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EDITED BY
Luca Secondi,
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David Nartey Obemah,
Kwame Nkrumah University of Science and Technology, Ghana

*CORRESPONDENCE
Yong-Guan Zhu
ygzhu@iue.ac.cn

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Consumer food storage practices and methods at the household-level: a community study in Ghana

Ebenezer Afriyie[1,2], Monika Zurek[3], Freda E. Asem[4], Bernard Okpattah[5], John K. Ahiakpa[6] and Yong-Guan Zhu[1]*

[1]Institute of Urban Environment, Chinese Academy of Sciences, Xiamen, China, [2]University of Chinese Academy of Sciences, Beijing, China, [3]Environmental Change Institute, University of Oxford, Oxford, United Kingdom, [4]University of Ghana, Accra, Ghana, [5]Asinyo Agri-Commerce Ltd., Accra, Ghana, [6]Research Desk Consulting Ltd., Accra, Ghana

Introduction: Household-level food storage can make food available to consumers, and promotes food security. Nevertheless, attention is mostly devoted to enhancing food storage at the farmer and national levels, neglecting the household level. It is therefore critical to assess food storage practices of households. This study examined food storage practices of households, evaluated expert opinions on household-level food storage, and assessed the effect household characteristics has on food storage and food security.

Methods: Dzorwulu and Jamestown communities in Accra, Ghana, were chosen as the study locations. The study consisted of a survey, expert interviews and structural equation modeling. For the survey, 400 food household heads selected using systematic sampling method responded to a semi-structured questionnaire. Seventeen (17) experts were also purposively sampled and interviewed.

Results and Discussion: The results showed that, most households stored foodstuffs they often consumed, with generally low storage of fruits and vegetables. Perishable foods such as cassava, tomato, yam, and banana were stored by 37.8, 42, 38.3 and 43.8% of households, respectively, for 1–3days. Households often stored food within a period of 2weeks, due to poor storage facilities and lack of food storage knowledge. About 85.8% of households had never received training on food storage. Most households used baskets, bowls, sacks and polyethylene bags to store food at home, and some used refrigerators and deep freezers. Regarding the link between food storage and food security, household heads' income showed a significant positive moderating effect ($p \leq 0.01$), households' socioeconomic status had a positive effect, while household size indicated a significant negative moderating effect ($p \leq 0.01$). The experts asserted that, household-level food storage enhances food security and food safety, and reduces food expenditure and food wastage. The limited food storage knowledge of households should be a basis for intervention to enhance proper food storage practices within households.

KEYWORDS

household-level food storage, food security, food safety, food waste, household income, Ghana

1. Introduction

Achieving food security and ending hunger is a major aim of the United Nations' sustainable development goals, SDG 2 (United Nations, 2015). Nevertheless, the number of people affected by hunger in the world were between 702 and 828 million in 2021, and about 2.3 billion people were moderately or severely food insecure in the world in the same year (FAO et al., 2022). Another concern is also the pressure on food security from climate change – the Food and Agriculture Organization (FAO) noted that because of its impact on agriculture, climate change will negatively affect food security in all of its dimensions (FAO, 2016), and hence increase economic pressure on food access. Simulations performed using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) predict that inflation-adjusted prices of maize, rice and wheat (the three most important staple grains in the world) would increase between 31 to 106% by the year 2050 (Nelson et al., 2010). Generally, rise in food prices will lead to increase in food insecurity and poverty, especially for urban poor households.

A key contributing factor towards global food insecurity is post-harvest losses (Makalle, 2012). Post-harvest loss causes direct physical and quality loss of food which can reduce its economic value and may also make it unsuitable for human consumption. It is estimated that about one-third of food produced globally (valued at US $1 trillion) is lost or wasted annually, with *per capita* food losses in Sub-Saharan Africa projected to be about 37% or 120–170 kg/year (FAO, 2011; Sheahan and Barrett, 2017). Although there are losses along the food value chain from production to consumer level, food loss during storage is regarded to be most critical, particularly in developing countries, since most losses occur at this stage (Aulakh et al., 2013; Majumder et al., 2016). There can be 50 to 60% loss of food grains during storage due to factors such as poor storage practices (Kumar and Kalita, 2017). Also, nearly 50% of most food crops cultivated in Ghana for example are wasted and do not get to the final consumer, and food wastage in Accra, the capital city of Ghana, is mainly attributed to factors such as inadequate financing and inappropriate food storage structures (Nyo, 2016). Nevertheless, food storage can make enough food available to consumers and enhance food security when adequate effort is made in promoting efficient food storage methods and use of improved storage structures.

In most parts of the world, attention is usually devoted to enhancing food storage at the national and farmer levels, neglecting food storage at the consumer or household-level. In India for instance, the central government procures food from farmers, store and distribute it to mostly vulnerable urban and rural consumers or households at affordable prices (Spielmann and Aggarwal, 2017). Governments of several countries in Africa including Ghana undertake similar food policy to stabilize food prices and help farmers to easily market their produce. The National Food Buffer Stock Company (NAFCO) established in 2010 in Ghana is responsible for avoiding food surpluses from the market by buying cereals such as rice and maize from farmers at a minimum guaranteed price and store them in warehouses during the glut season. In the lean season, the cereals are released onto the market to stabilize prices and make the food readily available to consumers (Armah et al., 2019). Despite this food policy capable of making food prices stable and ensuring food availability during lean seasons, it has still not been able to eradicate hunger and avoid food insecurity, especially in poor households (Spielmann and Aggarwal, 2017). In China, the Scientific Grain Storage Project has been implemented by the government to minimize food storage losses by promoting advanced storage facilities including metal mesh warehouses, metal silos and steel framework warehouses to farmers at subsidized prices (Luo et al., 2021). Similarly, improved storage facilities such as hermetic storage bags and silos are being promoted for use to farmers in Ghana to reduce postharvest losses. Regardless of the effort geared towards enhancing food storage at the national and farmer levels in Ghana, little attention is paid to promoting food storage at the consumer or household-level in the country.

In prehistoric times, household-level food storage was a robust and common adaptation strategy for coping with inter-annual variability in crop production and securing annual supply of food. A study by Dean (2006) assessed the variations in household food storage capacity within prehistoric households in Tsegi Canyon, Northeastern Arizona, around 1,250 and 1,300 CE. The study revealed that households increased their corn store rooms or granaries while their living spaces decreased, in order to store more grains. Overall, in the study area, granary spaces increased by 61% at the expense of living spaces, during the period when agricultural production worsened. Household storage bins were also used to store 3 to 10 tons of grains for 2 to 3 years among the Hausa people of present-day Nigeria around the 18th century (Spielmann and Aggarwal, 2017). Household-level food storage is critical for minimizing postharvest losses and securing food supply to consumers. Hence, it is important to channel efforts on investigating and developing appropriate strategies for enhancing food storage within households. The aim of this study was therefore to assess food storage practices of households in Accra, Ghana. We also evaluated the opinions of experts on household-level food storage practices, and assessed the direct and moderating effect of household characteristics on food storage and food security.

2. Methods

2.1. Study design

The study consisted of a survey, expert interviews and partial least squares-structural equation modeling (PLS-SEM). The survey was carried out from November, 2020 to January, 2021. Semi-structured questionnaires were administered to food household heads – the person who has the major task of planning and preparing food for members of a household (Webber et al., 2010). The interviews were conducted between October to November, 2020 by interviewing experts in food storage, food security, food safety, food value chain and post-harvest technology. The structural equation modeling was done by using data collected from the survey to predict the impact of household characteristics on food storage and food security.

2.2. Data collection

2.2.1. Survey

This study forms part of a larger study, and so the procedure for collecting the survey data is the same as described earlier by Afriyie et al. (2022). Data was collected from households in two communities,

Dzorwulu and Jamestown, located within Accra, Ghana, (5°33'00" N, 0°12'00" W, 61 m) (Attipoe and Li, 2016). These study areas were selected because of the different socioeconomic statuses of their inhabitants. Dzorwulu is inhabited by 3,309 households who are mainly of middle-income socioeconomic status, with some high-income status households (Owusu et al., 2013; AWMA, 2019). Jamestown has 5,013 households that are mostly regarded to be of low-income status, residents usually live in congested housing and have low educational levels (Boatemaa et al., 2018; AMA, 2019). Using stratified random sampling procedure, a total of 400 respondents were selected for the study, with 160 respondents from Dzorwulu and 240 from Jamestown [using Eqs. (1)–(2)]. Systematic sampling method was used to select households at an interval of 1:22 [using Eq. (3)]. Pieces of paper with numbers from 1 to 22 written on them were shuffled in a container, and one number was randomly chosen to decide the penultimate household (Ovuga et al., 2005). We observed a spacing of 22 households from a selected household to the next.

Sample size was determined at 95% level of confidence, 50% degree of variability and 5% level of precision (Cochran, 1963):

$$n = \frac{z^2 p(1-p)}{d^2} \quad (1)$$

Proportional allocation

$$n_h = \frac{N_h}{N} \times n \quad (2)$$

Estimating the systematic sample interval (k) was done according to Subramani et al. (2014) and Sudakar (1978):

$$k = \frac{n}{N} \quad (3)$$

Where; N = total number of households, n = sample size, N_h = number of households in a community, n_h = sample size of a community, d = margin of error, z = the confidence interval, and p = degree of variability.

The survey questionnaire was made up of 47 questions and required about 40 min to complete. Generally, it aimed to find out the food storage behavior and practices of households, and effect of food storage on food security, safety, food wastage and expenditure as indicated in the supplementary file. A total of 400 questionnaires that were administered were all valid, which represents 100% response rate. The questionnaire was pre-tested by administering to 35 households in Osu, a community in Accra that has similar characteristics as the study areas. In pre-testing the questionnaire, we were able to; ensure respondents understood its content, avoid ambiguity, and determine the time needed to complete it. The survey was conducted in Ga and Twi (local languages), and English, which were the languages preferred by the respondents.

2.2.2. Expert interviews

The expert interviews were done by face-to-face interviewing 17 experts from the Ministry of Food and Agriculture of Ghana (MoFA), Departments of Agriculture (Regional, Metropolitan and Municipal), Kwame Nkrumah University of Science and Technology (KNUST), Council for Scientific and Industrial Research (CSIR) and SEND Ghana (Non-Governmental Organization promoting agricultural development in Ghana), using purposive sampling technique. The interviews were all carried out in English language by the same researcher by asking questions about household-level food storage methods, factors affecting it, and its influence on food security, waste, food safety and expenditure, using open-ended interview guide which consisted of nine (9) questions.

2.3. Data analyses

Data obtained from the survey were subjected to descriptive analysis using Statistical Package for the Social Sciences (SPSS) (version 26). Food commodities stored by households, storage period for various foods within households, and storage methods for food commodities were assessed. Food commodities were classified under the six food groups of Ghana including starchy roots and plantain; cereals and cereal products; legumes; animal products; fruits, vegetables and mushrooms; and fats and oils (Nti, 2008). Canned, cooked and leftover foods were also included in the analysis. The SPSS was also used to estimate the socioeconomic status (SES) of households through principal component analysis (PCA). The PCA is a statistical technique that is used for reducing variables in a dataset into smaller set of variables or dimensions (Vyas and Kumaranayake, 2006). Data for variables that capture living standards, including, household ownership of durable assets (example; car, television, refrigerator), and infrastructure and housing characteristics (example; sanitation facility, housing floor material, source of water) were subjected to PCA to estimate the SES of the sampled households (Rutstein and Johnson, 2004; Vyas and Kumaranayake, 2006). Additionally, the expert interviews were directly transcribed verbatim in English. Analysis of the transcripts was carried out by inductive coding using NVivo (version 12), *in vivo* codes and codes assigned by the researcher were used for data coding (Lamers et al., 2021). Key themes emerged were used to analyze the results based on the responses from the participants. The partial least squares-structural equation modeling was carried out by the use of SmartPLS software 3.2 (Ringle et al., 2015). Validity and reliability of formative and reflective constructs were tested (Hair et al., 2017). The model did not have any formative constructs and all concepts were modeled as reflective constructs, hence reliability was assessed using Cronbach's alpha and composite reliability tests (Hair et al., 2019). Composite reliability values were between 0.71 and 1.00, well beyond the 0.70 recommended threshold, and average variance extracted values were also between 0.56 and 1.00, indicating acceptable convergent validity, because they were beyond the recommended 0.50 threshold (Saunders et al., 2019; Afriyie et al., 2022).

3. Results

3.1. Socio-demographic characteristics of respondents

The survey comprised of participants who were mainly females (85%), mostly had Junior High School/Middle level education (31.5%) and were mainly between 40 to 59 years of age (40.8%). A majority of the survey participants were also traders (60.8%) (Table 1). The expert interviews were done with interviewees who were between ages 27 to

TABLE 1 Distribution (%) of respondents and households by characteristics (n=400).

Variable	%	Variable	%
Age of respondents		*Household size*	
Less than 18 years	0.3	1	18.8
18–25 years	13	2–3	41
26–39 years	38.8	4–5	28.5
40–59 years	40.8	6 or more	11.8
60 years and above	7.2	*Socioeconomic status of households (SES)*	
Sex of respondents		Higher-income/richest	2.3
Female	85	Upper-middle-income	6.5
Male	15	Middle-income	18
Education of respondents		Lower-middle-income	16.5
Tertiary (Degree/diploma)	15.8	Lower-income/poorest	56.8
SHS/secondary	25.8	*Education of household heads*	
JHS/middle	31.5	Tertiary (Degree/diploma)	20.3
Primary	19.5	SHS/secondary	26
None	7.5	JHS/middle	28
Occupation of respondents		Primary	17.8
Professional/technical/managerial/clerical	6.3	None	8
Agricultural self-employed	0.8	*Occupation of household heads*	
Trade	60.8	Professional/technical/managerial/clerical	13
Service	6.3	Agricultural self-employed	2.5
Skilled manual	15.8	Trade	41.8
Unskilled manual	9.3	Service	7.2
None	1	Skilled manual	23
Monthly income of respondents (GH₵)		Unskilled manual	12.5
above 2,500	22.8	None	0
2001–2,500	10.5	*Monthly income of household heads (GH₵)*	
1,501–2000	2	above 2,500	29
1,001–1,500	15.5	2001–2,500	7
501–1,000	38	1,501–2000	4
500 and below	11.3	1,001–1,500	13.8
		501–1,000	39.5
		500 and below	6.8

SHS, Senior High School; JHS, Junior High School; GH₵, Ghana Cedi. Principal Component Analysis (PCA) was used to estimate the socioeconomic status of households (Rutstein and Johnson, 2004; Vyas and Kumaranayake, 2006; Kabudula et al., 2017).

58 years, with 35.3% being males and 64.7% females (Table 2). The experts had educational levels of Bachelor's degree (47.1%), Master's degree (35.3%), and Doctorate degree (Ph.D.) (17.6%).

3.2. Survey

3.2.1. Food storage methods used by households

The study showed that most households stored starchy roots such as cassava in polyethylene bag (15.8%), bowl (15.8) and on the floor (10.3%) (Figure 1A). Yam and plantain were usually kept on the floor (28.4, 31% respectively), in deep freezer (12.1, 10.8% respectively) and in a polyethylene bag (13.3, 16% respectively). Rice was mainly stored by 49.8% of households in a sack while 22.2% kept maize in a bowl. Bread was usually stored by households in a refrigerator (40.5%) and polyethylene bag (31.5%). Majority of households kept meat (48%) and fish (47%) in deep freezer, 49.8% of households stored milk in a refrigerator while 37.5% stored groundnut in a polyethylene bag. Additionally, households usually used basket to store orange (23%), pepper (29.6%), onion (38.3%) and garden eggs (28.1%) (Figure 1B). Banana was mainly stored in a polyethylene bag (17%) while tomato was mostly kept in a bowl (28.1%). Deep freezer was often used to store cooked food (39.5%) and leftover food (34.5%). Overall, middle- and higher-income households usually used refrigerator and deep freezer to store perishable foods. Households without these storage facilities resorted to using methods such as storing in a bowl, basket, and on the floor, and therefore could not store food for longer period. Non-perishable food commodities were often stored using a sack, polyethylene bag and bowl.

The study also revealed that 65.8 and 31% of households owned refrigerator and deep freezer, respectively for storing food (Table 3). We found that 2.6% of lower-income households rented spaces in deep freezers from other people to store their food and paid an amount ranging from 2 to 5 Cedis (which is 0.34 to 0.86 United States Dollars; using Bank of Ghana exchange rate) per day, as at the time of the study. Some other households also used various

TABLE 2 Characteristics of expert interview participants.

Serial number (SN)	Sex	Age	Education	Specialization
01	Male	41	Bachelor's degree	Food security
02	Female	55	Master's degree	Food safety
03	Female	50	Bachelor's degree	Food safety
04	Female	58	Master's degree	Food value chain
05	Male	34	Bachelor's degree	Food storage
06	Female	37	Bachelor's degree	Post-harvest technology
07	Female	41	Master's degree	Food value chain
08	Female	29	Bachelor's degree	Food safety
09	Female	38	Ph.D.	Food security
10	Male	35	Bachelor's degree	Post-harvest technology
11	Male	53	Ph.D.	Food storage
12	Male	42	Master's degree	Post-harvest technology
13	Female	37	Master's degree	Food security
14	Female	49	Master's degree	Food safety
15	Female	33	Bachelor's degree	Food value chain
16	Female	46	Ph.D.	Food security
17	Male	27	Bachelor's degree	Food storage

indigenous ways to store food. For instance, wood ash is sprinkled or smeared on cut surfaces of leftover fresh yam to increase shelf life, onion is mixed together with lime, and pieces of charcoal are put into soup when storing to avoid spoilage (Table 4). Additionally, a majority of households (85.8%) had not received any training on food storage (Table 5), meaning that a training intervention could have helped households to enhance their food storage practices.

3.2.2. Food commodities stored by households

The results showed that food commodities stored by most households included yam (80%), rice (80.7%), bread (86.7%), fish (80.2%), groundnut (81.2%), tomato (86.2%), pepper (89.2%), onion (90.5%), palm oil (91.5%), and leftover food (84.5%) (Figures 2A,B). Generally, there was low storage of fruits and vegetables, and maize, a staple food commodity was stored by 61% of households. Leftover food being mostly stored implies that majority of households avoided food wastage by not throwing away foods they were unable to finish consuming. Households did not generally store millet, snail, taro, Bambara nuts, palm kernel oil, groundnut oil and coconut oil probably because they did not usually consume them. The study also revealed that all households stored basic foodstuffs including tomato, pepper, onion, garden eggs, bread, and palm oil (Figures 3A,B). The higher the socioeconomic status of a household, the more it is able to store most foods. Lower-income households were generally the least to store most food commodities. This can be attributed to the fact that they do not have appropriate storage facilities, or they usually buy what they can consume for the day, since poor households often do not have enough money to buy food in bulk to store.

3.2.3. Storage period for various foods by households

The results showed that food commodities mostly stored by households for 1–3 days were cassava (37.8%), yam (38.3%), plantain (36.5%), bread (40%), milk (27.8%), orange (43.3%), banana (43.8%), tomato (42%), cooked food (60.5%), and leftover food (78.8%) (Tables 6A,B). Majority of households stored maize (25%), fish (32.8%), egg (32%), groundnut (36.8%), pepper (39.5%), onion (42.5%), garden eggs (35.8%), and canned food (18%) for 4–6 days. Rice, palm oil, and refined vegetable oil were mainly stored by 29.8, 27.5, and 21.3% of households, respectively for 1–2 weeks. Although a majority of households generally stored most food commodities within a period of 2 weeks, some of them stored rice, oats, meat, fish, poultry, groundnut, onion, palm oil, palm kernel oil, refined vegetable oil, coconut oil, shea butter, and canned food for a month or more.

3.3. Expert interviews

The results of the expert interviews are grouped into six main themes: the effect of household-level food storage on (1) the eating pattern and food preference of consumers, (2) food security, (3) food expenditure, (4) food wastage, (5) food-based nutrition and safety, and (6) factors that affect household-level food storage.

3.3.1. Eating pattern and food preference of consumers

The majority of participants mentioned that food storage at the household-level compels consumers to eat the same food over the period during which it remains in storage. Although households may prefer to eat a different food, they do not, because the food in storage will go bad if not eaten, especially when the storage facility is not suitable, as narrated by a participant below;

> *"People eat what food is available at home so that it doesn't go bad. Once the food is there and I know it may go bad, I am forced to eat the same food more often so that it will finish without going bad, even though I may prefer to eat a different food"*. (Food safety expert, SN03)

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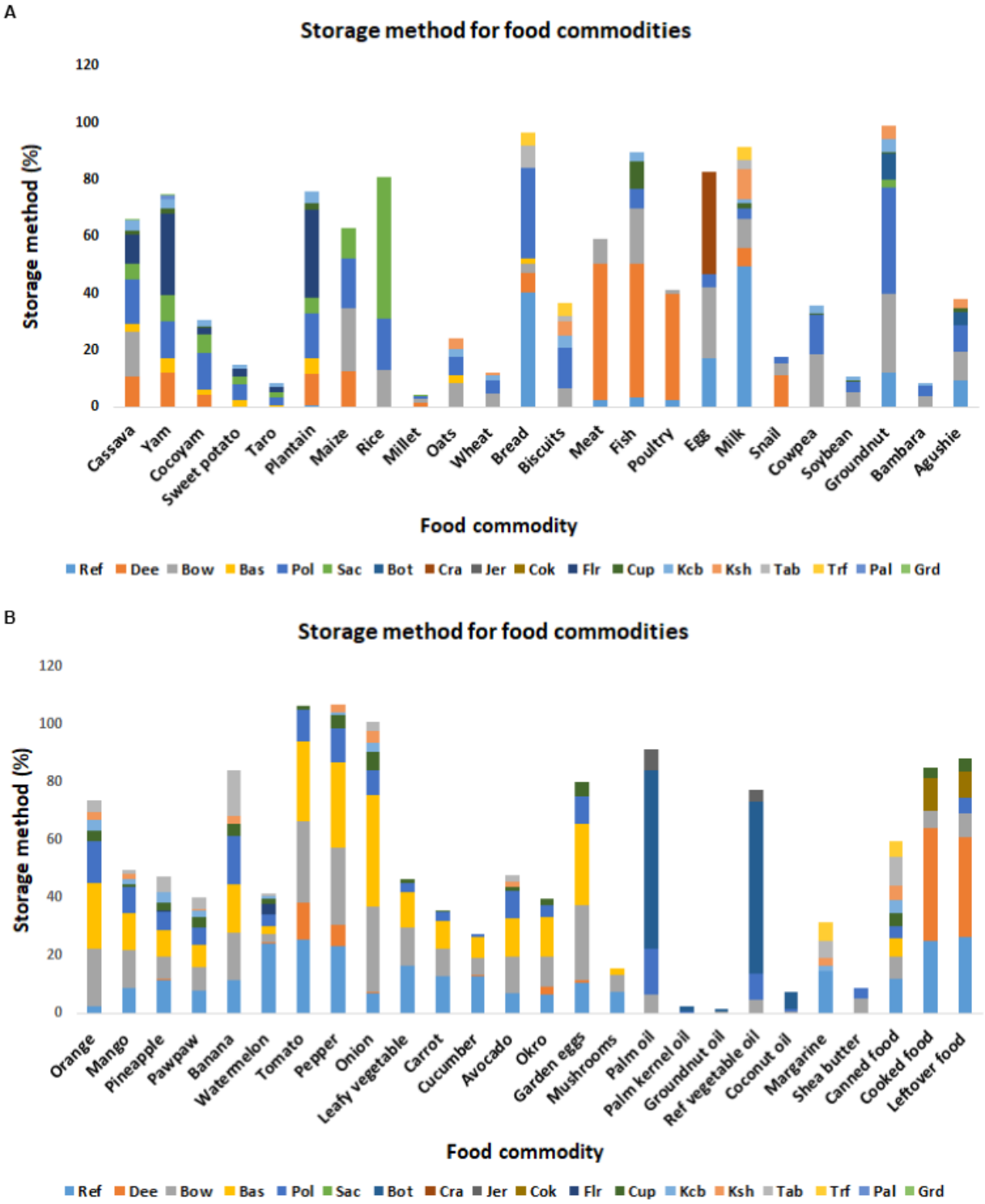

FIGURE 1
(A) Common storage methods for starchy roots and plantain, cereals and cereal products, animal products, and legumes, **(B)** common storage methods for fruits, vegetables and mushrooms, fats and oils, canned, cooked, and leftover foods. Ref, refrigerator; Dee, deep freezer; Bow, bowl; Bas, basket; Pol, polyethylene bag; Sac, sack; Bot, bottle; Cra, crate; Jer, jerry can; Cok, cooking pot; Flr, floor; Cup, kitchen cupboard; Kcb, kitchen cabinet; Ksh, kitchen shelf; Tab, on top of table; Trf, on top of refrigerator; Pal, pallet; Grd, in the ground.

One of the experts revealed that even for households having proper storage facilities, most of them cook food, particularly stews and soups, and store them for use during the week or beyond. This helps to save time and energy needed to cook frequently every day, but compels households to eat the same stew and soup for the period they remain in storage till they are exhausted, which affects their eating pattern and food preference.

> *"Some households with proper storage facilities cook stews and soups during weekends and store them in refrigerators and deep freezers for use during the week or beyond"*. (Food value chain expert, SN15)

3.3.2. Food security

Most participants asserted that household-level food storage improves food security within households. Some of them affirmed that when there is food scarcity, households that always store food will be secured compared to those who do not. Some dimensions of food security such as availability, accessibility and utilization were cited, as recorded verbatim below;

> *"When households are able to buy food in bulk and store at home, it makes food always available, accessible and properly utilized by the households"*. (Post-harvest technology expert, SN12)

> *"The ideal situation is to be able to shop for and eat fresh and healthy food every day, but in cases of food disruptions, consumers may face challenges. For instance, when there is food price increase or food shortage, consumers who always store food at home will have an upper hand compared to those who do not. Therefore, it is important to always store food to ensure food availability at home"*. (Food value chain expert, SN07)

TABLE 3 Households that have refrigerator and deep freezer to store food.

Socioeconomic status	Refrigerator	Deep freezer
Lower-income	91(22.8%)	1(0.3%)
Lower-middle-income	65(16.3%)	20(5%)
Middle-income	72(18%)	68(17%)
Upper-middle-income	26(6.5%)	26(6.5%)
Higher-income	9(2.3%)	9(2.3%)
Total	263(65.8%)	124(31%)

It was observed that 2.6% of households in the lower income class rented spaces in deep freezers to store their food and paid an amount ranging from 2 to 5 Cedis (0.34 to 0.86 USD; using Bank of Ghana exchange rate) per day, as at the time of the study.

Additionally, it was revealed that in order to improve food security, households should be able to buy food in bulk and store for longer period, preferably beyond the lean season. Participants noted that food prices in Ghana are lower during glut seasons and higher during lean seasons, therefore it will be in the best interest of households to buy food in bulk to store during glut seasons to avoid the high food prices and possible food scarcity during lean seasons.

> *"When food is in abundance during surplus season and you are able to store, you can always fall on what you have stored during the lean season since it will be available"*. (Food security expert, SN13)

> *"Most foods are seasonal and prices change, hence it is good to store when in season and the cost is less so that during off-season there will be food available for use"*. (Food safety expert, SN03)

3.3.3. Food expenditure

According to some participants, household-level food storage is cost-effective and enhances food surplus due to bulk purchases and discount deals which helps households to buy more food with the same amount of money or less. Also, by planning and avoiding frequent food purchases, households are able to save money, to minimize food expenditure.

> *"Storing food in bulk at home cuts down on costs since you get reduced price when you buy in bulk or you can even get surplus or additional foodstuff"*. (Post-harvest technology expert, SN06)

> *"When food is stored at home, it helps to spend less money on food since it prevents buying food regularly and in bits which may be expensive"*. (Food storage expert, SN11)

However, storage facilities such as deep freezer and refrigerator needed to store food require the use of electricity, which can be costly. Therefore, the participants indicated that whilst purchasing food in bulk and storing makes food available and minimizes costs, keeping the foodstuff in good condition and of high quality can be expensive. Below are the verbatim responses from some of the participants.

TABLE 4 Various indigenous ways of food storage used by households.

Commodity	Different forms of storage	% Response
Cassava	Stored in granular flour form (*gari*)	10.2
	Pour hot water on cassava in sack to store for longer period	0.8
Yam	Sprinkle wood ash on cut surfaces to prevent it from going bad quickly	6.5
Maize	Store maize in dough or flour form	19.3
Meat	Stored as smoked	9
Poultry	Stored as smoked	1.3
Fish	Stored as smoked, salted or fried	26.3
Snail	Stored as smoked	6.3
Milk	Store opened can milk in cold water in a bowl	2.5
Onion	Mix onion together with lime when storing to increase shelf life	4.1
Cooked food	Put pieces of charcoal in soup before storing to prevent it from going bad quickly	1.5

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TABLE 5 Household training status on food storage.

Socioeconomic status	Have you or your household received training on food storage?		
	Yes	No	Not sure
Lower-income	5(2.2%)	194(85.5%)	28(12.3%)
Lower-middle-income	1(1.5%)	56(84.8%)	9(13.6%)
Middle-income	1(1.4%)	66(91.7%)	5(6.9%)
Upper-middle-income	2(7.7%)	21(80.8%)	3(11.5%)
Higher-income	3(33.3%)	6(66.7%)	0(0%)
Total	12(3%)	343(85.8%)	45(11.3%)

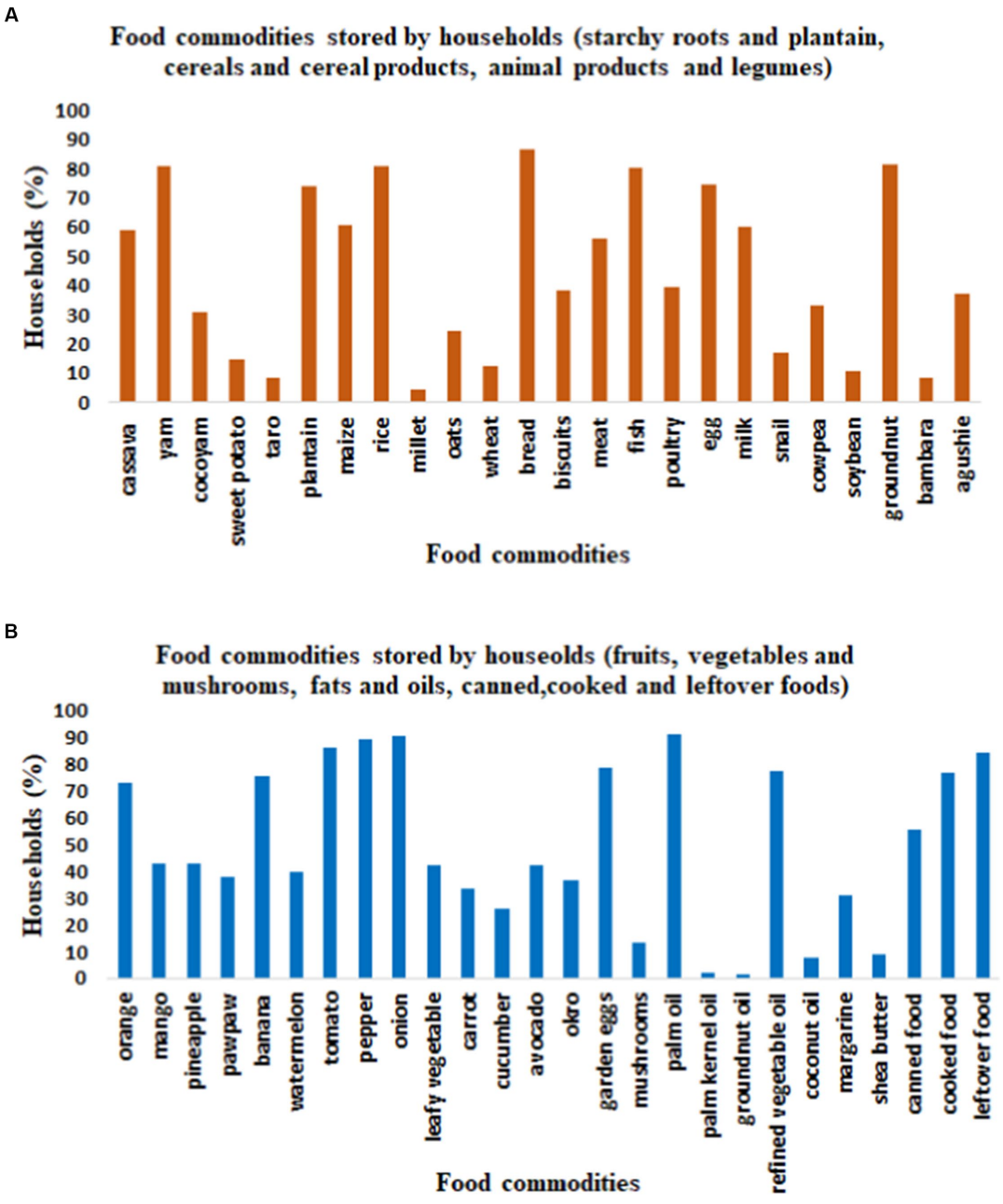

FIGURE 2
(A) Food commodities stored by households – starchy roots and plantain, cereals and cereal products, animal products, and legumes, **(B)** food commodities stored by households – fruits, vegetables and mushrooms, fats and oils, canned, cooked, and leftover foods.

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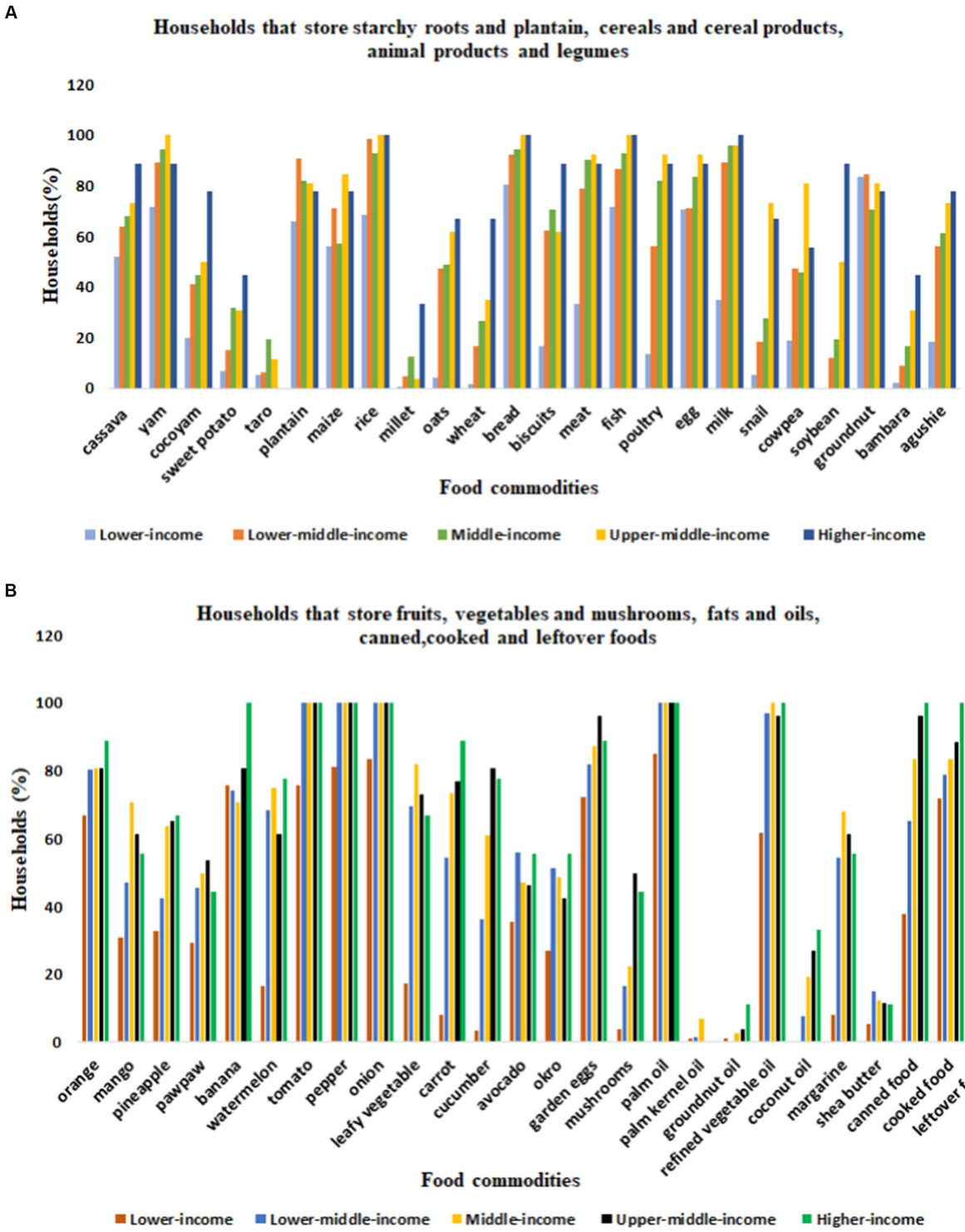

FIGURE 3
(A) Various socioeconomic households storing starchy roots and plantain, cereals and cereal products, animal products, and legumes, **(B)** various socioeconomic households storing fruits, vegetables and mushrooms, fats and oils, canned, cooked, and leftover foods.

> *"I don't think it helps much, because for instance if I buy tomatoes in bulk at a cheaper price but I store in the refrigerator or deep freezer for longer period, the problem is, the cost goes into the electricity bill"*. (Food value chain expert, SN04)

> *"Buying food in bulk and storing is relatively cheaper but ability to pay for electricity to store some foods in refrigerators and freezers is also a factor to consider"*. (Post-harvest technology expert, SN12)

TABLE 6 (A) Storage period for starchy roots and plantain, cereals and cereal products, animal products, and legumes.

Commodity	% Response					
	Never	1–3days	4–6days	1–2weeks	3–4weeks	More than 1month
Starchy roots and tubers						
Cassava	41	37.8	15	4.8	1.5	0
Yam	19	38.3	33.3	9.5	0	0
Cocoyam	69	15.8	10.5	3.5	1.3	0
Sweet potato	85	9	4.5	1.5	0	0
Taro	91.8	5.8	2.5	0	0	0
Plantain	25.8	36.5	25.5	11.3	1	0
Cereals and cereal products						
Maize	39	18.5	25	12.3	5.3	0
Rice	19.3	17.5	16	29.8	12.3	5.3
Millet	95.8	1.3	1.5	1.3	0.3	0
Oats	75.5	11.5	5	5.5	1.8	0.8
Wheat	87.8	6	3.5	1.8	1	0
Bread	13.3	40	39.5	7.2	0	0
Biscuits	61.5	20.3	13.3	5	0	0
Animal products						
Meat	44	29.5	17.8	6.3	1.8	0.8
Fish	19.8	25	32.8	16.5	3.5	2.5
Poultry	60.3	21	11.3	5	1.3	1.3
Egg	25.3	20.3	32	21	1.5	0
Milk	39.8	27.8	24	8.3	0.3	0
Snail	82.8	7.2	5	5	0	0
Legumes						
Cowpea	67	6.8	16.5	9.5	0.3	0
Soybean	89.2	3.8	4.5	1.8	0.8	0
Groundnut	18.8	26.2	36.8	15.5	2	0.8
Bambara	91.3	3	3.8	1.5	0.6	0
Agushie	63	17	15.5	4.3	0.3	0

3.3.4. Food wastage

The analysis revealed that household-level food storage contributes to reducing food wastage, especially when food is properly stored. The participants mentioned that because households plan and store the quantity of food they need within a particular period of time, they do not usually waste the food.

> *"Storing food at home reduces food wastage, especially when there is proper means of storing"*. (Food safety expert, SN08)

> *"If food is stored well in the house, it reduces food going waste since you plan and store the quantity you need"*. (Food storage expert, SN11)

Improper storage of foodstuff, unplanned use of foodstuff and unforeseen circumstances such as electricity failure can however cause stored food, particularly in refrigerators and deep freezers, to go bad or wasted.

> *"If you don't store food well or if you don't check how long you are storing the food, it will go bad and become waste"*. (Food value chain expert, SN04)

> *"Sometimes electricity or power outage causes food stored in refrigerators and deep freezers to go bad, thereby wasting the food"*. (Food security expert, SN16)

3.3.5. Food-based nutrition and safety

The participants held that storing food at the household-level has a positive effect on food-based nutrition and safety. Food storage encourages households to cook food at home, therefore they are not exposed to food handled or stored and cooked outside under unhygienic conditions or food that do not contain enough nutrients.

> *"When you store food at home, it makes you cook food at home and so you will rarely buy cooked food outside. Food cooked outside may*

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TABLE 6 (B) Storage period for fruits, vegetables and mushrooms, fats and oils, canned, cooked, and leftover foods.

Commodity	% Response					
	Never	1–3days	4–6days	1–2weeks	3–4weeks	More than 1month
Fruits, vegetables and mushrooms						
Orange	27	43.3	24.8	5	0	0
Mango	56.8	29.3	11.5	2.5	0	0
Pineapple	57	29.8	12.3	1	0	0
Pawpaw	62.3	22	13.5	2.3	0	0
Banana	24.5	43.8	27.8	4	0	0
Watermelon	60	23.5	13	3.3	0.3	0
Tomato	13.8	42	34.8	4	5.5	0
Pepper	10.8	37.5	39.5	7	5.3	0
Onion	9.5	26.5	42.5	15.5	3.5	2.5
Leafy vegetable	57.8	23.3	14.5	4.3	0.3	0
Carrot	66.3	18.8	8.8	6	0.3	0
Cucumber	74	15.8	7.8	2.5	0	0
Avocado	57.8	26.5	13.3	2.5	0	0
Okro	63.5	25.8	9.5	1.3	0	0
Garden eggs	21.5	35.3	35.8	7.5	0	0
Mushrooms	86.8	4.8	5.2	3.3	0	0
Fats and oils						
Palm oil	8.5	16.5	21.3	27.5	19.8	6.5
Palm kernel oil	97.8	0.5	0.3	1	0.3	0.3
Groundnut oil	98.3	1	0.5	0.3	0	0
Refined vegetable oil	22.5	19	19.3	21.3	14.5	3.5
Coconut oil	92.3	0.8	0.5	3.5	2	0.8
Margarine	69	10.5	12.8	6.8	1	0
Shea butter	91.3	0.5	2.5	3.3	2	0.5
Canned food	44.3	17.3	18	11	7.2	2.3
Cooked food	23.3	60.5	14	2.3	0	0
Leftover food	15.5	78.8	5.3	0.5	0	0

> *not contain all the necessary nutrients, it may also be cooked in an unhygienic place and hence may pose health problems".* (Food security expert, SN01)

> *"When you store food well at home, you are able to eat safe and healthy food because you make sure you store in a clean and suitable environment".* (Food security expert, SN16)

A majority of the participants also asserted that household-level food storage enhances food nutrition and safety through diet planning. They revealed that storing food helps households to plan their meals and diets to ensure that optimum amounts of nutrients are retained and does not pose any health challenges.

> *"Mostly when storing food at home, you store the ones you can get enough nutrients from and once food is stored well it will not have any health problems".* (Food value chain expert, SN04)

> *"Once you have the various foods stored at home, when planning meals, cooking or eating, you will ensure you have all the needed nutrients and because you are cooking or handling it yourself, you take the necessary safety measures".* (Food safety expert, SN14)

3.3.6. Factors that affect household-level food storage

Most participants cited some factors that affect household-level food storage to be electricity, temperature, shelf life of food, pest infestation, improper storage practices, unsuitable storage facilities and financial capability of households. Electricity is important because *"if there is no power or electricity supply, you cannot use storage equipment like refrigerator and deep freezer"* (Food security expert, SN01). These storage equipment or facilities are at the core of household-level food storage. Some of the participants asserted that the shelf life of food is critical in determining the storage period of food. Additionally, fertilizers and agro-chemicals used to spray

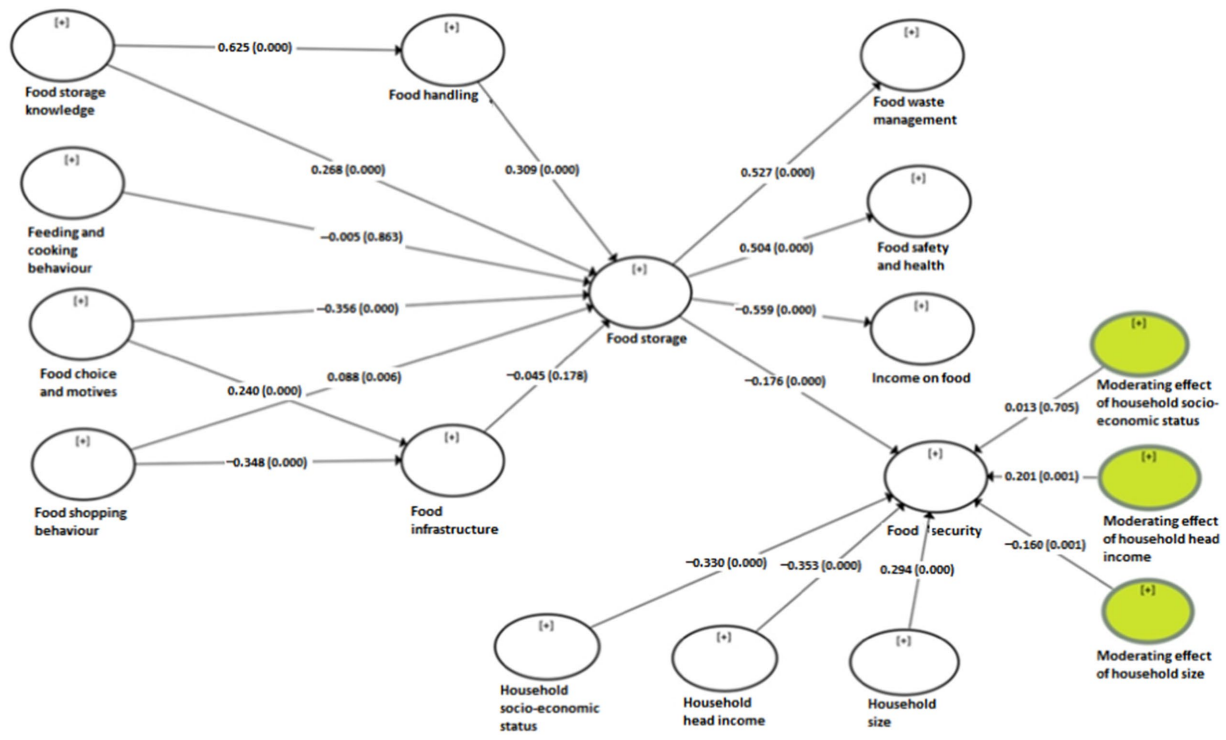

FIGURE 4
A network analysis of direct and moderating effect of household characteristics on the relationship between food storage and food security. The +/− shows the strength of the association between and among the clustering variables, and the [+] shows a positive association between variables at significance level $p \leq 0.05$.

foodstuff just before harvesting can also affect the shelf life of food, as indicated by the verbatim responses below;

> *"The period or time of storage should be considered with regards to the shelf life of the food commodity, and the use of proper storage facilities should be of importance"*. (Food safety expert, SN02)

> *"The shelf life of the food commodity, and the fertilizer and agro-chemicals used to spray the food before harvesting can affect how long it can be stored"*. (Food security expert, SN09)

Food in storage should be well protected against pests since *"stored foods can be easily infested by storage pests when they are not properly handled and stored"* (Food safety expert, SN14), especially when households do not have suitable storage facilities. Also, *"some people do not have the capital or money to purchase storage equipment like a refrigerator or deep freezer"* (Food storage expert, SN05) or they use improper food storage methods due to lack of knowledge.

> *"Inadequate knowledge in storing the various types of food affects the way food is stored at home"*. (Food security expert, SN16)

3.4. Partial least squares-structural equation modeling

3.4.1. Direct effect of household characteristics on food storage and food security

Results from the PLS-SEM showed that, the direct effect of households' socioeconomic status on food security was negative and statistically significant ($\beta = -0.330$, p value $= 0.000$, $p \leq 0.01$) (Figure 4). Income of household head also exhibited a negative and statistically significant relationship with food security ($\beta = -0.353$, p value $= 0.000$, $p \leq 0.01$). This indicates that averagely the socioeconomic status of sampled households in the study was low with majority of household heads having low income, hence this will generally not lead to achieving household food security through food storage. Household size showed a positive and statistically significant direct effect on food security ($\beta = 0.294$, p value $= 0.000$, $p \leq 0.01$). This implies that the average household size of participants in the study does not put a household at a food security risk, but could rather promote food security.

3.4.2. Moderating effect of household characteristics on food storage and food security

The PLS-SEM results also revealed that households' socioeconomic status had a positive moderating effect on the relationship between food storage and food security, although not significant ($\beta = 0.013$, p value $= 0.705$, n.s) (Figure 4). This means that improving households' socioeconomic status can increase the strength of the link between food storage and food security, and vice versa. Therefore, higher socioeconomic status of a household can help to improve food security through food storage. Income of household head also showed a significant positive moderating effect on the relationship between food storage and food security ($\beta = 0.201$, p value $= 0.001$, $p \leq 0.01$). This implies that to ensure household-level food storage lead to the attainment of food security, the income of household head needs to be improved, particularly within poor households. The findings also indicated that moderating household size had a negative and significant effect on the link between food storage and food security ($\beta = -0.160$, p value $= 0.001$, $p \leq 0.01$). Hence, large

household size will impede the achievement of household food security through food storage.

4. Discussion

The study findings indicate that food commodities such as rice, groundnut, fish, tomato, palm oil, and pepper were often stored by most households. These are some of the key food commodities used for preparing major dishes consumed by households in Ghana daily, which implies that households in the study areas usually store foodstuffs they mostly consume. Aberman et al. (2022) in their study in Ghana reported that these were some of the main food commodities that participants usually purchased for consumption. The generally low storage of fruits and vegetables by households in the study communities can be attributed to the fact that, relatively their consumption is usually low, which affected their overall storage since households infrequently consumed them. We also observed that, higher-income households were capable of storing most foods compared to lower-income households. Higher-income households had the financial resources to acquire improved storage facilities that enabled them to store most foodstuffs than what lower-income households could store. Since rich households have the ability and capacity to invest in and adopt improved agricultural technologies (Ali and Erenstein, 2017).

The study found that households mostly stored perishable foods including cassava, bread, yam, tomato, plantain, cooked food, banana and leftover food for 1 to 3 days. Food commodities have period of time they can be stored before deteriorating and are not safe to consume. The type of food, type of storage facility and storage conditions like temperature are some of the factors that affect the shelf life of food (Xue et al., 2014; Garden-Robinson, 2020). Participants for the expert interviews also acknowledged that the period of storing food at home can be influenced by fluctuations in the supply of electricity, financial capability of households and food storage practices employed by households. Bread for example when stored at room temperature has about 7 days shelf life, but when it is stored in a deep freezer, the shelf life can increase to 3 months (Boyer and Mckinney, 2018). Meat and fish can be kept for between 4 to 12 months when frozen; vegetables and fruits can also be stored for about 2 weeks or longer and still be of good quality when appropriate storage techniques are employed (Boyer and Mckinney, 2018; Garden-Robinson, 2020). The findings also revealed that most of the sampled households stored food within a period of 2 weeks, which can be ascribed to the use of inappropriate storage facilities, and lack of adequate up-to-date knowledge in storing the various foods for a longer period, since most the households do not have any training in food storage.

Furthermore, our findings revealed that, well-to-do households usually used deep freezer and refrigerator for storing perishable foods, due to their suitability in preventing food spoilage. Refrigerator and deep freezer are effective for; slowing down bacterial growth, minimizing food spoilage and preserving food quality, hence prolonging the shelf life of food commodities (Aung and Chang, 2014). During freezing, the physical state of the substance or food is changed by converting water into ice when energy is removed through cooling below freezing temperature, such as −18°C (Rahman, 2007). The results also showed that households made use of various storage methods to store their food including; using a basket, sack, bowl, polyethylene bag and in the ground. Households used polyethylene bags for storing food in this study due to its relatively cheaper price, durability and ease of use, and also because it is capable of delaying deterioration of perishable foodstuffs such as cassava for some days. However, Rujnic-Sokele and Baric (2014) noted that polyethylene bag is non-degradable, poses great danger to aquatic life and in some countries there is a levy on its use or it is banned. A study carried out to assess food storage practices of farmers by Prempeh et al. (2017) reported that cassava was stored by 27% of farmers in polyethylene bags, 8% in the ground or pit, 34% in sacks, 26% in water and 6% stored cassava under a shade. Wumbei et al. (2019) also conducted a study in Wulensi, Ghana to show that 63% of farmers stored yam in traditional barns, while 8% stored it in the ground, and 29% of farmers kept it under trees covered with grass.

In addition to the survey outcomes, the expert interviews also revealed findings regarding the impact of household-level food storage. We found from the experts that, most households are compelled to eat the same food for the period it remains in storage until it is finished, lest it goes to waste, particularly due to inappropriate storage facilities. With appropriate cost-effective storage facilities and up-to-date knowledge in food storage practices, households can store varieties of food commodities so that they can have options to choose any food they prefer to eat. Having dietary diversity or eating different food types is critical for obtaining various micro- and macro-nutrients to ensure nutrient adequacy (Sibhatu et al., 2015). All the experts who were interviewed asserted that storing food at the household-level promotes food security. This supports a study by Tesfaye and Tirivayi (2018) who reported that storing food, particularly using improved storage technologies promotes food and nutrition security, and could be an important factor in alleviating the problems of feeding the increasing global population. Darfour and Rosentrater (2016) also reiterated that in order to minimize food and nutrition insecurity in Ghana, it is critical to improve food storage practices in the country by building the capacity of households, consumers and relevant stakeholders. Although most experts acknowledged that household-level food storage helps to reduce food expenditure, some of them asserted that using facilities such as refrigerator and deep freezer to store food can be costly due to high electricity bills. A study by Sakah et al. (2019) showed that households in Ghana use refrigerators and deep freezers for a whole 24 h period, with spikes around 8:00 pm and 2:00 pm because of dinner and lunch times, respectively. Their study revealed that households' use of these storage facilities contributes to 15% of peak electricity load, which makes it the third priority target for minimizing high electricity consumption in Ghana. It is therefore ideal for households to always buy and use energy efficient food storage facilities in order to minimize electricity consumption and save some money.

The expert interviews also indicated that storing food within households helps to reduce food wastage, especially when households have suitable storage facilities to store food. On the other hand, when households do not store food or do not take full responsibility of ensuring that food is properly handled and stored, there could be significant food waste generation. Food wastage within households is mostly caused by unplanned or unintended outcome of entangled daily routines revolving around food, including improper handling and storing of food (Dobernig and Schanes, 2019). The food waste generation rate of sampled households in Accra was reported to be averagely 0.12 kg/person/day (Attipoe and Li, 2016). Rutten and Verma (2014) however noted that, reducing food waste by 50% in Ghana by the year 2025 will help to improve food production and enhance food security in the country. The qualitative results revealed that, food storage at the household-level enhances food-based nutrition and safety, because it encourages households to plan their diets and also cook food at home. Therefore, households are able to obtain optimum nutrients from food and are not exposed to any health problems by eating

food cooked under unhygienic conditions outside home. This is in support of a research by Lin and Guthrie (2012), which indicated that due to dietary guidance or planning, food cooked at home were richer in nutrients than food cooked away from home. Food cooked at home was higher in nutrients such as calcium and significantly lower in fat content, while food cooked away from home was higher in cholesterol, sodium and saturated fat, and lower in dietary fiber. Improper food hygiene and food safety practices by street-cooked food handlers have also been reported to be a major cause of food-borne illness among consumers (Sani and Siow, 2014; Ayaz et al., 2018). It is therefore important to promote food storage within households in order to enhance effective food safety practices and safeguard the health and wellbeing of consumers.

Additionally, the results showed household head's income and socioeconomic status of household to have a positive effect on the link between food storage and food security. Increasing the income of household head and improving household's socioeconomic status therefore enhances the achievement of household food security through food storage, and vice versa. Income is a key determinant that affects food storage and food security of households. Poor households struggle to acquire sufficient nutritious food and adequate resources such as proper food storage structures (De Marco and Thorburn, 2009). They become vulnerable to limited availability and access to food, which subsequently affect its re-distribution to household members (Drammeh et al., 2019). However, rich households are able to buy and consume adequate nutritious food, and acquire suitable food storage facilities. Various studies have reported that increase in household income lead to improvement in food security. For example, studies done in Nigeria and Ghana revealed that household food security improved by 1.65 times by increasing households' monthly income (Babatunde and Qaim, 2010; Owusu et al., 2011). Antwi and Lyford (2021) also reported that a unit increase in the income of households lead to increasing the probability of achieving high household food security status by 5.3%. Also, household size had a negative effect on the relationship between food storage and food security. This implies that large household size has the likelihood of worsening food security, regardless of the food storage techniques used. When there are more members in a household, demand for food increases, and can outweigh the household's food supply, especially for poor households (Antwi and Lyford, 2021). The larger the size of a household, the likelihood of available food to each household member becoming lesser, which subsequently affect the household's food and nutrition security status (Olayemi, 2012). According to a study by Antwi and Lyford (2021), a unit increase in household size reduced the likelihood of household to attain high food security status by 3.4%.

5. Conclusion

To increase food security in urban households, it is crucial to understand consumer food storage practices at the household-level. The study found that rich households are able to store more food than poor households, since they have financial capability to acquire appropriate food storage facilities, while poor households mainly resort to traditional food storage methods and facilities. The findings indicated that most households do not have any training in food storage, contributing to the short period they stored food. The study also revealed that households must eat the same stored food until it is finished to avoid wasting it, especially due to poor storage facilities. Income of household head and socioeconomic status of households was found to positively affect food security through food storage.

Policies that promote the use of cost-effective storage facilities, enhance up-to-date food storage expertise, and facilitate the provision of social interventions to particularly poor households, will enable consumers to store varieties of food commodities for longer periods at home, to be able to always access available food and consume variety of foods, in order to promote food and nutrition security. Future research and assistance geared towards providing training interventions and upgrading indigenous food storage methods and facilities are necessary for building households' capacity to adopt proper food storage practices.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of the Institute of Urban Environment, Chinese Academy of Sciences. The participants provided their written informed consent to participate in this study.

Author contributions

EA collected the data, performed the analysis, and wrote the manuscript's draft. BO participated in data analysis and commented on the first draft of the manuscript. JA contributed to the writing and revising the manuscript. MZ, Y-GZ, and FA supervised the overall project and revised the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

BO was employed by Asinyo Agri-Commerce Ltd. JA was employed by Research Desk Consulting Ltd.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2023.1194321/full#supplementary-material

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