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Research Article

Assessment of the public awareness on radionuclides and radiological health risks associated with the consumption of free-range chicken in Bahi district, Tanzania

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Abstract

In rural communities, free-range chickens are vital for food and income, however, they risk contamination from radioactive elements in polluted feed, water, and soil, which can taint chicken meat and eggs. This study was conducted to assess the level of public awareness of radiological health risks associated with the consumption of free-range chicken in the Bahi district. A standardized questionnaire was administered to 341 inhabitants of four villages and analyzed statistically using SPSS version 27. Approximately 44.3% of respondents were aware of radionuclide contamination in free-range chicken, and 67.1% recognized cancer as a health risk. Awareness of other health impacts, such as birth defects (3.2%) and organ damage (9.7%), was low. Approximately 57.5% of the respondents identified soil as the primary source of radioactive contamination in the area. There was a startlingly low level of knowledge regarding testing facilities and local authority interventions (10.3% and 2.4%, respectively). Consumption frequency and awareness levels were significantly correlated ($p < 0.05$), with daily consumers demonstrating higher awareness and willingness to pay for certified products than non-daily consumers. The study concludes that while awareness of contamination risk exists, institutional support and practical understanding are lacking in the field. This study recommends targeted food safety education, testing initiatives, and radiological risk outreach.

Keywords: Bioaccumulation, Food security, Households, One health, Vulnerable.

Introduction

Free-range chickens are one of the most common sources of food and income in rural societies in Tanzania, particularly in the Bahi District of Dodoma Region (Marwa et al., 2018). Free-range chickens are usually kept under traditional management systems (scavenging) and depend on natural foods such as insects, grasses, kitchen leftovers, and occasional supplementary feeds (Mramba et al., 2025). Despite free-range chickens supporting food security and being a source of income for households, this rearing practice also leaves them vulnerable to environmental contaminants, including exposure to disease outbreaks and naturally occurring radionuclides, resulting from inadequate biosecurity measures (Gemeda et al., 2026).

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The most important radionuclides are uranium-238 (^{238}U), thorium-232 (^{232}Th), and potassium-40 (^{40}K), which are present in the earth's crust at variable concentrations and are naturally present in soil, water, and food (Joel et al., 2021). All of these radionuclides can enter the food chain and become part of a free-range chicken diet. Radionuclide bioaccumulation in chickens, especially in the liver and muscles, may pose radiological risks to local populations. Continuous consumption of chicken meat containing radionuclides may increase the possibility of internal radiation exposure, which can lead to cancer and other related radiological health risks (Hoque et al., 2023). Radionuclide bioaccumulation in foods is highly variable and influenced by the nature of environmental formations of a particular area (Ugbede et al., 2021)

A past study conducted in the Bahi district by Marwa et al. (2014) showed high levels of uranium contamination in various foodstuffs and groundwater; the uranium content in water was as high as 1233 µg/L, against the World Health Organization standard of 30 µg/L. The detected uranium concentration in soda ash was 1910 µg/kg, which is an extremely high and alarming value given its local consumption and export, as well as in finger millet grains (32 µg/kg), catfish (17.98 µg/kg), and flamingo meat (31.78 µg/kg). These values are much higher than the internationally accepted natural background level of 14 µg/kg of uranium in common foodstuffs (Alexander et al., 2009). The contamination in water is more than 41 times the permissible limit; therefore, it requires immediate intervention to prevent long-term health impacts.

A similar study conducted to determine the activity concentrations of naturally occurring radionuclides in the chicken reared and consumed in Osun State, Nigeria revealed that the concentration levels of Th-232 and Ra-226 exceeded the standard limits set by the international organization, while K-40 and annual effective dose from chicken consumers were below the Food and Agriculture Organization dose limits (Amodu et al., 2018). This information will be useful in comparing the situation in Bahi District to determine whether local conditions also enhance risks to merit regulatory or environmental interventions. Another study from Nigeria showed that activity concentrations of ^{232}Th and ^{226}Ra in chicken meat may exceed recommended limits, posing potential health risks to consumers (Kolapo & Afees, 2021).

Most existing studies have focused on evaluating the activity levels of natural radionuclides in various food products and estimating radiological doses; however, there remains a notable gap in the literature regarding the level of public awareness of radiological hazards. Public perception, knowledge, and awareness of radiological risks resulting from natural radionuclide contamination play important roles in changing consumer mindsets, dietary selections, and adherence to risk mitigation strategies. Risk communication in food safety is essential for community engagement to make informed decisions to improve transparency and trust in food safety regulations in vulnerable regions (Onyeaka, 2025). Well-informed communities can participate in regulatory and public health intervention programs, whereas low awareness may result in unintentional exposure.

Therefore, this study aimed to assess the level of public awareness of radionuclides and the radiological health risks associated with the consumption of free-range chickens raised in the Bahi district. By identifying knowledge gaps and evaluating awareness levels, this study aims to inform targeted food safety education and risk communication strategies, ultimately supporting improved health outcomes and regulatory interventions.

Materials and Methods

Study area

The data for this study were obtained from the Bahi District, located in the Dodoma Region, Tanzania, with approximate coordinates of 5.8500° S latitude and 35.3167° E longitude. According to the 2022 census, the population of the Bahi district grew to 322,526. The study involved four villages: Ibihwa, Sokoni, Makulu, and Nagulo (**Fig. 1**). These villages were selected based on various ecological and anthropogenic characteristics, proximity to uranium-rich deposits (Kimaro & Mohammed, 2015), and previous records of contamination and human activities, such as livestock keeping and

agricultural practices. This aligns with the study objectives, as free-range chicken rearing and consumption are dominant in these areas. High levels of radionuclide contamination have also been reported in these areas in previous studies (Marwa et al., 2014). By selecting villages with different potential levels of exposure to naturally occurring radionuclides, this study captured a range of contamination scenarios, enabling findings that can be generalized to similar regions.

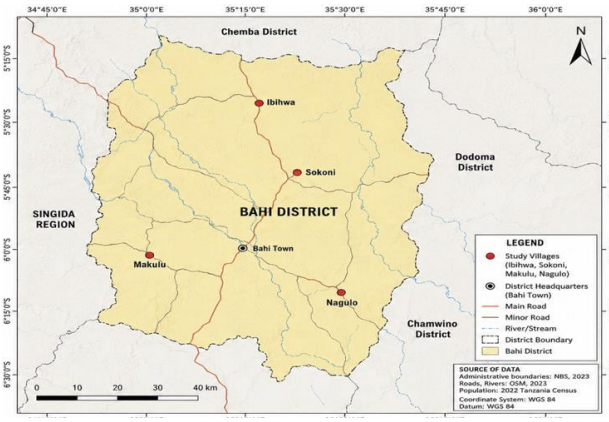

Figure 1. A geographical map showing the study area in the Bahi district.

Research design

Descriptive and inferential statistical techniques were used in this study. In the Bahi District, 341 randomly chosen residents from four villages were given a standardized questionnaire (Al-makhroumi et al., 2022). The variables included demographic characteristics, free-range chicken consumption patterns, awareness of radionuclide risks, and perceptions of food safety. Descriptive statistics were used to summarize frequencies and percentages, while chi-square tests were used to determine the association between chicken consumption frequency and awareness levels.

Data analysis

The collected data were entered into Microsoft Excel and subsequently imported into SPSS version 27 (IBM Corporation, Armonk, USA) for descriptive and inferential statistical analyses to characterize the levels of radioactive contamination and associated risks (Mishra et al., 2019). Descriptive analysis, such as percentages, graphs, charts, and frequency distribution, was used to determine the distribution of respondents. Inferential analysis (chi-square) was used to determine the association between the consumption of free-range chicken and radiological health effects. The association was considered significant at $p < 0.05$.

Ethical considerations

A research permit was requested from the Vice Chancellor of Sokoine University of Agriculture (SUA), and the research was subsequently approved by the Directorate of Postgraduate Studies, Research, Technology Transfer, and Consultancy (DPRTC) of SUA (SUA/DPRTC/MFQ/D/2023/0004/05). A research permit was obtained from the Executive Directors of the Bahi District Councils (IRDP/MPPME/23/0035). Prior to each interview, verbal informed consent was obtained from each participant following a thorough explanation of the study's purpose and significance. Participation in this study was voluntary. All data collected in this study were handled with utmost confidentiality and in full adherence to established research ethical standards.

Results and Discussion

Demographic characteristics of the respondents

Table 1 shows that the respondents were well-distributed among the four villages, with Sokoni accounting for 30.5% of the total number of respondents, slightly above the lowest percentage of 21.1% represented by Nagulo. About 53.7% of the respondents were aged between 31 and 45 years, 61.3% were female, and 69.2% had attended primary school. The main occupations were farming (49.6%) and livestock keeping (44.3%), while half of the respondents had lived in Bahi for more than 20 years (50.4%). These demographics represent a well-established agricultural community, characteristic of rural settings in Tanzania, where free-range poultry production is practiced (Marwa et al., 2018).

Free-range chicken consumption patterns

The free-range chicken consumption patterns observed in this study are shown in **Table 2**. Free-range chicken consumption was related to almost all

respondents (98.5%) as compared to commercially reared chicken, and reasons given included taste (73%) and its availability (22.6 %).

Table 1. Distribution of respondents based on the demographic information

Variables	Categories	Frequency	Percent
Villages	Sokoni	104	30.50
	Makulu	87	25.50
	Nagulo	72	21.10
	Ibihwa	78	22.90
Age	Less than 18	1	0.30
	18-30	59	17.30
	31-45	183	53.70
	46-60	83	24.30
	60 and above	15	4.40
	Total	341	100.00
Gender	Male	132	38.70
	Female	209	61.30
	Total	341	100.00
Education level	No formal education	3	0.90
	Primary education	236	69.20
	Secondary education	94	27.60
	College/University	8	2.30
	Total	341	100.00
Major occupation	Farmer	169	49.60
	Livestock keeper	151	44.30
	Others	21	6.20
	Total	341	100.00
Years of experiences	Less than 5 years	8	2.40
	5-20 years	161	47.20
	More than 20 years	172	50.40
	Total	341	100.00
Household size	1-5	258	75.70
	6-9	82	24.00
	Above 9	1	0.30
	Total	341	100.00
Income sources	Farming	199	58.40
	Livestock keeping	124	36.40
	Formal employment	3	0.90
	Others	15	4.40
	Total	341	100.00
Type of current residence	Own	332	97.40
	Rent	9	2.70
	Total	341	100.00

The distinctive taste of free-range chicken can be attributed to dietary diversity, fat composition, higher myoglobin content, age at slaughter, and slower growth rates (Vlad et al., 2025), which are closely associated with traditional rearing systems, natural feeding practices, and minimal chemical inputs, contributing to the firmer texture and enhanced sensory qualities preferred by consumers (Pîrlea et al., 2025). Similarly, Ndenga et al. (2017) reported that indigenous chicken production systems in Kenya support these superior taste characteristics and consumer preferences. Nonetheless, although free-range chicken is highly preferred, may pose radiological health impacts to consumers when they scavenge in contaminated environment. Therefore, assessing radionuclide concentrations in free-range chicken is essential for public health protection. As free-range chickens have the natural characteristic of foraging in contaminated soil and water, internal radiation doses caused by such poultry may play a substantial role in cases of low situational awareness (Joel et al., 2021; Geletu et al., 2021).

Table 2. Free-range chicken consumption patterns

Variables	Categories	Frequency	Percent
prefer free-range chicken for commercial	Yes	336	98.50
	No	5	1.50
	Total	341	100.00
Reasons for free-range chicken preference	Taste	249	73.00
	Cost	14	4.10
	Availability	77	22.60
	Others	1	0.30
	Total	341	100.00

Table 3. Free-range chickens were produced, and the amount used for consumption was determined

Variables	Categories	Frequency	Percent
Free-range chickens raised by the respondent	Yes	333	97.70
	No	8	2.30
	Total	341	100.00
Number of free-range chickens reared	Less than 10	24	7.00
	10-20	141	41.30
	More than 20	176	51.60
	Total	341	100.00
Amount of free-range chicken consumed in a week	Less than 1kg	229	67.20
	1-2kg	111	32.60
	More than 2kg	1	0.30
	Total	341	100.00

Free-range chicken farms and consumption

Table 3 shows that a large number (97.7%) of respondents kept free-range chickens, and more than half (51.6%) reared over 20 chickens. Compared to the rest of the households, a smaller proportion of the respondents consumed less than 1 kg of chicken meat per week (67.2%), possibly due to economic reasons or larger families. The amount of meat consumed was almost 0.25 kg/week, which does not seem significant; however, due to limited doses, the long-term consumption of contaminated meat can be considered dangerous to health in the long term (UNSCEAR, 2020). The high prevalence of

backyard poultry farming also indicates a close association between the environment, poultry, and human intake, supporting the observation that environmental health surveillance is a principal aspect in the Bahi district. There are no mines in this area, but natural geological formations are rich in radioactive minerals.

Table 4. Free-range chicken organs were consumed by the respondents

Variables	Categories	Frequency	Percent
Do you consume organs or bones	Yes	334	97.90
	No	7	2.10
	Total	341	100.00
Parts consumed by respondent	Liver	206	60.45
	Gizzards	134	39.25
	Others	1	0.30
	Total	341	100.00
Do free-range chickens have nutritional value?	Yes	261	76.50
	No	9	2.60
	Not sure	71	20.80
	Total	341	100.00

Table 5. Respondents' knowledge and awareness of radioactivity

Knowledge and awareness of radioactivity	Frequency	Percent
Media is a source of information of natural radioactivity in food	70	20.50
Internet is a source of information of natural radioactivity in food	7	2.10
Friends/Relatives is a source of information of natural radioactivity in food	6	1.80
Awareness of free-range chickens could be contaminated with radionuclides	151	44.30
Health hazards are associated with the consumption of radionuclides contaminated food	207	60.70
Cancer may be caused by radionuclide exposures	228	67.10
Organ damage may be caused by radionuclide exposure	33	9.70
Birth defects may be caused by radionuclide exposure	11	3.20
Awareness of local authorities about of radionuclides	35	10.30
Knows signs or symptoms related to radionuclide exposure	15	4.40
Laboratories enough used to test radionuclides in the region	8	2.40
Health professional for food contamination risks ever	14	4.10
Children and pregnant women are at a greater risk from contaminated food	241	70.70
Free-range chickens are safe to eat without testing	176	51.60
Food safety education should be included in schools.	332	97.40
Local communities need to be more involved with ensuring the safety of food	328	96.20

Preferences of free- range chicken parts

Table 4 shows that 99.9% of respondents consumed chicken organs or bones, particularly liver (60.45%), while 39.25% reported consuming gizzards. According to data from the Nigeria General Household Survey Panel (2018–2019), there is a high consumption of poultry parts at the household level (Olutegbe et al., 2026). Furthermore, United Nations Scientific Committee on the Effects of Atomic Radiation reported that radionuclide residues in poultry raised in contaminated environments may exceed the recommended safety

limits of 50 Bq/kg for ^{226}Ra, 30 Bq/kg for ^{232}Th, and 400 Bq/kg for ^{40}K in internal organs (UNSCEAR, 2020). Therefore, even though liver consumption is minimal, other organ meats should also be monitored due to their potential health risks (Hoque et al., 2023).

Sources of radionuclide contamination in free-range chickens

The source of free-range chicken radionuclide contamination in the Bahi District is shown in **Figure 2**. Most respondents (57.5%) believed that soil was the main source of contamination. The next most common was feed (37.0%), followed by water (5.3%). This result shows that the community is highly aware of environmental exposure. People especially view scavenging of contaminated soil as a major risk for radionuclide intake. A factor in radionuclide intake. This is in line with scientific data that naturally occurring radionuclides, such as Uranium-238 and Thorium-232, are predominantly soil-based and settle in the food chain through ingestion during foraging (Joel et al., 2021). This apparent underrating of water and feed could imply poor knowledge of the indirect routes of exposure. The cues demonstrated raise a certain degree of incomplete but encouraging environmental knowledge in favor of the idea of implementing specific education to develop a more comprehensive concept of contaminant transmission channels and the importance of preventative actions.

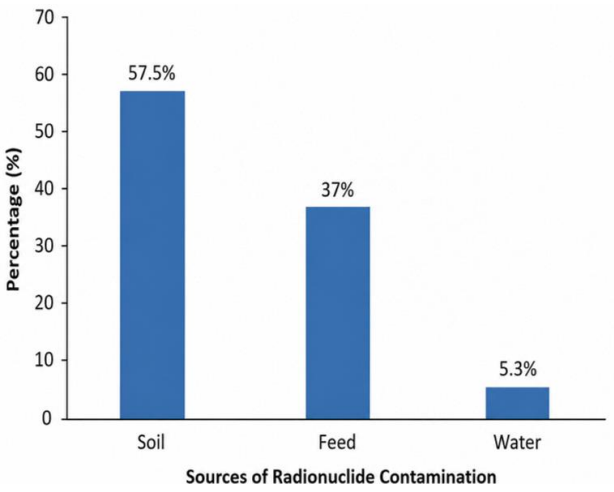

Figure 2. Sources of radionuclide contamination in free-range chickens.

Knowledge and awareness of radioactivity

Awareness and knowledge of respondents on radioactivity

Table 5 indicates a generally low level of public awareness of radioactivity and its associated health risks. For instance, although 44.3% of respondents acknowledged that free-range chickens could accumulate radionuclides, only 10.3% were aware of the efforts made by the local government. Although 67.1% of the respondents were aware of cancer as a possible health effect, there was little awareness of organ damage (9.7%) and birth defects (3.2%). This correlates with the results obtained by Auwal et al. (2025), who emphasized that knowledge of radiological hazards is low in rural African settings. Furthermore, very few respondents (2.4%) believed that there were e sufficient laboratories to conduct tests, indicating a lack of adequate food analysis facilities in rural communities. This feature links with those established by Mundigl et al. (2021) regarding public knowledge in reducing unintentional radiological exposure in the local community.

Assessment of respondents' food safety awareness

As shown in **Figure 3**, food safety awareness in the Bahi District is generally low. Specifically, 60.1% of respondents reported low awareness, 38.1% moderate awareness, and only 1.8% high awareness levels. This distribution raises public health concerns regarding community engagement with food safety issues, particularly in areas facing environmental hazards such as naturally occurring radionuclides (Kimaro & Mohammed, 2015). The predominance of low awareness (60.1%) suggests limited access to credible food safety information, ineffective institutional communication, and insufficient outreach programs, findings consistent with the low levels of awareness regarding radionuclide testing and educational initiatives reported in preceding figures. Lower socioeconomic groups in low-income countries often face constrained access to media, limited food safety information, low literacy levels and underdeveloped healthcare systems. Furthermore, it can be suggested that the low percentage of respondents who define their awareness of food safety as high may signify not simply a lack of information but also a lack of trust in local initiatives or organizations, as observed in rural

Bangladesh (Hoque et al., 2023). This evidence substantiates the necessity of community-focused education campaigns, easy testing services, and the incorporation of food safety education into local health and agricultural extension to create a stronger, more educated country in response to risks in the Bahi District.

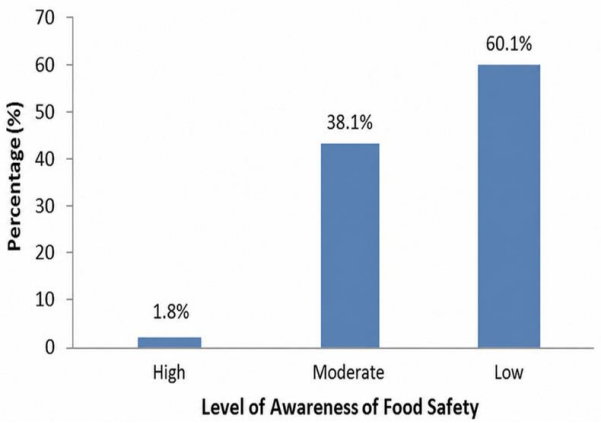

Figure 3. The level of respondents' awareness of food safety.

Relationship between educational attainment and knowledge of radionuclide risks and food safety

Figure 4 shows the relationship between educational attainment and knowledge of radionuclide risks and food safety. These findings indicate that the level of primary education was 69.2%, followed by secondary education at 27.6%. A few respondents attained college/university education (2.3%), whereas respondents with no formal education were approximately 0.9%. Educational level is a determinant of knowledge of food safety, radionuclide risks, and related subjects. Respondents who have attained secondary or university education are more likely to possess greater knowledge because they are typically exposed to formal science subjects and communication skills training. This exposure enables them to access a wider range of information sources, such as the Internet, books, and media. Despite being the largest group, respondents with primary education may have moderate knowledge drawn from personal experience, an understanding of natural contamination sources, and fundamental skills learned in primary education. Respondents with no formal education are more likely to depend on informal education and traditional beliefs (Pereira & Ortiz, 2022).This group has limited access to written documents and, as a result, is expected to have the lowest level of knowledge.

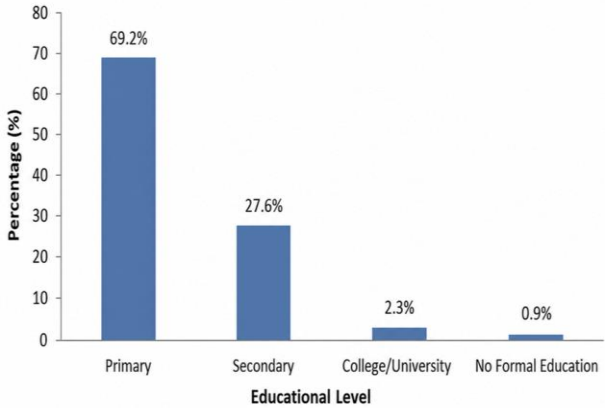

Figure 4. Educational attainments of respondents.

Association between free-range chicken consumption frequency and awareness of radiological health risks

Significant associations were observed between the frequency of free-range chicken consumption and awareness of radiological health risks (**Table 6**). Respondents who consumed free-range chicken daily demonstrated relatively higher awareness of community radionuclide education programs (25.0%) than occasional consumers (1.8%), and the association was statistically significant (χ^2 = 18.881, p = 0.001). These results confirm that respondents who were frequent users were more likely to have food safety information and increased concerns about the potential health risks of radiation. However, stronger perceptions that radionuclides may contribute to poultry mortality were observed among weekly (86.0%) and daily (75.0 %) users compared to occasional users (71.2%) (χ^2 = 9.068, *p* = 0.028), indicating increased awareness and higher frequency of use. However, knowledge of the natural sources of radioactivity in food did not differ significantly among the consumption groups (*p* = 0.77), suggesting a widespread knowledge gap within the community. Regarding food safety perceptions, half of the daily consumers (50.0%) believed that the food they consumed was unsafe, compared to 22.4% of weekly consumers and 47.2% of occasional consumers (χ^2 = 19.539, *p* = 0.001). Furthermore, daily consumers showed the highest

willingness to pay more for tested and certified chicken products (75.0%), whereas occasional consumers demonstrated the lowest willingness (16.2%) (χ^2 = 19.641, p = 0.001). These findings are consistent with previous studies emphasizing the importance of targeted food safety education and radiological risk communication programs in rural high-risk communities (Alburayh et al., 2025).

Table 6. Association between the frequency of free-range chicken consumption and awareness of radiological health risks

Variables	Categorie	Daily n=4(%)	Weekly n=107 (%)	Occasionally n=229 (%)	Never n=1 (%)	χ^2 (df)	*p*-value
Awareness of natural sources of radioactivity in food	Yes	1 (25.0)	31 (29.0)	56 (24.5)	0 (0.0)	1.128 (3)	0.770
	No	3 (75.0)	76 (71.0)	173 (75.5)	1 (100.0)		
	Total	4 (100.0)	107 (100.0)	229 (100.0)	1 (100.0)		
Awareness of local radionuclide awareness programs	Yes	1(25.0)	13 (12.1)	4 (1.8)	0 (0.0)	18.881 (3)	0.001*
	No	3 (75.0)	94 (87.9)	224 (98.2)	1(100.0)		
	Total	4 (100.0)	107 (100.0)	228 (100.0)	1(100.0)		
Perception that free-range chicken deaths could be caused by radionuclides	Yes	3 (75.0)	92 (86.0)	163 (71.2)	1(100.0)	9.068 (3)	0.028*
	No	1(25.0)	15 (14.0)	66 (28.8)	0(0.0)		
	Total	4 (100.0)	107(100.0)	229 (100.0)	1(100.0)		
Perception that food consumed daily is safe	Yes	2 (50.0)	24(22.4)	108 (47.2)	0 (0.0)	19.539 (3)	0.001*
	No	2 (50.0)	83(77.6)	121(52.8)	1(100.0)		
	Total	4 (100.0)	107(100.0)	229 (100.0)	1(100.0)		
Willingness to pay more for tested and certified chicken	Yes	3 (75.0)	36 (33.6)	37(16.2)	0 (0.0)	19.641 (3)	0.001*
	No	1(25.0)	71(66.4)	192 (83.8)	1(100.0)		
	Total	4(100.0)	107(100.0)	229 (100.0)	1(100.0)		

Perceptions and risk assessment

As shown in **Figure 5**, when asked how they would respond if they suspected that the meat was contaminated, 65.1% of respondents indicated that they would stop eating it, 31.4% would report the issue to the authorities, and only 3.5% would continue eating it. This pattern indicates that most respondents theoretically exhibit risk-averse behavior. Nevertheless, the quite low proportion of those who were ready to report indicates a lack of confidence in or access to regulatory institutions. This minority who would persist in consumption either did not believe the threat or were economically required to do so. These trends reflect those observed by Yusriadi & Cahaya (2022) who revealed that rural populations might become aware of food safety hazards, yet they might not have the

mechanisms or resources to formally report such risks.

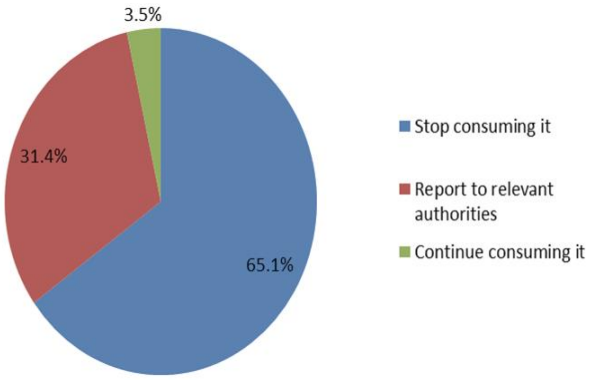

Figure 5. Perception of respondents when meat is contaminated

Research limitation

Some limitations have to be considered when interpreting the findings of this research. First, it should be noted that this is a cross-sectional research design based on assessing the awareness level and perceptions of the public at a single point in time, which cannot asses any changes over time. Secondly, it is self-reported information from structured questionnaires, which could be subject to response bias because participants might exaggerate their awareness level and behaviours. Thirdly, the geographic limitation, which includes only four villages in Bahi, is worth mentioning because it would reduce generalizability. Lastly, the study is focused only on participants' perceptions and does not consider analysis of radionuclide contamination.

Conclusion

This study demonstrates a complex relationship between the frequency of free-range chicken consumption and community awareness of radiological health hazards in Bahi District. Although the number of residents who produce poultry in the backyard and eat free-range chicken regularly is substantial, many of them have limited knowledge about the origins, harmful effects, and prevention of radionuclide contamination. The majority of the respondents pinpointed the soil as the major source of contamination and claimed to be theoretically willing to cease the consumption of contaminated meat. Nevertheless, the practical awareness concerning natural sources of radionuclides and the presence of testing services is very low, and only a minor percentage has attended awareness activities. Albeit three-quarters of the daily consumers reported their readiness to pay a premium price for tested chicken. These results exemplify the impact of the pattern of consumption on awareness, although they also illuminate thematic obstacles in the process of knowledge into action. Overall, the results suggest that residents of Bahi District have only moderate awareness of radiological risks, hampered by a lack of institutional infrastructure, outreach initiatives, and community education programs necessary to facilitate informed decision-making and promote positive food safety practices.

In light of the study' findings, the following is recommended: Implement community-oriented food safety education initiatives centered on free-range poultry and radioactive contamination. Programs should concentrate on environmental channels (soil, feed, water) and dangers associated with chronic exposure. Local authorities and health stakeholders should improve radionuclide testing services and cultivate confidence via participatory communication. Incorporate food safety education into agricultural extension programs and educational curricula. Subsidizing testing or certification may enhance safe consumption among at-risk populations. These efforts seek to mitigate radioactive health hazards in Bahi District.

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Conflicts of interest

The authors declare no conflicts of interest.

Disclaimer

Authors hereby declare that NO generative AI technologies, such as large language models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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