, consumers preferred deceased fertilized chicken eggs over incubated ones, with appearance and odor serving as the primary disincentives for the latter. Dead fertilized eggs were most often consumed with the yolk and albumen kept separate. Commercial eggs are less expensive than meat, they are a viable protein choice for people of all income levels, particularly in recessionary times. The new generation is increasingly concerned about their health, which has led to the increasing popularity of eggs, a high-quality protein source. Nutritional analysis revealed that whole boiled chicken eggs had the highest moisture content, dead fertilized eggs contained the most fat, and incubated eggs provided the greatest protein and vitamin A levels.

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Conflict of interest

The authors have no conflict of interest to declare.

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