



Research article

Assessment of chocolate retail in Ghana and willingness to use cooling devices

Vincent Abe-Inge^a, James Arabe^a, Jacob K. Agbenorhevi^{a,*}, Ibok N. Oduro^a,
Latifatu Mohammed^b, John-Lewis Z. Zaukuu^a, Frank A. Asante^c,
Genevieve Pawar^c, Nana Ofori Owusu^d

^a Department of Food Science and Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

^b Institute of Industrial Research, Council for Scientific and Industrial Research, P. O. Box LG 576, 92 Boundary Road, Accra, Ghana

^c Cocoa Processing Company Limited, Private Mail Bag, Tema, Ghana

^d Expandable Polystyrene Products Limited, Dadeban Road, Accra, Ghana

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ABSTRACT

Cold temperature (≤ 20 °C) storage or handling is required to maintain the quality characteristics of chocolate after production throughout the supply chain. The objective of this study was to assess the retail conditions, challenges, and willingness of retailers to use cooling devices. A total of 228 chocolate retailers sampled from Kumasi and Accra were interviewed using questionnaires with both closed and open-ended questions. The purposive, snowballing, and random sampling techniques were used. The collected data were analyzed using SPSS version 26. The majority of the respondents were female (82 %), aged between 21 and 30 years (33.9 %) and had a maximum of Junior High School education (39.0 %). About 15.4 % were registered retailers of Cocoa Processing Company - Ghana, 56.1 % sold on the streets of which 71.1 % sold under no shade and 71.9 % sold all day. A proportion of 76.2 % reported having challenges in their chocolate retail business. Among these challenges softening dominated with about 78.1 % of the retailers reported experiencing it in their daily operations. Spoilage (18.9 %), damage during handling (35.1 %), oily surface (34.2 %), darker surface appearance (10.1 %), and whitish surface appearance (39.9 %) were other challenges faced by retailers. The majority (76.8 %) of the respondents affirmed elevated temperatures caused melting, oil leakage and fat bloom in chocolate leading to rejections by clients. A significant proportion (81.1 %) indicated a cooling device for retail is necessary and were willing to use it when made available. The findings show that vending conditions were generally unsuitable for the shelf-stability of chocolates. An innovative vending device with cooling system would serve as possible intervention to mitigate the challenges faced by chocolate retailers.

1. Introduction

The history of chocolate traces back to the Maya when it was consumed as a cocoa drink prepared with hot water, cinnamon and pepper [1]. Currently, chocolate is consumed globally by all genders and persons within solid food consumption ages. Chocolate and its

* Corresponding author.

E-mail address: jkagbenorhevi.cos@knust.edu.gh (J.K. Agbenorhevi).

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products are the most utilized and widespread desserts and snacks globally [2–5]. It is often consumed either in the form of solid bars as confectionary or in the form of a semi-solid product as a spread. It is one of the major driving forces of cocoa bean production in the world. Chocolate, specifically, is made from cocoa liquor, cocoa butter, milk, sugar, and additives often formulated in compositions and quantities depending on the target type of chocolate. The main types of chocolate include milk chocolate, dark chocolate, and white chocolate. The type of chocolate is mainly determined by the quantity of cocoa liquor it contains. Dark chocolate, milk chocolate, and white chocolate are required to contain at least 35 %, about 10 %–12 %, and 0 % of cocoa liquor, respectively [6]. The chocolate production starts with the feeding of ingredients; cocoa butter, cocoa liquor, sugar and milk into the jacketed mill grinding chamber, that has been pre-heated to about 60 °C. At the end of the conching operation, the liquefied chocolate masse is pumped and stored in tanks at a temperature of about 40–45 °C. The goal of tempering chocolate is to cause the chocolate to set rapidly, with superior gloss, hardness and with brittle snap which will not develop bloom during storage. Tempering involves cooling of the chocolate masse to about 29–32 °C with continuous stirring and mixing. During moulding, tempered chocolate is dosed into moulds. The moulds are carried into a cooling chamber and gradually cooled at ~10 °C [4,5].

Chocolate is consumed at all times of the year in Ghana. However, it is often patronized the most every February when it is gifted on the 14th of February as part of the St. Valentine's Day celebration.

Chocolate consumption and cocoa production contributes largely to the export revenue and Gross Domestic Product (GDP) of Ghana since Ghana is one of the largest producers of cocoa in the world. Ghana produced at least 689,000 MT of cocoa since 2012, representing the second largest producer in the world, accounting for about USD 2.3 billion in 2022 of the country's export earnings [7]. Chocolate production and cocoa farming provides employment opportunities for millions of Ghanaians, providing a livelihood for majority of Ghanaians in the cocoa cultivation regions. Despite the large tonnes of cocoa produced in Ghana, the nation earns less than 3 % of the over USD 60 billion annual revenue of the cocoa industry due to low consumption of cocoa products among Ghanaians [8].

Chocolate consumption is associated with a significant intake of bioactive compounds which in turn are associated with the prevention of non-communicable chronic diseases including cardiovascular diseases and Type 2 diabetes. These health benefits of chocolate trace back to the 17th century when cocoa itself was implored in Europe to promote good health and cure a myriad of ailments according to Pucciarelli and Grivetti [9]. Specifically, it was implored mostly in the treatment of coughs and colds. Other studies have also reported the health benefits of cocoa and its products on all organ systems in the body [10]. For instance, Field et al. [11] reported the ability of cocoa to increase blood flow and blood oxygenation in the grey matter areas of the brain. Besides, chocolate consumption has been observed to significantly reduce LDL cholesterol levels [12], decrease blood pressure [13], reduce fasting blood glucose levels [14], confer skin protection [15] and demonstrate anti-inflammatory and immunological effects [16]. The health benefits of cocoa and its major product – chocolate – are attributed to its over 300 bioactive components which constitute mainly polyphenols as reported by Fung [17]. These health benefits remain one of the major references in chocolate marketing, patronage, and consumption.

However, the consumption of chocolate, like all other foods, is greatly influenced by its sensory properties mainly flavor, texture, and appearance [18]. Texture particularly plays a key role in the sensory quality score of chocolate and is the target attribute in the tempering stage of chocolate making. Besides achieving a firm and best snap chocolate, tempering is also aimed at achieving a smooth, glossy surface and stable chocolate. These attributes mainly characterize the quality of chocolate but can be altered through poor handling and storage. The exposure of chocolate to oxygen, humid conditions, and elevated temperatures (30 °C and above) result in fat and sugar blooming defects [19–21]. Specifically, fat bloom which involves the de-crystallization, migration, and re-crystallization of fat crystals on the surface of chocolate is caused by exposure of chocolate to elevated temperatures. According to Afoakwa [22], exposing even well-tempered chocolate to elevated temperatures would lead to fat blooming. Sugar bloom on the other hand involves the dissolution of sugars on the surface of the chocolate due to exposure to humid conditions or a rapid relocation of chocolates from a higher temperature condition to a lower temperature zone [22]. Both defects reduce the glossiness and increase stickiness in chocolate making it unappealing to consumers and affecting the shelf life.

Storage at a constant temperature and 75 % relative humidity has been reported to have little influence on the sensory, lipid polymorphism, texture, bloom formation, and the concentration of volatiles of chocolates [23]. Storage temperatures of 6 °C, 12 °C, and 18 °C were recommended as suitable for maintaining the quality of chocolates and eliminating the incidences of fat bloom as well as sugar bloom [19,20,24]. Despite these recommendations, chocolate retailers in Ghana seem to have no or little access to such conditions during retail as they mostly sell chocolate products in the streets, open markets, and shops under sheds or in head pans. These retail conditions may lead to the exposure of chocolate to direct sunlight or higher temperatures which in turn risks its quality before it reaches the consumer and shelf-life [19,20,23,24]. Little research has been conducted to assess the suitability of the vending conditions of chocolate retailers in Ghana. This study is essential to support the adoption and implementation the use of cooling devices in handling chocolates during retail. The objective of this study, therefore, was to assess the vending conditions and challenges associated with chocolate retail in Ghana as well as assess the willingness of chocolate retailers especially street vendors to use cooling devices in handling chocolates during retail.

2. Materials and methods

2.1. Study area

This study focused mainly on Accra and Kumasi where the majority of the chocolate retail occurs as observed by the marketing division of a major chocolate producing company in Ghana. Both cities are located in the Greater Accra and the Ashanti regions respectively in the Southern Zone of Ghana. Greater Accra region is surrounded by the Central region (west), Eastern region (north),

Volta region (east), and the Gulf of Guinea (south). Ashanti region on the other hand surrounded by the Central region in the south, Eastern region in the east, Western region in the west, and Bono Ahafo, and Bono East regions in the north. Areas of Accra included in this study were Kasoa, Jubilee House, 37 Military Hospital, Opeibea House, Kwashieman, Okponglo, and Ministries. In Kumasi; Abrepo, Aboabo, Lake Road, Asokwa, Santasi, Adum, Prempeh II Street, Asafo, KMA, Ashtown, Kejetia Market, KNUST Junction, Ayeduase, KNUST campus, and Anloga Junction were the areas included. These were the major areas identified for street vending/retailing of chocolate in the two cities.

2.2. Questionnaire design

The questionnaire was structured into five (5) sections including *biodata, residential conditions data, vending/retailing conditions, challenges associated with retailing/vending, and willingness to vend/retail in cooling devices*. The questionnaire involved both open and closed-ended questions. The biodata parameters included age, gender, educational level, and marital status. The age ranges spanned from 10 years up to 50 years and above. Residential conditions data aimed at assessing the ownership of cooling storage systems by respondents and power availability among them.

2.3. Sampling, sample size and survey

A total of 271 retailers were interviewed. The sample size was achieved by combining the retailers listed by our collaborating chocolate manufacturer in addition to other retailers that were obtained randomly and through snowballing. Hence, the purposive, random, and snowball sampling techniques were combined in this study. Purposive sampling was used for vendors (35) registered by the Cocoa Processing Company (CPC), Tema, Ghana. The questionnaires were first pretested and fine-tuned using ten (10) vendors before administering them to the respondents. Questionnaire administration was done with five (5) trained field assistants who could translate the English language into the local dialect (mainly *Twi* for Kumasi and *Ga* for Accra). The data collection took place from 14th to December 23, 2021 when the prevailing weather conditions were sunny, hot, and less rainy. The survey targeted mainly street vendors, however retailers in shops, open markets, and supermarkets were also sampled for the purpose of comparison. A verbal consent was obtained, and the questionnaires ([Supplementary file-S1](#)) were administered one-on-one to respondents who could neither read nor write and their responses were recorded. Retailers who showed no interest and those who retailed based on the absence of the actual retailers were excluded. Participants freely took part in the research and were made to understand that the information provided will be treated confidential-no release of participant data without their knowledge. The survey questionnaire contained an ethics statement under the heading of the questionnaire (S1). Thus, “this survey is part of the KReF6 Chocolate Project being carried out by KNUST in collaboration with CSIR-Institute of Industrial Research, Cocoa Processing Company-Ghana, and Expandable Polystyrene Products Ltd. Therefore, data collected from this survey are solely for research purposes and will be treated with the highest possible confidentiality”. This was explained to all potential participants. Those who did not show interest or willingness to participate were not interviewed and thus not included in the survey.

Table 1
Socio-economic data of respondents.

Variable	Frequency, n (%)
Gender	
Male	41 (18)
Female	187 (82)
Age group	
Below 20	20 (8.8)
21–30	77 (33.9)
31–40	67 (29.5)
41–50	48 (21.1)
Above 50	15 (6.6)
Level of Education	
None	15 (6.6)
Primary School	32 (14.0)
Junior High School	89 (39.0)
Senior High School	68 (29.8)
Tertiary Education	24 (10.5)
Marital Status	
Single ^a	110 (48.5)
Engaged	5 (2.2)
Married	100 (44.1)
Divorced	7 (3.1)
Widowed	5 (2.2)
Have Children	
Yes	133 (58.3)
No	95 (41.7)

^a Single means never married.

2.4. Data analysis

The total answered questionnaires were obtained and sorted. The incomplete questionnaires and ones with obviously questionable responses were eliminated [25]. Questionnaires that had up to five (5) unanswered questions were not included. After which, a total of 228 appropriately answered questionnaires were obtained and analyzed. Responses for closed-ended questions were analyzed using the Statistical Package for Social Sciences version 26 whereas responses for open-ended questions were read and summarized. Closed-ended responses were coded and entered into SPSS and the frequencies and percentages were generated. Valid percentages of all responses were used in the results and discussion section.

3. Results and discussion

3.1. Socio-economic data of respondents

As shown in Table 1, the majority (82 %) of the respondents involved in the chocolate retail business were female whilst 18 % were male. This observation can be attributed to the general dominance of females in the food retail or vending business in Ghana. Most (33.9 %) of the vendors were within the age range of 21–30 years whereas vendors aged 50 years and above constituted the least group (6.6 %). The proportions of respondents aged below 20 years, 31–40 years, and 41–50 years were 8.8 %, 29.5 %, and 21.1 % respectively. Cumulatively, 72.2 % of the retailers were 40 years and below. Almost all (93.4 %) of the vendors had at least primary education with 89.4 % receiving at most secondary education. Overall, the majority (39.0 %) of the retailers reported having received a Junior High School education. This was followed by 29.8 % of retailers with Senior High School education hence a total of 68.8 % of retailers with high school education. Retailers with tertiary education represented a proportion of 10.5 % whereas those who reported no level of formal education were only 6.6 %. The educational background of retailers could influence their knowledge on good handling practices to minimize the effects of unfavorable vending conditions. About 48.5 % of the chocolate retailers in this study were single (never married), 44.1 % married, 3.1 % divorced, 2.2 % widowed and 2.2 % engaged. The majority (58.3 %) of the respondents, including unmarried, married, divorced, widowed, and engaged respondents, reported to have between 1 and 6 child/children. Generally, the study results revealed respondents involved in the chocolate retail business are mainly young energetic (<40 years), unmarried, parenting, and female high school leavers. The proportion of females and high school leavers in this study is similar to the findings of Nkosi and Tabit [26] which showed over 70 % of street food vendors were female and mainly had, at most, high school education. This is however contrary to the findings of Loukieh et al. [27] who reported 100 % food vendors in their study in Lebanon. Food handling is often customarily associated with women in many developing countries [28], hence its retail activities including vending are mainly dominated by women. The relatively low level of education of the respondents coupled with the significant levels of unemployment in developing countries explains their inability to secure formal employment [29]. Therefore, engaging in small-scale businesses like chocolate retail becomes a considerable alternative as it requires a relatively low start-up capital [30]. The results also reflect the effects of low girl child education in the past in many developing countries. Due to the conception that women belonged to the kitchen, many girls were not allowed to access formal education beyond high school, a period during which they were often required to marry. The possession of children among respondent signals they engage in the chocolate retail business to earn their livelihoods. It is therefore necessary to give attention to minimizing losses in their businesses and subsequently contribute to improving their total livelihoods through interventions to curtail eminent challenges associated with chocolate retail.

3.2. Availability of cooling/storage facilities and power among respondents

Availability of power/cooling systems at the residence or retail sites of the respondents were assessed (Table 2). Most of the

Table 2
Availability of storage/cooling facilities and power among respondents.

Variable	Response	Frequency ^a , n (%)
Storage facility		
	Refrigerator	Yes 160 (70.5) No 67 (29.5)
Freezer	Yes 42 (18.5) No 185 (81.5)	
	Air-conditioned room	Yes 11 (4.8) No 216 (95.2)
Cool dry rooms	Yes 163 (71.81) No 64 (28.19)	
	None	Yes 13 (5.7) No 214 (94.3)
Electricity Availability		
	Always available	Yes 58 (25.7)
	Occasionally available	Yes 163 (72.1)
	Not available	Yes 5 (2.2)

^a Values represent valid frequencies and percentages.

respondents (94.3 %) had at least one cooling system at their retail sites or homes whereas 5.7 % had no cooling facilities at all. The cooling facilities included refrigerators (70.5 %), freezers (18.5 %), air-conditioned rooms (4.8 %), and cool dry rooms (71.81 %). This implies the availability of cooling systems to provide the required cooler storage temperatures of ≤ 20 °C recommended in previous studies [19,20,24] for minimizing the incidence of fat and sugar bloom defects. The operation of refrigerators, air-conditioned rooms, and refrigerators are, however, dependent on the availability of electrical power supply. About 72.1 % of the respondents reported the occasional availability of power at their residence or retail sites, 25.7 % reported a constant power availability whereas 2.2 % reported no power availability. The intermittent power supply indicates possible fluctuations in temperatures during the storage of chocolate. A constant power supply is essential to maintain a constant storage temperature important for maintaining the sensory quality of chocolate [23]. Also, there is the need to maintain colder and constant temperatures throughout the vending process. This is however often lost especially among the street vendors leading to the exposure of chocolate to elevated temperatures. In the case of a rapid relocation from a colder condition to a hotter one, a sugar bloom is likely to occur [22].

3.3. Vending conditions among respondents, types of chocolate, and income

Table 3, Table 4, and Fig. 1 show the vending conditions under which the respondents operated their chocolate retail business, types of chocolate sold, and income made by respondents. Only a few (15.4 %) of the respondents were registered retailers of CPC (a major producer and supplier of chocolates sold in Ghana), whereas 84.6 % were unregistered. Unregistered respondents cited reasons such as not knowing registration procedures, not knowing the benefits of registration, and the registration process being stressful. Meanwhile, some respondents had no reason not to register. Registration is essential for easy traceability and regulation of the quality of products supplied. It further allows for easy feedback from retailers and consumers, necessary for improving the total quality of products.

More than half (56.1 %) of the respondents sold their chocolates on the streets, 20.2 % in the open markets, 22.2 % sold in shops, and 1.3 % sold at other places (bus stations). Among the respondents who sold on the streets, 28.9 % sold at the roadside-under shade, 37.5 % sold at the roadside-open sun, and 33.6 % sold inside the traffic. This indicates that 71.1 % of street vendors operated outside sheltered areas. Street vending generally presents benefits such as low start-up capital [30] since vendors usually do not require the

Table 3
Vending conditions among respondents.

Variable	Frequency, n (%)
Registration status	228 (100)
Registered	35 (15.4)
Not registered	193 (84.6)
Location of retail site	228 (100)
Street	128 (56.1)
Open market	46 (20.2)
Shop	51 (22.4)
Other	3 (1.3)
Part of street	128 (56.1)
Roadside-under shade	37 (28.9)
Roadside-open sun	48 (37.5)
Inside traffic	43 (33.6)
Type of shop	51 (22.4)
Air-conditioned	6 (11.8)
Electric fanned	38 (74.5)
Other	7 (13.7)
Period of sale	228 (100)
7am–11 a.m.	2 (0.9)
11am–3 p.m.	6 (2.6)
3pm–9 p.m.	56 (24.6)
All day	164 (71.9)
Ability to sell stock taken out in a day	228 (100)
Yes	12 (5.3)
No	100 (43.9)
Sometimes	116 (50.9)
Duration used to sell a carton of chocolate	228 (100)
≤ 1 week	164 (71.9)
2 weeks	28 (12.3)
3 weeks	12 (5.3)
4 weeks	13 (5.7)
> 4 weeks	11 (4.8)
Storage of chocolate among respondents	228 (100)
Refrigerator	40 (17.5)
Freezer	2 (0.9)
Air-conditioned rooms	10 (4.4)
Cool dry rooms	164 (71.9)
Others	12 (5.3)

Table 4
Types and sizes of chocolate sold by respondents.

Variable	Frequency, n (%)
Type/Flavor of Chocolate	228 (100)
Milk Chocolate	57 (25.0)
Dark Chocolate	7 (3.1)
White Chocolate	0 (0.0)
Lemon Flavored Chocolate	2 (0.9)
More than one of these	162 (71.1)
Size of Chocolate (grams)	228 (100)
100	25 (11.0)
50	9 (3.9)
20	3 (1.3)
Mixture of these	191 (83.8)

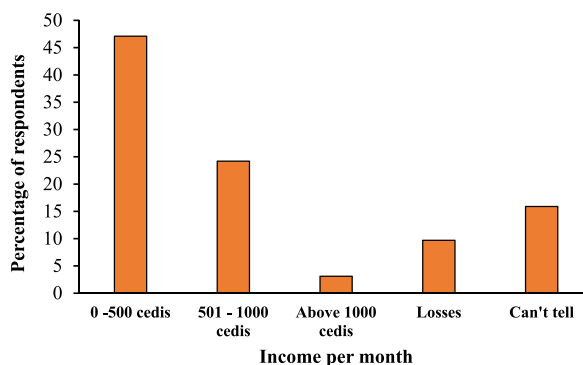


Fig. 1. Income per month generated by respondents from chocolate sale.

Table 5
Challenges associated with chocolate retail among respondents.

Variable	Frequency, n (%)
Have Challenges in Business	227 (99.6)
Yes	173 (76.2)
No	40 (17.6)
Not sure	14 (6.2)
Spoilage	228 (100)
Yes	43 (18.9)
No	185 (81.1)
Damages during handling	228 (100)
Yes	80 (35.1)
No	148 (64.9)
Softening	228 (100)
Yes	178 (78.1)
No	50 (21.9)
Oily surface	228 (100)
Yes	78 (34.2)
No	150 (65.8)
Darker Surface Appearance	228 (100)
Yes	23 (10.1)
No	205 (89.9)
Whitish Surface Appearance	228 (100)
Yes	91 (39.9)
No	137 (60.1)
Do Elevated Temperatures Negatively Affect Chocolate?	228 (100)
Yes	175 (76.8)
No	15 (6.6)
Sometimes	27 (11.8)
Not sure	11 (4.8)
Any client complaints on your chocolate?	228 (100)
Yes	81 (35.5)
No	122 (53.5)
Not Aware	25 (11.0)

construction of shelters for their operations. Also, there would be no requirement for a business license as well as taxes hence the costs involved in these are avoided among street vendors. However, the unsheltered conditions of street vending expose the chocolate product to unfriendly temperatures and drizzling rains which eventually alter the product's factory quality before it reaches the consumer. Among shop sellers, a majority (74.5 %) operated under electric fanned conditions, 11.8 % in air-conditioned rooms whereas 13.7 % operated under none of these conditions. Respondents stationed in the open markets also operated under no cooling conditions. In total, about 94.3 % of the respondents operated under ambient conditions with no available cooling systems. Respondents reported using ice, refrigerators, and napkins moistened with chilled water to re-solidify melting chocolates during business hours. However, temperature and relative humidity which contribute significantly to maintaining the quality and shelf-stability of chocolates are not adequately controlled among the respondents under these vending conditions [19,20]. Previous studies have revealed storage temperatures above 20 °C have adverse effects on the quality attributes and shelf-stability of chocolates [20,23,24]. It is therefore clear that chocolate sold under the conditions observed in this study would most likely undergo deteriorative changes including fat and sugar bloom.

Respondents operated at different times of the day. However, 71.9 % of them sold chocolates all day, 24.6 % from 3 p.m. to 9 p.m. (GMT), 2.6 % from 11:00 a.m.-3:00 p.m. (GMT) whilst only 0.9 % sold during hours before 11:00 a.m. (GMT). Street vendors constituted the majority (33.77 %) of retailers that sold all day (33.77 %) and between 3 p.m. and 9 p.m. (GMT) (20.18 %). Among these, only 5.3 % of retailers were able to sell all chocolate stock taken out daily for vending. About 71.9 % indicated they used about a week or less to sell a carton of chocolates. This implies chocolates sold by these retailers are most likely repeatedly exposed to the observed unfavorable conditions of vending for about 1–7 days before finally reaching the consumer. This explains the consumer complaints reported by 35.5 % of the respondents (Table 5).

The storage of chocolate among respondents outside business hours was assessed. As shown in Table 3, 71.9 % of the respondents stored their stock of chocolates in cool dry rooms, 17.5 % in the refrigerator, 4.4 % in air-conditioned rooms, 5.3 % in any other available place, and 0.9 % in the freezer. Subjecting chocolate to cold storage systems (freezers, air-conditioned rooms, or refrigerators) and later exposing it to high temperatures reduces its quality. Nightingale et al. [23] reported that storage of chocolates at constant temperatures had the least influence on sensory properties, fat bloom as well as loss of volatile concentrations in chocolates. Besides, temperatures in cool dry rooms may not be monitored and are difficult to maintain at the recommended suitable temperatures. Therefore, chocolates stored under these conditions could be exposed to undesirable temperatures when the atmospheric temperatures generally increase.

Table 4 shows the types and sizes of chocolate sold by the respondents. The majority (71.1 %) reported selling more than one type of chocolate. On the other hand, 28.9 % of the respondents sold only one type of chocolate. Of this cumulative value, 25 % sold milk chocolate, 3.1 % sold dark chocolate, and 0.9 % sold lemon-flavored chocolate whilst none sold white chocolate. Respondents who sold more than one type of chocolate often sold mainly milk in addition to either dark chocolates, lemon-flavored chocolates, or dark-milk chocolates. This indicates milk chocolate was the most sold type of chocolate among the respondents. This finding buttresses the earlier findings of Barry Callebaut USA [31] which indicated the most consumed chocolate in the USA was milk chocolate.

The respondents either sold only a mixture of chocolate sizes or only one size of chocolate. About 11 % sold 100 g sized chocolates, 3.9 % sold 50 g sized chocolates, 1.9 % sold 20 g sized chocolates and a larger proportion (83.8 %) sold a mixture of either 2 or 3 of these sizes. The exposure of chocolates of different sizes to similar conditions of unfavorable elevated temperatures could cause greater damage to the smaller sized ones. This is because heat transfer is faster in smaller pieces than in larger pieces of the same product. Quality defects are therefore more likely to occur at faster rates in the smaller-sized chocolates than the larger ones.

Fig. 1 presents the estimated monthly income generated by chocolate retailers in Ghana. Close to half (47.1 %) of the vendors made between 0 and 500 cedis, 24.2 % made between 500 cedis-1000 cedis, 3.1 % made above 1000 cedis, 9.7 % reported losses and 15.9 % could not tell how much they earned. It indicates about 15.9 % earn a livelihood from retailing chocolates and other products. Whereas about 84.1 % of the respondents earned a livelihood mainly from the chocolate retail business. This is similar to the findings of McKay et al. [32] and Nkosi and Tabit [26] who revealed street food vendors depended solely on profits made from their businesses to sustain their households. The location of sales as well as the duration of business hours might influence the varying profits made by vendors. However, the respondents attributed lower profit margins and losses to some observed challenges associated with the chocolate retail business which are presented in detail in the next section.

3.4. Challenges associated with chocolate retail business among respondents

The challenges faced by the respondents in their chocolate retail business were assessed. The majority (76.2 %) of them affirmed that they encounter some challenges in the chocolate business, 17.6 % said they had no challenges in the business whilst 6.2 % were not sure. These challenges mainly included spoilage (18.9 %), damages during handling (35.1 %), softening (78.1 %), oily surfaces (34.2 %), whitish surface appearance (39.9 %), darker surface appearance (10.1 %) and others (12.3 %). Spoilage included mainly expiration and mould growth (before expiration dates), damages mainly included breakages whereas 'others' included pest infestation and package detachment. It is evident that softening was the most dominant challenge faced by the respondents in their chocolate vending business. It was attributed to the exposure of chocolates to elevated temperatures by 76.8 % of the respondents. This signals the awareness of the undesirable effects of elevated temperatures on the chocolates among the respondents. However, they are probably compelled to vend under the unfavorable conditions presented in Table 3 and described in the previous section. This is because the majority (84.1 %) of the respondents depended on chocolate vending to earn a livelihood.

Softening of chocolates at elevated temperatures reported by respondents in this study is a common challenge as previously reported [20,21,24]. Ostrowska-Ligeza et al. [33] suggested that possible softening in chocolate products when exposed to higher

temperatures may be related to the product approaching the melting point of the fat content. According to Afoakwa et al. [22], exposing a well-tempered chocolate to higher temperatures or direct sunlight may result in the blooming of fat in the chocolate. The mechanism of fat bloom is associated with the dissolving of chocolates (softening) at high temperatures and upon recrystallization, the absence of inoculation ensures a direct formation of the stable form V leads to the gradual transformation of an unstable form into a stable form. In addition to softening, the phenomenon causes the migration of fats to the product surface, and the subsequent appearance of an oily chocolate surface accompanied by undesirable textural changes [20]. This explains the oily surface challenge observed among the respondents in this study. These challenges account for the consumer complaints observed by 35.5 % of the respondents.

3.5. Respondents' willingness to retail in cooling vending devices

Temperature control is essential in the shelf-stability of all food products and very critical in maintaining the post-production quality of chocolates. The major challenge among the chocolate vendors in this study was softening which is due to exposure of chocolates to elevated temperatures. There is therefore the need to implement cooling systems to ensure a constant cooling effect throughout the supply chain of chocolates. This is especially important during vending to ensure chocolates are kept under the required cooler temperatures. The willingness of the respondents to vend in cooling devices was therefore assessed and the results are as presented in Table 6. Almost all the respondents (about 81.1 %) found it necessary to vend using a cooling device, 11.0 % were not certain about its necessity and 7.9 % indicated it was not needed. About 74.6 % indicated vending in a cooling device would improve their income, 7.0 % did not find it worth improving their income and 18.4 % were not sure of its effect on their income. A proportion of 10.1 % indicated vending in the cooling devices would increase their work stress. Overall, 69.7 % of the respondents were very willing to use a cooling device in their chocolate vending business whereas 21.1 % were not sure. About 9.2 % were not interested and this was based on reasons that the device may occupy space at their vending sites (for respondents in shops), would consume energy, they cannot afford the device, and the device would increase the stress of their business. Vending in a cooling device could help keep chocolate under the recommended temperatures of ≤ 20 °C suggested by previous studies [19,20,24].

As presented in Fig. 2, the respondent's preferences for the design style of the cooling device differed. About 37.9 % of the respondents preferred a tabletop type of cooling device, 37.4 % preferred a device that could be carried by hand, and 21.3 % preferred one that can be carried on the head. A few (3.3 %) preferred a device that can be pulled/pushed along. This difference in preference is due to the nature and location of retail among the respondents. Stationary retailers generally preferred a tabletop type of cooling device. Mobile retailers on the other hand preferred a cooling device that can be carried on the head, by hand, or pulled along. All respondents expressed their interest in a cooling device that can display their chocolates to attract clients in addition to the cooling effect and being affordable.

4. Conclusions

The study revealed that most chocolate retailers operated under conditions unfavorable to maintaining the quality of chocolate. Respondents mainly exposed chocolates to direct sunlight, drizzling rains, and subsequently humid and hot environments. Those who sold in shops with electric fans or air-conditioning as a means of cooling were very few. The majority of the retailers sold chocolates throughout the day (where temperatures are quite high in the afternoons). Quite a number of vendors indicated that chocolate stock taken out in a day does not finish hence it takes more than a day to sell a box of chocolates.

Challenges such as softening and the presence of oily surfaces were the major challenges encountered by the retailers. The retailers affirmed that these challenges were mainly due to the exposure of their chocolates to elevated temperatures. Therefore, they found it

Table 6
Respondents' attitude towards and perception on handling chocolate in a cooling device during sales.

Question	Frequency, n (%)
Cooling device is necessary	
Yes	185 (81.1)
No	18 (7.9)
Don't know	25 (11.0)
Device will improve income	
Yes	170 (74.6)
No	16 (7.0)
Not sure	42 (18.4)
Device will increase stress	
Yes	23 (10.1)
No	133 (58.3)
Not sure	72 (31.6)
Willing to use device	
Very willing	159 (69.7)
Not interested	21 (9.2)
Not sure	48 (21.1)

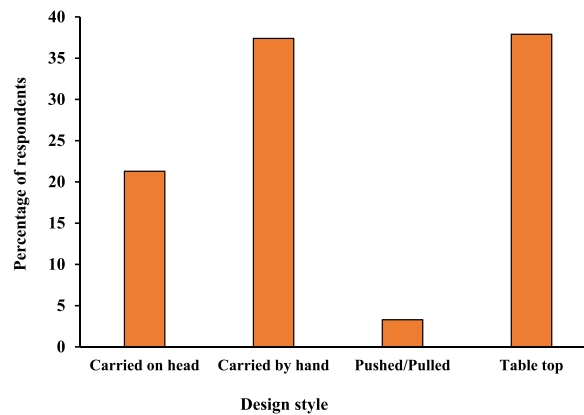


Fig. 2. Respondents' expected design style of cooling device.

necessary for a cooling vending device to be used in their retail operations. Also, the respondents were very willing to use a cooling device as they believe would contribute to maintaining chocolate quality and subsequent reduction of losses and improvement in income generation. Affordable cooling vending devices capable of attractively displaying their contents should be developed for chocolate vendors, especially street vendors. Also, further studies should be conducted to assess the quality of chocolates sold under the different conditions reported in this study in order to further establish the necessity for a cooling vending device.

Ethics statement

The survey questionnaire contained an ethics statement under the heading of the questionnaire. Thus, "this survey is part of the KReF6 Chocolate Project being carried out by KNUST in collaboration with CSIR-Institute of Industrial Research, Cocoa Processing Company and Expandable Polystyrene Products Ltd. Therefore, data collected from this survey are solely for research purposes and will be treated with the highest possible confidentiality". This was explained to all potential participants. Those who did not show interest or willingness to participate were not interviewed and thus not included in the survey.

Data availability statement

The experimental data used to support the findings of this study are as presented in the paper and are available from the corresponding author upon request.

CRediT authorship contribution statement

Vincent Abe-Inge: Writing – review & editing, Writing – original draft, Methodology, Investigation. **James Arabe:** Writing – review & editing, Writing – original draft, Methodology, Investigation. **Jacob K. Agbenorhevi:** Writing – review & editing, Visualization, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Ibok N. Oduro:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition, Conceptualization. **Latifatu Mohammed:** Writing – review & editing, Resources, Methodology, Investigation, Funding acquisition, Conceptualization. **John-Lewis Z. Zaukuu:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Frank A. Asante:** Writing – review & editing, Supervision, Resources, Methodology, Funding acquisition, Conceptualization. **Genevieve Pawar:** Writing – review & editing, Resources, Methodology, Funding acquisition, Conceptualization. **Nana Ofori Owusu:** Writing – review & editing, Resources, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2024.e36961>.

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