



# Retailers' knowledge and practices on the storage and handling of certified vegetable seeds: A case study of the Ashanti Region, Ghana

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## ARTICLE INFO

### Keywords:

Vegetables  
Certified seeds  
Seed quality  
Seed retailers  
Seed storage practices  
Seed marketing challenges

## ABSTRACT

Poor seed storage and handling practices adversely affect seed quality. To investigate retailers' knowledge and practices in handling and storing certified vegetable seeds to ensure seed quality maintenance, a survey was conducted with a questionnaire and a thermo-hygrometer in the Ashanti Region. Results indicated retailers were aware of the factors that affected seed quality during storage. Retailers stored seeds at room temperature, and repackaged seeds in smaller sizes due to challenges like lack of cold storage, lack of credits, seed pricing and seed package sizes. Retailers require cold storage facilities to ensure continuous supply of quality seeds to farmers.

## 1. Introduction

Vegetables constitute a key portion of human diets globally [12]. Aside providing much required micronutrients, antioxidants and phytochemicals that protect the body against diseases [44], production and consumption of vegetables also has the potency of creating employment and generating income in developing countries [43]. Vegetable production in the urban and peri-urban centres has thus been cited to have the potential of contributing to the achievement of the first two United Nations sustainable development goals; reduction of extreme poverty and hunger [1]. Increased vegetable production generates high income and employment opportunities compared to other sectors of the agricultural economy, thus making vegetables an essential component of any agricultural growth plan [38]. The exportation of vegetables like chillies and okra to European countries such as Germany, Britain, Italy, Belgium and Switzerland has yielded significant foreign exchange for Ghana [6],[20].

Despite their nutritional and economic benefits, vegetable production and marketing in Ghana has been constrained by poor quality and availability of seeds [13]. Seeds are fundamental inputs in crop production. Seed quality, irrespective of the scale of crop production, governs crop productivity level amidst all other crop production inputs [8]. Nonetheless, to achieve high agricultural productivity, quality seeds should be complemented with appropriate crop protection chemicals,

fertilizers, irrigation and mechanization systems, and technical know-how [16].

Researchers and research institutions produce breeder and foundation seeds for seed companies, seed producers and seed growers to also produce certified seeds. These seeds certified by Ghana Seed Inspection Division (GSID) meet minimum quality standards and normally kept under cold storage by seed companies, who usually sell seeds to retailers to be sold to farmers, or sometimes, sell directly to farmers [14]. Agrochemical shops are those who buy the chunk portion of certified seeds and have proven beyond doubts to be the most suitable channels through which seeds are marketed [4],[40].

The maintenance of the quality of seeds at retailers' end is essential for continuous supply of quality seeds to farmers. Retailers' knowledge and experience in handling seeds is therefore crucial. Lack of knowledge has been reported to be a barrier to technology providers [26]. There is a positive relation between previous work experience and entrepreneurial intention because one's years of experience from same or related work provides them with management and problem solving skills, and helps them in getting initial business contracts [24,45]. Age plays a vital role in seed business owing to the fact that usually, seed retailers' interest in adopting new innovations diminishes as they get older [28]. Younger people with a high level formal of education have greater ability in gathering information [41]. On-the-job experiences usually create familiarity with acceptable practices involved in seed handling. High

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<https://doi.org/10.1016/j.sfr.2021.100059>

Received 11 May 2021; Received in revised form 12 July 2021; Accepted 15 September 2021

Available online 23 September 2021

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literacy level is essential for the growth of the seed industry because knowledge about the level of education of the retailers serve as a guide in the planning and delivery of technical services [28]. Actors in the seed business who are literate have a higher probability of being acquainted with information, and have better abilities in processing information and fishing out appropriate technological solutions to alleviate their challenges [2]. Exploring vegetable seed retailers' socio-demographic characteristics would be beneficial for future research and serve as a guide the formulation of policies.

Several barriers hinder the availability of certified seeds in Ghana. First of all, there is lack of a robust seed production industry resulting in high importation of most hybrid seeds which obviously comes with import duties [35]. According to Ghana National Seed Policy [30], other constraints of seed availability include the high cost of seed resulting in farmers' over reliance on farmer-saved seeds, timelines of seed availability which affects farmers' planning, appropriateness of the size and packaging of seeds which causes retailers to repack seeds, varietal and physical qualities that may not suit farmers' taste, and need for complementary inputs and services that come at extra cost. Technologies employed in the seed business is capital intensive [3] resulting in low investments in the venture. However, partnership is a vital tool for increasing productivity, profits, and quickening dissemination of new technologies to stakeholders in the seed industry [21,34,39], it could be a tool for improving seed availability.

Other factors also block the preservation of quality seed. The greatest of such factors is lack of cold storage facilities [14,30]. There is also inadequate resources in terms of personnel and logistics for GSID to enhance effective post-certification market surveillance to ensure seed quality maintenance [30]. Other factors include mishandling of seeds by marketers such as repackaging of sourced seeds into transparent plastic bags which may expose seeds to harsh environmental conditions and foreign materials like inert matter and air-borne fungal spores. Storage of seeds with agrochemicals is also a threat to the preservation of seed quality. Dane and Dalgic [9] found that solutions prepared from Benomyl, a fungicide, was able to cause many anomalies in mitotic cell divisions in the root tips of onion during germination and growth. Legume seeds treated with herbicides also resulted in reduction in nodules formation, thereby reducing the rate of nitrogen fixation [23, 37]. Identifying the barriers that block the availability and preservation of quality vegetable seeds and finding appropriate solutions would be essential for the sustainability of Ghana's seed industry.

Several factors influence seeds during storage. Temperature, relative humidity and seed moisture have been cited as the most important factors that cause a decline in seed quality [5,29,32]. Low temperature and low relative humidity are a prerequisite for the maintenance of seed quality during storage [11]. High temperature and high relative humidity increase seed moisture content which eventually causes seed deterioration. Vieira et al. [42] indicated that the rate of seed deterioration is directly related to the moisture content of the seed; the higher the moisture content of the seed, the faster the rate of seed deterioration. Another factor that influence seed quality is storage length. Schmidt [36] indicated that in order to prevent seeds from deteriorating, they should not be stored for lengthy periods under tropical conditions. Retailers' awareness of these factors is a prerequisite for the preservation of quality seeds.

Certified vegetable seeds of high quality are crucial for food security as well as agricultural sustainability in Ghana. Retailers' awareness of the factors that affect seed quality during storage, coupled with the availability of seed storage facilities, are essential for availability and conservation of certified vegetable seeds in the country. Mishandling of certified vegetable seeds such as seed repackaging and storage of seeds with agrochemicals could also affect seed quality. The present study seeks to investigate retailers' knowledge and practices on the storage and handling of certified vegetable seeds, particularly in the Ashanti Region, to ensure seed quality maintenance. Available literature on this topic is scanty; this study therefore seeks to explore the research area

and make immense contribution to knowledge to be used in policy formulation and future research in Ghana's seed industry.

This article is organized into 5 sections; the subsequent sections following the Introduction are Methodology and Data, Results, Discussion, Conclusion and Recommendation.

## 2. Methodology and data

### 2.1. Study site

The field survey was conducted in the Ashanti Region of Ghana from January to December, 2019. The Ashanti Region is a cosmopolitan region sited within the middle belt of Ghana and lies between longitudes 0.15W and 2.25W, and latitudes 5.50N and 7.46N [19]. Occupying a total of 24,389 square kilometers of land area, the Ashanti Region represents 10.2% of Ghana's total land area [19]. The region currently has 43 metropolitan, municipal and districts (MMDs) with Kumasi, the second biggest city in Ghana, as its capital [7,17]. The region has a total population of 4,780,280. This figure represents 19.4% of Ghana's total population making it the most populous region in the country [18]. The Ashanti Region has 412,055 agricultural households, representing 36.6% of the total households in the region, and 16.5% of all agricultural households in Ghana [18].

### 2.2. Sampling of certified vegetable seed retailers

Ghana Agricultural Inputs Dealers Association (GAIDA) revealed that majority of seed retailers were located in the capital, Kumasi, while others were mostly located in markets and lorry stations of municipal/district capitals. The regional capital, Kumasi was selected using purposive sampling since majority of the retailers were located within the Kumasi Metropolis. Twelve (12) other municipal/district capitals were additionally selected using simple random sampling. These were Atwima Twedie, Mankranso, Obuasi, Konongo, Ejisu, Tepa, Asante Mampong, Manso Nkwanta, New Edubiase, Nkawie, Asante Bekwai and Ejura. Each district capital produced varying number of retailers or respondents. However, no certified vegetable seed retailers were identified in three municipal/district capitals namely, Ejura, Atwima Foase, and Mankranso at the time of visit. In all, twenty-five (25) retailers/respondents were sampled (Table 1). Males formed 68% of the retailers and the rest females. Retailers' age ranged between 20 and 60 years with an average age of 37 years (Table 2) with 96% of them having gained formal education to at least the basic level (Fig. 1). Their level of on-the-job experience also ranged between 0 to 40 years with an average experience of 14 years in business (Fig. 2).

### 2.3. Tools used for the survey

The vegetable seed retailers were interviewed one-on-one with the

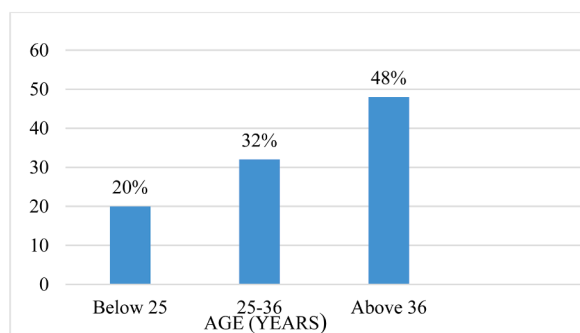
**Table 1**  
Metropolitan/municipal/district, capital and number of retailers.

Metropolitan/Municipal/District	Capital	Number of Retailers
Kumasi Metropolitan	Kumasi	9
Bekwai Municipal	Bekwai	3
Mampong Municipal	Mampong	1
Atwima Nwabiagya Municipal	Nkawie	1
Obuasi Municipal	Obuase	3
Ejisu Municipal	Ejisu	1
Asante Akim Central Municipal	Konongo	1
Adansi South District	New Edubiase	2
Amansie West District	Manso Nkwanta	1
Ahafo Ano North Municipal	Tepa	3
Ahafo Ano South West District	Mankranso	-
Atwima Kwanwoma District	Atwima Twedie	-
Ejura-Sekyedumase Municipal	Ejura	-
Total: 13	Total: 13	Total: 25

**Table 2**

Literacy level of retailers.

Level of Education	Frequency	Percentage (%)
B.E.C.E	3	12
W.A.S.S.C.E	12	48
HND	1	4
Diploma	2	8
Bachelor's degree	5	20
Master's Degree	1	4
No Formal Education	1	4
Total	25	100



**Fig. 1.** Age distribution of retailers.

aid of a pre-tested questionnaire. The questionnaire was a 5-page document with both close and open-ended questions that were relevant to the objectives of the study. The questionnaire centred mainly on socio-demographic profile of retailers, retailers' seed sources, day to day atmospheric conditions for seed storage, retailers' awareness of the factors that affect seed quality during storage, practice of repackaging of sourced seeds, storage of seeds with agrochemicals, feedback from farmers (buyers), and retailers' marketing challenges. An IN-OUT Thermo-Hygrometer was used in recording the storage temperature and relative humidity at all the commercial retail shops sampled. Data on questionnaire were analysed using IBM SPSS Statistics 20.

### 3. Results

#### 3.1. Type of business organisation

Three business organisational types, namely, sole proprietorship, company, and co-operative were identified in the survey. Majority (80%) of the businesses fell under sole proprietorship. This was followed by companies which formed 16% of the total whilst co-operative organisation formed 4% of the total (Fig. 3).

#### 3.2. Certified vegetable seed suppliers

Response from retailers on their sources of certified vegetable seeds showed that they all (100%) received their certified vegetable seeds from seed companies.

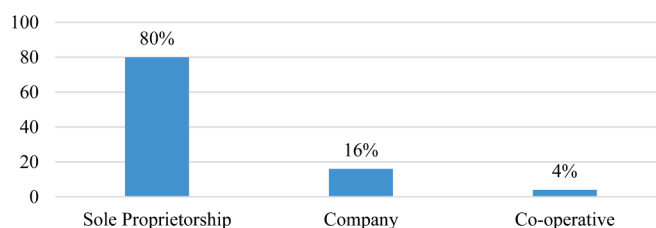
#### 3.3. Awareness of the factors that affect seeds in storage

Most (92%) of the retailers were aware of the factors that affect seed quality during storage whilst 8% had no idea about such factors (Fig. 4).

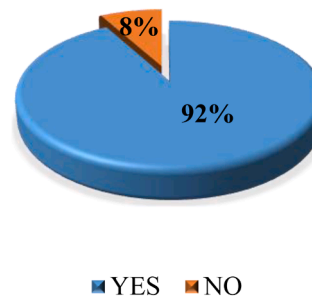
In multiple response analysis of factors that affect the quality of vegetable seeds in storage as indicated by retailers who were aware of such factors, storage temperature was the most predominant factor (64%) cited by retailers (Table 3). Moisture content and relative humidity followed with 11.8% each (Table 3).

#### 3.4. Retailers' seed storage conditions

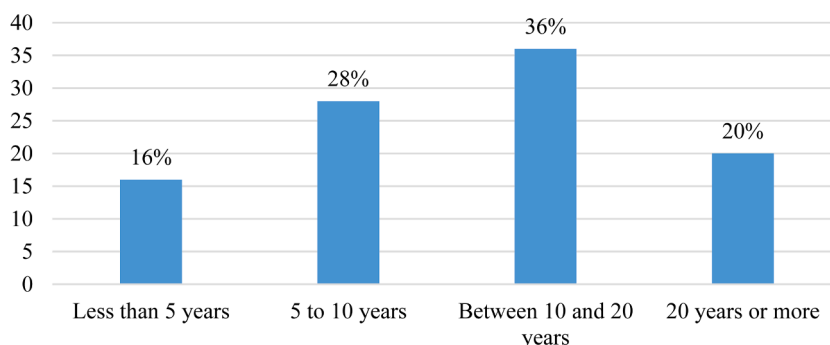
Results from the temperature recorded at the various retail shops indicated that majority (40%) of the shops had temperatures ranging from 31.0 °C to 32.9 °C. A temperature range of 29.0 °C to 30.9 °C followed with 28% whilst 20% of the shops had temperatures ranging from 33.0 °C to 34.9 °C. Eight percent of the shops recorded a temperature range of 35 °C to 36.9 °C whereas 4% had temperatures below



**Fig. 3.** Type of business organisation.



**Fig. 4.** Retailers' response to whether they were aware of factors that affect vegetable seed quality during storage.



**Fig. 2.** Number of years in business.

**Table 3**  
Factors that affect vegetable seeds in storage.

	Responses
Factors	Frequency Percentage
Storage temperature	22 64.7
Moisture content	4 11.8
Relative humidity	4 11.8
Pests	2 5.9
Poor processing	2 5.9
Total	34 100.0

20 °C (Table 4).

Results of the relative humidity measured at the various retail shops indicated that majority of the shops (32%) had relative humidity figures ranging from 60% to 64%. This was followed by shops that had relative humidity ranges of 55–59% (24%), 50–54% (20%), and 40–44% (16%). Shops that had relative humidity measuring from 45% to 49% had the least percentage (8%) (Table 5).

3.5. Effect of storage duration on vegetable seed quality

Retailers' response to whether the length of storage time had effect on vegetable seed quality is displayed in Table 6. Most retailers representing 87.5% out of 24 valid responses indicated that length of storage time had effect on vegetable seed quality; seed quality declined with time while 12.5% indicated that storage time had no effect on seed quality; effect depends on storage conditions.

Multiple response analysis of the effects of storage duration on vegetable seed quality as provided by respondents who were of the view that length of storage time had effect on vegetable seed quality is shown in Table 7. Majority (81.8%) of the respondents indicated that long storage period resulted in poor germination of seeds (Table 7).

Analysis of response by retailers on how long they kept vegetable seeds in stock showed that majority (44%) of the retailers kept seeds in stock for a period of 1–3 months (Table 8). The same percentage of retailers (20%) followed with storage durations of 10–12 months and over 12 months (Table 8). Twelve percent of the retailers also kept seeds in stock for a period of 4–6 months while only 4% kept seeds in stock beyond 12 months (Table 8).

3.6. Storage of vegetable seeds alongside agrochemicals

Survey results showed that 84% of the retailers kept vegetable seeds and agrochemicals in the same retail shop whilst 16% of them did not (Fig. 5).

Majority (76%) of the retailers did not know of any such effects (Table 9). Only 8% of the respondents knew some negative impacts while 16% did not provide any answer since they had not kept vegetable seeds with agrochemicals (Table 9).

3.7. Repackaging of certified vegetable seeds at retailers' shops

Most (56%) retailers repackaged their sourced certified vegetable seeds whilst 44% of them did not (Fig. 6).

Multiple response analysis on why retailers repackaged their sourced

**Table 4**  
Temperatures of retail shops.

Temperatures (°C)	Frequency	Percentage (%)
Below 20	1	4
29.0 - 30.9	7	28
31.0 - 32.9	10	40
33.0 - 34.9	5	20
35.0 - 36.9	2	8
Total	25	100

**Table 5**  
Relative humidity of retail shops.

Relative Humidity (%)	Frequency	Percentage (%)
40 – 44	4	16
45 – 49	2	8
50 – 54	5	20
55 – 59	6	24
60 – 64	8	32
Total	25	100

**Table 6**  
Retailers' response to whether the length of storage time had effect on vegetable seed quality.

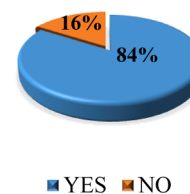
Response	Frequency	Percent (%)	Valid Percent (%)
Yes	21	84	87.5
No	3	12	12.5
Total	24	96	100.0
No response	1	4	
Total	25	100	

**Table 7**  
Identified effects of storage duration on vegetable seed quality.

Responses	Frequency	Percentage (%)
Poor germination	18	81.8
Poor plant establishment	2	9.1
Moulding	1	4.5
Expiry of seeds	1	4.5
Total	22	100.0

**Table 8**  
Storage duration of vegetable seeds in stock.

Duration (Months)	Frequency	Percentage (%)
1 – 3	11	43
4 – 6	3	12
7 – 9	1	4
10 – 12	5	20
Over 12	5	20
Total	25	100



**Fig. 5.** Response to whether retailers kept vegetable seeds together with agrochemicals.

**Table 9**  
Retailers response to whether agrochemicals had negative impact on vegetable seed quality.

Response	Frequency	Percent (%)	Valid Percent (%)
Yes	2	8	9.5
No	19	76	90.5
Total	21	84	100.0
No response	4	16	
Total	25	100	

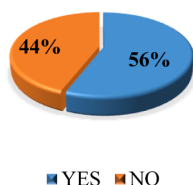


Fig. 6. Retailers' response to whether they repackaged their sourced certified vegetable seeds.

certified vegetable seeds indicated that, request for smaller quantities of seeds by small-scale vegetable farmers was the most cited reason (50%), followed by farmers' inability to afford the cost of seeds in larger containers (46.6%) (Table 10). The least cited reason was the request for small seed quantities for growth and yield tests of new varieties by large-scale vegetable farmers (4.6%) (Table 10).

### 3.8. Feedback on the quality of purchased seeds

Retailers' response showed that, 76% of them received complaints from farmers while 24% did not receive any complaints (Fig. 7).

Most (60%) complaints were about poor germination of the seeds (Table 11). The next was low plant establishment which formed 16.7% of the complaints. Presence of virus followed with 10% while presence of insects, and moulding followed the complaints with 6.7% apiece (Table 11).

### 3.9. Germination tests on stored vegetable seeds

Retailers' response indicated that majority of them (56%) did not conduct simple germination tests on their seeds prior to retailing whilst the remaining 44% did (Fig. 8).

### 3.10. Vegetable seed marketing challenges and suggested solutions

Challenges in certified vegetable seed marketing faced by retailers and farmers and the actors' suggested solutions are presented in Table 12 and Table 13, respectively.

## 4. Discussion

### 4.1. Socio-demographic profile of retailers

The study revealed that vegetable seed retailing is a male-dominated venture as they formed 68% of the sample, and even where females were respondents, most of them were either spouses of the owners or shop attendants for male owners. This observation confirms an earlier report by [22] where males formed 82% of the total agricultural input dealers surveyed in the Ashanti Region. Mabaya et al. [27] also made similar observation where males accounted for 83% of the 3153 agro-input dealers surveyed across Ghana. Male dominance in the retail of certified vegetable seeds may be attributed to a correlating male predominance in agriculture and other allied activities because agricultural activities are prima facie regarded as male-subjugated activities, and that, females involved in agricultural activities are just seen as helpers [10].

Table 10  
Retailers' reason for repackaging certified seeds.

Reasons	Frequency Percent
Request for smaller quantities by small-scale farmers	14 50.0
Farmers' inability to afford cost of seeds in larger containers	13 46.4
Request for smaller quantities for growth and yield tests	1 4.6
Total	28 100.0

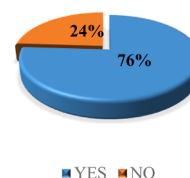


Fig. 7. Percentage respondents indicating receipts of complaints from buyers after purchase of vegetable seeds.

Table 11  
Specific complaints received by retailers from buyers.

Complaints	Frequency	Percentage (%)
Poor germination	18	60
Presence of insects	2	6.7
Moulding	2	6.7
Presence of virus when planted	3	10
Low plant establishment	5	16.7
Total	30	100.0

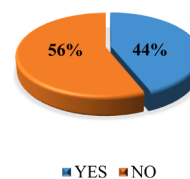


Fig. 8. retailers response to whether they conducted germination test on stored vegetable seeds.

Table 12  
Vegetable seed marketing challenges faced by retailers and suggested solutions.

Challenges	Suggested solutions
Lack of storage facilities	Formation of a vibrant seed retailers' association and request for a central seed storage facility from government to grant all members access to affordable cold storage
Poor access to credit facilities	Formation of functional vegetable seed retailers' association to mutually assist members financially, and access group loans to increase business capital.
Poor communication network between actors	Improving communication between actors in the seed industry to identify challenges and provide appropriate solutions

Table 13  
Vegetable seed marketing challenges faced by farmers and suggested solutions.

Challenges	Suggested solutions
High cost of seeds	<ul style="list-style-type: none"> <li>Government should cut down import duties on vegetable seeds to help reduce cost.</li> <li>Investments should be made in breeding and local vegetable seed production to reduce cost of importation</li> </ul>
Seed package sizes	Suppliers should package seeds in varying sizes to meet every farmer's demand
Variations in maturity times of varieties	Educating farmers on early and late maturing varieties to help them decide when to cultivate

Yuan et al. [45] found a positive relation between previous work experience and entrepreneurial intention. The fact that most retailers were 36 years and over could therefore lead to the belief that most retailers' drive to set up certified vegetable seed trade business emanated from their previous organizational experiences; having spent some years working in an agricultural firm, or institution, or a related field. One's

years of experience from previous work provides a strong base to start a business as it provides management and problem solving skills, and helps in getting initial business contracts [24]. Age plays a vital role in seed business owing to the fact that usually, seed retailers' interest in adopting new innovations diminishes as they get older [28]. The high involvement of the youth in the study might therefore be a good indication of their inclination to embrace and adopt new agricultural and seed trade innovations. Vecchio et al. [41] also reported that younger people have greater ability in gathering information.

As earlier reported by [22] that only 4% of the agro input dealers sampled in the Ashanti Region had no formal education, this study also had similar finding. Vegetable seed retailers' high literacy level is essential for the growth of the seed industry. One reason being that, knowledge about the level of education of the retailers serves as a guide in the planning and delivery of technical services [28]. Adegbola and Gardebroek [2] argued that actors in the seed business who were literate had a higher probability of being acquainted with information, and had better abilities in processing information and fishing out appropriate technological solutions to alleviate their challenges. People with a high level of formal education have been reported to have greater ability in gathering information [41].

Retailers' on-the-job experiences might create familiarity with acceptable practices involved in seed handling. These revelations were evident as the retailers could assert logically their knowledge and experiences with respect to fundamental practices employed in the handling of certified seeds.

Although the formation of partnership has been reported to be an essential tool for increasing productivity and maximizing profits [21, 34], the study showed that majority of the retailers were sole proprietors. This could be cited as a probable contributory factor to the numerous challenges faced by certified seed retailers, most especially, access to credit and storage facilities, leading to the stunted growth of the seed industry in Ghana. Since certified seed retailing is capital intensive, retailers could have accessed credits or mobilized funds to solve most of their challenges much easier if they had formed partnerships than to solely bear all operational costs. Syngenta [39] reported that strong retail partnerships accelerated the dissemination of new technologies to the stakeholders in the seed industry, most especially, the farmers. The absence of partnership in this study therefore suggests that information about improved seeds could not be well disseminated to farmers leading to low patronage of improved seeds by the farmers in Ghana.

#### 4.2. Certified vegetable seed suppliers

All retailers sourced their seeds from seed companies who mainly imported seeds from their sister companies, or other foreign suppliers. These findings corroborate the statement made by Saavedra et al. [35] that most countries in Africa import most hybrid seeds. Seed companies tend to utilize the opportunity created as a result of the virtually non-existing local vegetable seed production industry in Ghana and import a wide variety of vegetable seeds. The lack of a robust local vegetable seed production industry could not only be attributed to the unavailability or limited number of vegetable seed breeders in Ghana, but also, the huge investments that would be required in the breeding, and production of seeds of exotic vegetables under controlled environmental conditions.

#### 4.3. Retailers' knowledge on factors that affect seed quality during storage

Agricultural innovation in recent years has been seen to be not limited to the production and exchange of knowledge, or just the adoption of technology, and have thus been characterized by two main approaches, viz. the Agricultural Knowledge and Information System (AKIS) and the Agricultural Innovation Systems (AIS). The AKIS

recognizes the significance of information transfer from farmers to research systems, but seems to propose that farmers will receive most technologies from researchers [25]. The AIS on other hand aims to enhance knowledge exchange and interactions between actors and institutions that mold innovation processes within and outside the agricultural sector [41]. However, infrastructural failures such as lack of physical infrastructure such as roads as well as knowledge and financial infrastructure are major barriers to the performance of innovation systems [25].

Retailers' knowledge about seed storage is crucial for the maintenance of seed quality. Lack of knowledge has been reported to be a barrier to technology providers (Long et al., 2015). The main sources of information on seed storage are seed companies and GSID whilst retailers and extension officers provide information on seeds to farmers. The study revealed that retailers had adequate knowledge about the factors that affect seed quality during storage. They cited temperature, relative humidity and seed moisture content as the major factors that affected seed quality during storage, corroborating the findings of various authors [5,11,29,42]. They were adequately informed that high temperature, high relative humidity and high seed moisture content facilitated seed deterioration. Retailers further cited storage duration as another factor that affects seed quality during storage, with a general assertion that seed quality wanes with time, especially when seeds are kept under tropical conditions. This is in accordance with the assertion made by Schmidt [36] that in order to prevent seeds from deteriorating, they should not be stored for lengthy periods under tropical conditions.

#### 4.4. Retailers' seed storage and handling practices

Retailers mostly stored seeds at room temperature under predominantly high temperatures and high relative humidity. However, cold storage such as storage of seeds in refrigerators or in air-conditioned rooms was the recommended practice. Retailers were aware of these recommended practices but could not adhere to such practices owing to the fact that they could not afford the high costs involved in the procurement and maintenance of cold storage facilities. Whilst cold storage maintained seed quality and prolonged seed shelf life, storage of seeds under high temperature and relative humidity reduced seed viability and vigour and seed shelf life ([5,11,29,42]). Feedback from farmers on poor germination of some purchased seeds was a confirmation of the adverse effects of high temperature and high relative humidity at the retail shops. Though variations in seed storage practices with respect to socio-demographic profile of retailers was not considered in this article, it should be reported that unlike agrochemical shops, seed companies adhered strictly to recommended practices. Agrochemical dealers could not adhere to instructions from seed companies, government agencies like GSID, extension officers and NGOs on best seed storage practices not because they were unaware, but due to storage barriers. Assistance from government, foreign donors, NGOs, etc. in the provision of cold storage facilities for seed retailers would ensure the availability and continuous supply of quality seeds to farmers, which consequently increases vegetable productivity, improves farmers' livelihoods, and ensures food and nutrition security.

It is worth noting that most retailers, in managing their storage barriers, kept seeds in stock for shorter periods to prevent them from deteriorating, corroborating the findings of Schmidt [36].

This article showed that vegetable seed retailers mostly kept vegetable seeds alongside agrochemicals (fertilizers, pesticides, and weedicides) in their shops. This is in agreement with the findings of Tahirou et al. [40] and AGRA [4] who reported that most seed retailers were agrochemical dealers. It is not recommendable that certified vegetable seeds be stored alongside agrochemicals as these chemicals pose threat to seed quality maintenance, especially, in case of chemical spillage on seeds. Research conducted by Dane and Dalgic [9] revealed that solutions prepared from Benomyl, a fungicide, was able to cause many anomalies in mitotic cell divisions in the root tips of onion during

germination and growth. Legume seeds treated with herbicides also resulted in reduction in nodules formation, thereby reducing the rate of nitrogen fixation [23,37]. This practice by most retailers differed from the instructions and practice of seed companies. Most retailers were also unaware of the possible effect of this practice. In order to ensure seed quality maintenance, continuous education from seed companies, NGOs, GSID, etc. would be required to create awareness that retailers isolate seeds from agrochemicals to prevent a possible accidental spillage of a chemical on seeds which might cause biochemical alterations in the seeds and render them useless for their purpose.

Most retailers repackaged their sourced vegetable seeds into smaller transparent plastic bags. This confirms 'appropriateness of the size and packaging of seeds' as a marketing challenge written in the National Seed Policy [30]. Despite smallholder farmers' request for smaller quantities of seeds and their inability to afford the cost of seeds in larger containers, the practice of repackaging contradicts the recommended provisions made for labelling of seed packages in Section 42 of the Plant and Fertilizer Act (Act 803) [33] which states that, seeds produced or marketed in Ghana shall be packed in containers which shall be securely closed and labelled with an approved label. Repackaged seeds assessed at the retail shops were neither securely closed nor properly labelled with an approved label. Whilst seeds in original containers maintain their integrity, repackaged seeds might not. Repackaging of seeds at retailers' end might not only expose seeds to harsh atmospheric conditions, but could also lead to varietal mix ups, entry of inert matter, and exposure of seeds to air-borne pathogens. To ensure seed quality maintenance, effective communication and collaboration between regulatory bodies, seed producers/companies, retailers, and farmers would be required to curb this menace. Whilst regulatory bodies ensure adherence to seed laws and regulations, seed companies should also package seeds in varying sizes to suit farmers' preference.

The study revealed that most retailers did not conduct simple germination tests on seeds before selling to farmers. This could be due to fact that farmers did not request as they perceived that since seeds were certified, they were of good quality. This assumption is in line with the statement made by Nishikawa [31] that seed certification is very important in crop production in the sense that it is one of the critical mechanisms that guarantees that farmers are supplied with seeds of good quality. However, seed certification may not provide adequate guarantee that the seeds would reach the farmer (end user) in the same state, as it moves through the various seed value chains. Interruptions and deferments in the event of seed conveyance, and how seeds are stored at the retailers' end could have significant negative impact on seed quality [15]. It is therefore imperative for seed retailers to conduct germination tests on randomly selected seeds to ascertain seed percentage germination during the course of retailing.

#### 4.5. Vegetable seed marketing challenges and suggested solutions

Most farmers could not afford the cost of certified seeds, leading to their over-reliance on farmer-saved seeds. Issues of seed pricing is in accordance with an assertion made in the National Seed Policy [30] that a number of attributes determine farmers' satisfaction and subsequent sustainability of a vibrant seed market, one of which is the price of the seed. The National Seed Policy [30] further outlines instability in seed prices as one of the challenges faced by seed marketing in Ghana. The high cost of seeds could be ascribed to the high dependence on seed importation which would usually come with import duties and other applicable taxes. Retailers therefore suggested that investments should be made in breeding and local vegetable seed production to reduce cost of importation. They further suggested a cut down on import duties paid on vegetable seeds to help reduce cost.

Retailers marketing challenges with respect to storage is in agreement with Etwire et al. [14] who reported that a major problem facing Ghana's seed industry is inadequate storage facilities. The National Seed Policy [30] also cited inadequate seed storage facilities as one of the

challenges faced by the country's seed marketing industry. Retailers' suggestion to manage this menace was to form a vibrant seed retailers' association and request for a central seed storage facility from government which would grant all members access to affordable cold storage.

Addressing seed package size as a marketing challenge, retailers explained that, farmers usually made complaints that seed package sizes were too small for the price they paid to purchase them. Some farmers also complained that seed package sizes were bigger than the quantities they required for cultivation. The National Seed Policy [30] also cited appropriateness of the size and packaging of seeds as one attribute that determines farmers' satisfaction which subsequently leads to a sustainable vibrant seed market. Retailers suggested that seeds should be packaged in varying sizes through effective communication and discussions between suppliers, retailers, and farmers.

Retailers' challenge with access to credits could be attributed to the fact that most of them were sole proprietors. Although sole proprietorship is easier to form, one significant disadvantage is that the owner is solely liable for all business costs and liabilities. Retailers could have pulled resources together to solve their financial challenges if they had formed partnerships. The formation of partnership has been reported to be an essential tool for increasing productivity and maximizing profits [21,34]. Suggestions by retailers to solve this challenge included the formation of functional vegetable seed retailers' association to mutually assist members financially, and also access group loans to increase business capital.

## 5. Conclusion and recommendation

Vegetable seed retailers in the Ashanti Region of Ghana were found to be educated to at least the basic level, and had adequate knowledge and experience in handling certified seeds. They were adequately informed that temperature, relative humidity, seed moisture content, and seed storage duration were the major factors that affected seed quality during seed storage. Retailers storage practices did not conform to recommended practices because they could not afford the purchase and maintenance of cold storage facilities as access to credit facilities was a challenge. This barrier could reduce the quality of seeds sold to farmers which was evident as some end users complained of poor germination. Another major marketing challenge was seed pricing as most farmers could not afford the price of certified vegetable seeds resulting in high patronage of farmer-saved seeds. Retailers suggested they form functional groups to mutually assist members in terms of storage and finance, and further called on government to cut down import duties and increase local seed production. Some retailers repackaged their sourced certified seeds into smaller transparent bags to reduce price and also meet farmers preferred quantity. Retailers were of the view that seeds should be packaged in varying sizes by suppliers, to address farmers' dissatisfaction about seed package sizes. Seeds were generally not stored appropriately which is a threat to availability and continuous supply of quality seeds. It is recommended that government, NGOs, seed companies and other stakeholders provide technical assistance for retailers, and help address their challenges through effective engagement and communication to ensure seed quality maintenance. Ensuring seed quality maintenance at retailers' end will ensure farmers are continuously supplied with quality seeds. This will help increase vegetable productivity and consequently boost farmers' income as well as food and nutrition security in Ghana.

### Declaration of Competing Interest

The authors declare no conflict of interest.

### Acknowledgement

This study was partially supported by the World Bank-Africa Centers of Excellence for Development Impact (ACE Impact) project through the

West Africa Centre for Crop Improvement (WACCI), University of Ghana, Legon. We are also grateful to the participants of the study for availing themselves and also sharing their valuable knowledge.

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