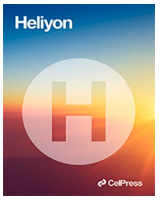
Heliyon 10 (2024) e30247

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

Tilapia consumption patterns and consumer preferences: Predictors and perspectives of consumers in Ghana

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ARTICLE INFO

Keywords:
Tilapia consumption
Ghanaian consumer

ABSTRACT

The objective of this study was to assess consumer behaviour towards tilapia and tilapia products and provide information linking production with consumption patterns and preferences as well as to predict factors that influence consumer preference, purchase behaviour, and willingness to patronize tilapia fillets using classification and regression trees. A total of 960 responses were obtained using convenient sampling. The findings of this survey indicate that tilapia is eaten mainly because of its taste. Regarding the various cooked tilapia options available in Ghana, 58.5 % preferred charcoal-grilled tilapia while sixty-six per cent (66 %) preferred to purchase their tilapia in the fresh state. Furthermore, sixty-five per cent (65 %) of the participants revealed that they consume tilapia at least once a month, indicating a link between production and consumption, as well as a continuous market for tilapia fish farmers. Most respondents (85 %) would prefer an easier way to prepare tilapia. The availability of tilapia in a fillet form appealed to about 50.8 % of respondents with 78 % indicating that they would purchase tilapia fillets if they were available on the market. For the parts of tilapia consumed, 70 % indicated that the head of tilapia was important to them and only 49 % of respondents indicated they would buy fillets without the head. The top three preferred fillet options in increasing order were chilled, frozen, and spiced. From the study of associations, income was the most important factor determining whether a consumer would purchase tilapia fillets or not. However, with regards to preference of head or tail region, age was the most important determining factor. Thus, consideration of all these factors would serve as a guide to businesspeople and actors within the tilapia value chain in Ghana and beyond.

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https://doi.org/10.1016/j.heliyon.2024.e30247
Received 25 September 2023; Received in revised form 15 April 2024; Accepted 22 April 2024
Available online 25 April 2024

1. Introduction

Fish is a healthy alternative to meat. Globally, seafood accounts for only 17 % of edible meat. However, with increasing demand for fish and declining marine stocks, a sustainable supply of wild fish as food may be a challenge. Consequently, mariculture and aquaculture activities could sustainably support countries like Ghana to achieve fish food security [1,2].

Fish forms about 60 % of the protein intake of Ghanaians and tilapia is a popular fish that is regularly eaten in Ghana, with family consumption figures of about 500 tonnes per year [3] and an annual per capita consumption of 28 kg [3,4].

As with other types of fish, tilapia is known to be good for health and nutrition because it is abundant in protein, vitamins, minerals, and polyunsaturated fatty acids [5]. Tilapia is reported to be the 9th most preferred fish because it is expensive [6]. However, a study by Mingle et al. [7] indicated it was the most preferred fish. Fish consumption is high in Ghana, with consumption of several types of fish like red snapper, herring, mackerel, tilapia, tuna, and small fish like anchovies, and bumper to mention a few. However, there is little information on specific consumption patterns and preferences.

In 2018, Ghana recorded fish capture and aquaculture figures of 376,767 tons and 76,630 tons, respectively [8]. This is a consequence of the efforts made by the Ghanaian government to promote tilapia aquaculture production to compensate for the depleting marine fish stocks [1,9,10]. Historically, fish farming started in the 1950s in Ghana when the government constructed ponds for hatcheries to support reservoir fishery development programmes. The dug-out earthen ponds, concrete ponds, and reservoirs were government-owned and were sited near irrigation dams. These facilities were used primarily for fingerling production, demonstrations, training of farmers, and for research purposes. After independence in 1957, a policy change saw the development of fishponds in all national irrigation sites, and 5 % of the total irrigation area was allotted to fish farming. This policy was not very successful, thus between 1982 and 1984, several privately owned fishponds were constructed [11].

In the early 2000s, further policy changes led to the formation of a Ministry of Fisheries under the Ministry of Agriculture, and the appointment of a deputy minister in charge of aquaculture. This led to the provision of free extension services to fish farmers, the promotion and formation of fish farmers' cooperatives, the provision of loans to purchase bulldozers for pond construction, and the production of fingerlings at government-operated fish hatcheries for sale to farmers. Even though fish production in Ghana started in earthen ponds, to produce the Nile tilapia, large-scale operations occur in ponds and cages on Lake Volta [12]. Today, most commercial-scale caged farms supply the bulk of tilapia (85 %) for the market and these commercial caged farms constitute less than 2 % of the farms. As a result, tilapia is available in diverse sizes, and the average Ghanaian has gradually developed a taste for tilapia

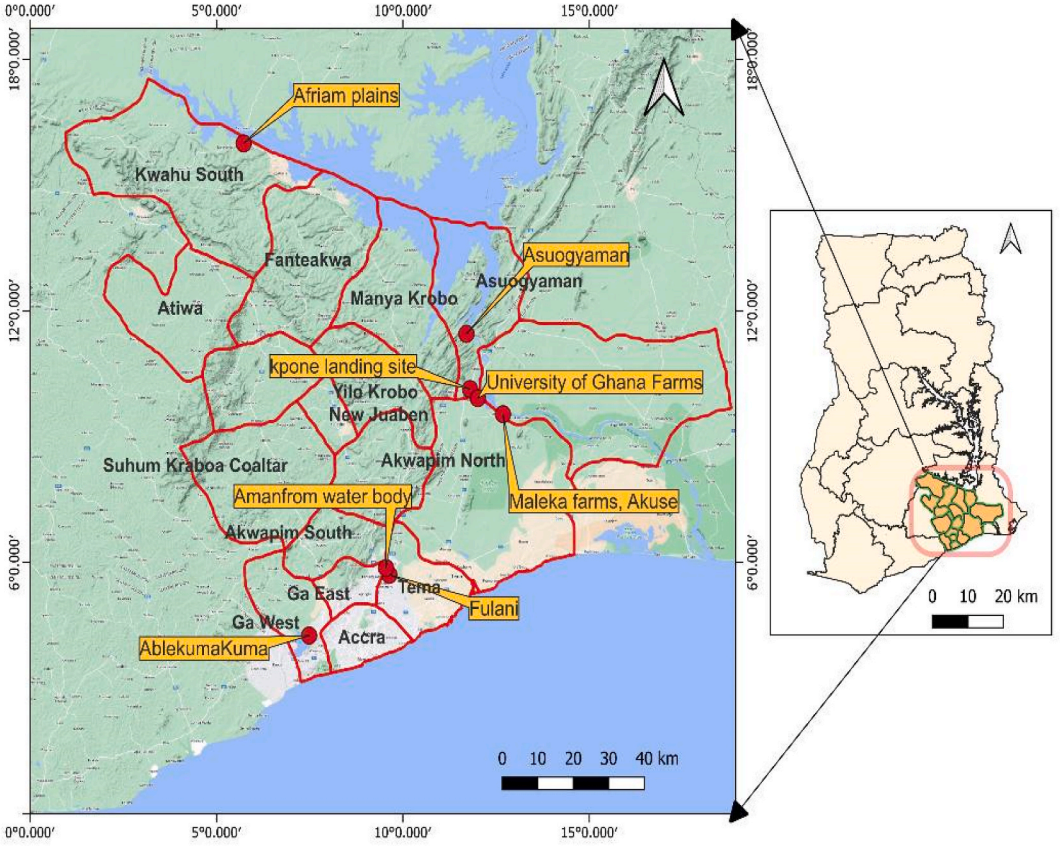

Fig. 1. Sectional map of Ghana showing the study areas in the Greater Accra and Eastern regions.

because of its availability [13]. Traditionally, as with other types of fish, for long-term preservation, tilapia is usually salted and dried or smoked. Additionally, because it is such a perishable meal, it needs to be kept chilled or refrigerated. To accomplish long-term preservation, tilapia is primarily processed in Ghana by frying, smoking, sun-drying, and salting [14,15]. In Ghana, it is frequently char-grilled and eaten with pepper and fermented maize dumpling sauces as street food and in other dining places [3]. According to Asiedu et al. [3], there are no establishments processing aquaculture products, limiting the potential of the aquaculture industry in Ghana. However, further development of the aquaculture industry will enhance the consumption of fish food and improve nutrition because of the increased consumption of tilapia. Despite the Government of Ghana's strong support for aquaculture, little is known about how expanded aquaculture affects tilapia consumption and the use of tilapia and tilapia products. In addition, there is a lack of variety with boneless versions of tilapia on the local market. Some people like tilapia but cannot manage the bones either as processors or consumers and may avoid them. Filleting of tilapia, (a process that involves the removal of fish flesh from the bones) will make way for its use in non-traditional ways, providing variety and versatility for consumers. The option of a tilapia fillet product will also be convenient for the working class. This paper, therefore, reports specifically on consumer behaviour and consumption patterns towards tilapia and tilapia products, and the factors predicted to influence preference, purchase, and willingness to patronize tilapia from the Ghanaian consumer's perspective.

2. Methodology

2.1. Data collection and questionnaire administration

A structured manual questionnaire and an online version using KoboToolbox were both used to collect the data. The questionnaire was structured into four sections, with questions on the demography of the consumer, how and why tilapia is acquired, and interest and willingness to pay for tilapia and tilapia products. Scientists evaluated the questionnaire, and staff of the Council for Scientific and Industrial Research - Food Research Institute (CSIR-FRI) pre-tested it. Before distribution, the questionnaire was modified based on the received feedback.

Questionnaires were given out to tilapia consumers in the Northern and Southern parts of Ghana, specifically from Ghana's Eastern, Greater Accra, Central, Western, Ashanti, Bono, and Northern regions. These study areas were zoned to ensure fair distribution and were picked to encompass the entire nation. Fig. 1 shows the map of the study area. Additionally, the online survey link was posted on various WhatsApp platforms and email lists to obtain responses from consumers of tilapia based on their willingness to participate in this study. Responses were sent directly to the web KoboToolbox software. The survey was conducted between September 2021 and December 2021. The sample size was calculated based on the Cochran formula [16].

2.1.1. Inclusion criteria

The inclusion criteria were anyone who purchases or prepares and consumes tilapia of 18 years and above and is legally allowed to make decisions independently and provide accurate information.

2.1.2. Ethical clearance

Provisional ethical was granted on June 22, 2021. Full ethical clearance and authorization (RPN 005/CSIR-IRB/2021) dated November 19, 2021 was obtained under the HealthyFoodAfrica Project from the Council for Scientific and Industrial Research (CSIR) Institutional Review Board.

2.2. Classification and regression tree (CART) analytical models

CARTs are machine learning techniques used for building prediction models from data [17]. It is fundamentally non-parametric. Furthermore, an advantage of this technique is that no assumptions are made regarding the underlying distribution of values of the predictor variables [18].

CART was used to study the relationship between categorical or continuous predictors and their responses. Specifically, the association between consumer's monthly expenditure on tilapia, preparation of tilapia prior to cooking, preference for tilapia fillets, purchase of tilapia fillets, tilapia region preference, purchase of filleted tilapia without the head, and socio-demographic variables (age, education, gender, and income) were studied using classification machine learning algorithms.

CART was adopted as described by Zacharis [19]. For the given predictors and the categorical response (binomial or multinomial), the response data set was split into two parts using homogeneity of data as a criterion. To decide which attribute to split, the Gini impurity measure was used.

A decision tree or classification tree is a statistical model for forecasting an outcome based on covariates to create a prediction rule that minimizes a loss function and measures the discrepancy between the predicted and true values [20]. The forecasted outcome in each subset is determined by averaging the outcomes of the individuals in the subset.

The predictors were treated as either continuous or categorical variables and based on this, an appropriate splitting was done. For a continuous predictor variable 'X' and a value "c", a split was defined by sending all records with the values of 'X' less than or equal to "c" to the left branch node, and all remaining records to the right branch node. The average of two adjacent values was then used to compute 'c'. A continuous variable with N distinct values generated up to N–1 potential splits of the parent node. For a categorical predictor variable 'X' with distinct values (c_1, c_2, …, c_k), a split was defined as a subset of levels that were sent to the left child node. A categorical variable with K levels can generate up to $2^{K-1} - 1$ split.

2.2.1. The Gini criterion

Suppose there are a total of K classes, each indexed by k. Let Pmk be the proportion of class k observations in node m. The Gini index was estimated as.

$$\sum_{k=1}^{k} \binom{n}{k} Pmk(1 - Pmk).$$

This measure is frequently used in practice and is more sensitive than the misclassification error to changes in node probability [21].

2.2.2. Pruning

Trees were trimmed to increase the classification's predictive power by preventing data overfitting and placing one piece of data in each leaf node. An independent test set was included in a v-fold cross-validation of the data because the data set's size was under 5000.

All the data sets were used to fit an initial overly large tree. The data was divided into $v = 10$ subgroups, and 10 separate models fitted. The first model used subgroups 1–9 for training and subgroup 10 for testing. The second model used groups 1–8 and 10 for training, and group 9 for testing. In all cases, an independent test subgroup was available. These 10 test subgroups were then combined to give independent error rates for the initial overly large tree which was fitted using all data sets.

2.2.3. Model adequacy

The most accurate classification tree was selected based on misclassification cost. The lowest misclassification cost was selected, and the receiver operating characteristic (ROC) was estimated. This was done by plotting the true positive rates (power of model) against false positive rates (type I error). The performance of the training data set was also compared to that of test data to assess overall model adequacy by comparing the training and test data for sensitivity or true positive rates (TPR), type I error or false positive rate (FPR), type II error or false negative rate (FNR) and specificity or true negative rate (TNR).

2.2.4. Data analysis

Descriptive statistics (medians, ranges, percentiles, proportions, and graphs) were used to summarize the variables of interest using Statistical Package for the Social Science (SPSS) version 25, and Minitab 21 was used for data analysis.

Chi-square test for association was used to determine associations between variables; the Kruskal Wallis test was used to determine statistically significant differences between two or more independent groups and the Mann Whitney test was used to compare if the two groups of variables of interest were significantly different.

Table 1
Demographic information of respondents.

Variable	Category	Frequency	Percent (%)
Sex	Male	437	45.5
	Female	523	54.5
Age (years)	Less than 20	17	1.8
	20–29	336	35
	30–39	343	35.7
	40–49	172	17.9
	50 and above	92	9.6
Ethnicity	Akan	473	49.3
	Ewe	198	20.6
	Ga Adangbe	187	19.5
	Guan	31	3.2
	Moli Dagbani	32	3.3
	Other	39	4.1
Level of education	None	2	0.2
	Primary	3	0.3
	Middle school/JHS	17	1.8
	Secondary	103	10.7
	Tertiary	833	86.8
	Other	2	0.2
Income	Less than GH'500	152	15.8
	GH'501–1000	186	19.4
	GH'1001–2000	164	17.1
	GH'2001–3000	165	17.2
	Greater than GH'3001	293	30.5

3. Results and discussion

3.1. Socio-demographic characteristics of consumers

Research has shown that socio-demographic characteristics may impact an individual's perceptions, preferences, or choices [22]. In this study, gender, age, ethnicity, educational level, and income status were the main socio-demographic factors considered. These are presented in Table 1.

3.1.1. Gender, age, and ethnicity

Table 1 describes the socio-demographic characteristics of respondents. Females constituted 54 % and males, 46 % of the total 960 respondents. This could be because women in general are known to be more involved with fish handling in Ghana, and hence they are more interested in a survey involving fish than men.

As shown in Table 1, about 36 % of respondents were between the ages of 30 and 39 years. Nearly 90 % of them were between the ages 20 and 49, with a mean age of 34.5 years. This matched the mean age of the study by Ragasa et al. [23], which looked at the demand and willingness to pay for safe tilapia and chicken meat among 803 Accra consumers.

The proportion of Akans, Ewes, and Ga Adangbes that participated in this study was 49 %, 21 %, and 19 %, respectively. On the other hand, Guans and Mole Dagbani had the fewest respondents (3 %) of the total sample. About 4 % of the respondents may have been from any of Ghana's more than 70 ethnic groups and did not identify with any of the five main multiple ethnic categories that were offered. There were more Akans than other ethnic groups representing almost 49 %. The study's participant's distribution of ethnicities follows a similar distribution as the Ghanaian population. According to Agyei-Mensah & Owusu [24], the Akans constitute 47.5 % of the population, the Mole-Dagbanis at 16.6 %, the Ewes at 13.9 %, the Ga-Adangbes at 7.4 % and the Guans at 3.7 % in Ghana.

Table 2
Tilapia consumption and acquisition preferences of consumers.

QUESTIONS	LEVELS	COUNTS	% PROPORTION	CHI-SQUARE (X^2)	P VALUE ($\alpha = 5$ %)
Tilapia consumption frequency	1-3 times a week	111	11.7	132	<0.001
	Once a month	320	33.6		
	Twice a month	188	19.8		
	Once in 6 months	185	19.5		
	Others	146	15.4		
Why do you consume Tilapia?	Nutrition	368	38	992	<0.001
	Cost	26	3		
	Health	155	16		
	Taste	570	59		
	Others	20	2		
Are you able to afford Tilapia?	Yes	655	68.2	128	<0.001
	No	305	31.8		
Is Tilapia available all year round?	Yes	765	79.7	338	<0.001
	No	195	20.3		
Location of Tilapia purchase	Akosombo	46	4.81	716	<0.001
	Tema	136	14.2		
	Sogakope	20	20.9		
	Weija	117	12.2		
	Kpong	31	32.4		
	Accra	351	36.7		
	Others	283	29.6		
Source of raw tilapia purchase	Fish landing port	67	7	639	<0.001
	Wholesaler at market center	116	12.1		
	Retailer at market center	441	46		
	Cold store	249	26		
	Hawkers	134	14		
	Delivery services	46	4.8		
Why purchase raw Tilapia at the location?	Cost	216	22.5	509	<0.001
	Size	102	10.6		
	Freshness	356	37.1		
	Convenience	438	45.7		
	Other reasons	29	3		
Tilapia form preference	Fresh	631	65.7	365	<0.001
	Frozen	317	33		
	Processed	125	13		
Ready to cook form preference	Smoked	641	66.8	194	<0.001
	Salted	475	49.5		
	Fillets	227	23.7		
Cooking method preference	Boiled/Steamed	353	36.8	272	<0.001
	Charcoal-grilled	564	58.8		
	Pan grilled	159	16.6		
	Fried	253	26.4		

3.1.2. Education and income

Most (87 %) of the respondents had some form of tertiary education i.e., doctorate/master/bachelor (first degree), a diploma, or a higher national diploma. Although this seemed to have skewed the data, a study of this population was desirable because they constitute the working class, earn a decent income, and are a potential target market for the developed tilapia products.

Salaries in Ghana vary based on qualification, career, and experience. A salary explorer website reported a starting monthly salary of about GH₵1280, an average salary of GH₵5070, and a high salary of about GH₵22,600 [25]. The national tripartite committee also increased the daily national minimum wage per person in 2023 to GH₵14.88 (equivalent to 1.37 United States Dollars (USD) at an exchange rate of 1 USD = 10.90 Ghana cedis). Most survey participants earned more than GH₵3000 per month (Table 1). This supports research by Ref. [26] who discovered that income status is closely linked to educational attainment, as seen in this study. Most of the respondents were civil servants, and the income trend validates study findings that indicate the average pay of a civil servant in Ghana is above GH₵3000 [27].

The educational background of respondents was categorized into primary, middle school, tertiary, and no formal education. The results indicated that only 0.2 % had no formal education, 0.3 % had only primary education. Many of the respondents had tertiary education (87 %), while about 11 % had secondary education, and only 1.8 % had junior secondary (middle school) education. There were less than 0.5 % of respondents with other educational backgrounds (e.g., Arabic education). A similar study by Darko et al. [28] revealed that the percentage of consumers of tilapia with tertiary education was high. They suggested that the level of education influenced the quality and quantity of tilapia fish consumed.

Most respondents earned more than GH₵3000 every month, representing almost 31 % (p-value <0.001). The second highest income earners were those in the GH₵501–1000 bracket which constituted about 19 %. Respondents earning GH₵1001–2000 and GH ₵2001–3000 represented about 17 % each and those earning less than GH₵500 represented about 16 %.

3.2. Tilapia consumption patterns and preferences

The survey determined the reason consumers dislike tilapia. Most respondents (53 %) reported that they dislike tilapia because it is too bony. Studies by Meira & Engle [29] in Nicaragua, indicated that the bony nature of tilapia was one of the reasons why it was disliked. On the other hand, in this study, taste, nutrient content, health, and affordability are the top four reasons people eat tilapia, with taste as the main reason. This was consistent with a study by Darko et al. [28] on consumers' preferences for farmed tilapia in Tanzania. According to them, people would be willing to pay more for tilapia if it were more readily available and had a better taste. Similarly, Ayuya et al. [30] and Uddin et al. [31] also asserted that consumers in Kenya and Bangladesh chose tilapia primarily based on taste. However, others reported that affordability and cost were the main reasons why tilapia was preferred [32,33].

Responses to questions on tilapia consumption and acquisition preferences are presented in Table 2. Most survey participants (34.1 %) eat tilapia once a month (Table 2) and this proportion of respondents was significantly higher ($p < 0.05$) than those who consume tilapia once every six months (19.5 %), twice a month (20.2 %), and 4–12 times a month (11.7 %). About 15 % of the respondents said "as and when" instead of utilizing the multiple-choice answers to indicate their intake rates. This means that consumption was determined by availability at parties and festivals rather than by actual purchase [34]. Therefore, with a 95 % confidence rate, it can be said that 65.6 % of customers in Ghana consume tilapia on average once each month, an indication of available markets for outputs of tilapia farming, despite the high cost of tilapia. However, investigations by Orire et al. [32] found that many tilapia consumers in the Makurdi metropolis, Benue state in Nigeria, consume tilapia at least thrice a week. This contrasts with the frequency of consumption in Ghana. The disparities in consumption rates could be caused by the economic disparities and income levels between these two nations. Ghana is a nation in which fish constitutes about 60 % of animal protein intake [35]. Given the current increase in tilapia farming and the expanding consumer demand for tilapia [6], it was encouraging to learn that consumers in Ghana regularly consume tilapia.

The preference for fresh tilapia over frozen and processed tilapia was significantly higher among 631 consumers (66 %) ($p < 0.05$). But when it came to tilapia that was ready to cook, consumers significantly ($p < 0.05$) preferred smoked tilapia to salted and filleted tilapia. Similar customer preferences for fresh tilapia were reported in Tanzania and Nigeria respectively by Refs. [28,32]. This demonstrates how fresh tilapia is preferred by all people above other tilapia varieties.

3.3. Tilapia cooking method preference

The way that tilapia is cooked is an important consideration. This is because the sensory characteristics of tilapia are influenced by the processing and cooking methods. About 59 % of consumers preferred tilapia charcoal-grilled and this preference was significantly higher than steamed tilapia, fried tilapia, and pan-grilled tilapia. Furthermore, using a 5-point Likert scale, consumers ranked grilled tilapia with the highest score of 5. This conforms to studies by Refs. [36–38] where grilled tilapia was the most preferred form of processed tilapia. More than half of the respondents in this study dislike tilapia because it is too bony. Hence, there is a good justification for considering deboning tilapia (filleting) during processing. Most respondents in this study indicated that they would very much prefer a ready-to-cook filleted tilapia, if available.

3.4. Affordability, availability, and willingness to pay for tilapia and tilapia products

About 68 % of respondents indicated they could afford tilapia and 80 % reported that tilapia was available all year round. This is a confirmation of the growing trend of tilapia farming in Ghana. The study further investigated the consumer's monthly expenditure on fresh and processed tilapia. Most respondents (40 %) spent less than GH₵50 per month on tilapia and tilapia products. Only 4 % of

respondents spent more than GH₵200 a month and overall, 78 % of respondents spent less than GH₵100 per month on tilapia and tilapia products. Thus, our results agree with Orire et al. [32] who indicated that the market prices or prevailing economic climates influence the choices consumers make.

Regarding location for tilapia purchase, most respondents (37 %) indicated Accra as the purchase point and their purchase point location was selected because it was convenient (45.6 %). The second highest majority (37.1 %) gave the freshness of tilapia as the reason for their preferred purchase point. Since most respondents chose their point of purchase based on convenience, it can be inferred that their place of stay, or work influenced their point of purchase. Again, the choice of purchase of tilapia from retailers at market centres (46 %) was significantly higher ($p < 0.05$) than other purchase points like cold stores, and delivery services from fish landing ports.

Further probing indicated that 49 % of respondents suggested that the preparation of tilapia prior to cooking did not take up much of their time and energy, 33 % suggested it took up a lot of their time and energy and 17 % found the preparation of tilapia prior to cooking tiresome.

Ultimately, 85 % of respondents would prefer it if there was an easier way to prepare tilapia prior to cooking and 78 % would prefer it if filleted tilapia were available on the local market.

In Ghana, consumers of fish have special preferences for certain parts of the fish. The head region was the most preferred part by 63 % of respondents and 70 % indicated that the head of a tilapia was important to them. Fillets are sold without the head of the fish. Therefore, it was important to determine whether the respondents would buy fillets without the head. The almost equal yes (51 %) and no responses (49 %) indicate that the decision to buy or not depended on other factors than the mere like or dislike of filleted tilapia. The choice between forms of filleted tilapia showed that spiced fillets (47 %) were significantly preferred. In decreasing preference orders, frozen and chilled fillets were also selected indicating that these options would be patronized if available on the Ghanaian market.

A median price of GH₵35 was suggested by respondents for 1 kg of filleted tilapia, and the association of the suggested price against gender, age, and income was not significant. The educational background of respondents was the only significant factor ($p = 0.008$) that determined the suggested price.

3.5. *Predicted factors influencing consumer preferences towards tilapia fillets*

3.5.1. *Monthly expenditure on fresh and processed tilapia and socio-demographic variables*

The tree diagram for respondents' monthly expenditure on fresh and processed tilapia is presented in Fig. 2. The 8 terminal node decision trees showed how the socio-demographics of respondents affected their monthly expenditure on fresh and processed tilapia.

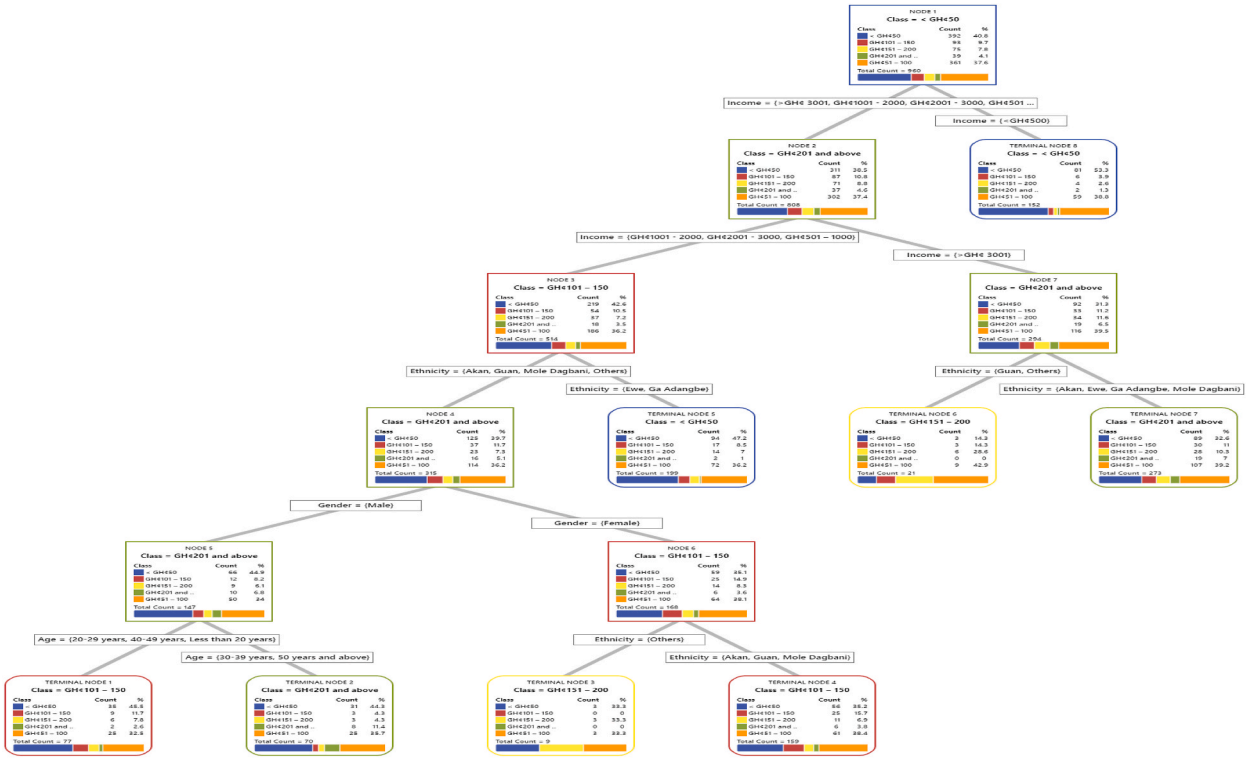

Fig. 2. An 8 terminal node CART for monthly expenditure as a multinomial response versus gender, age, income, ethnicity and education as categorical predictors.

This information is critical for market predictions on consumer expenditure upon the introduction of the tilapia fillet product.

From Fig. 3, the ethnicity of respondents emerged as the most important variable to consider when the monthly expenditure of future tilapia consumers is to be predicted. When ethnicity is 100 % important, the monthly income of consumers is 85.6 % as important as the ethnicity of consumers. Likewise, the age of consumers was also 66.9 % as important as ethnicity. Education and gender of respondents were the least important parameters to consider when the monthly expenditure on fresh and processed tilapia is to be known with an importance of less than 50 %.

Although the expenditure of tilapia consumers largely was influenced by their ethnicity, income status, and age in descending order of importance, on the contrary, a survey by Gebrezgabher et al. [22] that investigated consumers' preferences and willingness to pay for fresh tilapia fish farmed in treated wastewater in Ghana concluded that regardless of the source of fish, consumers generally accept fish reared in treated wastewater if lower prices are offered. Close to 78 % of consumers in this study were willing to spend GH₵100 or less on tilapia confirming the survey findings of [22] that, the source of tilapia in Ghana is insignificant to the consumer and they base their purchase decision on a lower price. This could, therefore, explain the reason monthly income was the second factor of relative importance.

3.5.2. *Preparation of tilapia prior to cooking versus socio-demographic variables*

Responses on how much time and energy they spent on preparation before cooking indicated that 33.3 % said it took a lot of time, 49.4 % said it did not take much time, and 17.3 % said it was very tedious. From the CART analyses on how consumers find tilapia preparation prior to cooking as a response, an eleven-node decision tree was built to study the associations with socio-demographic parameters (Fig. 4). The generated relative variable importance chart (Fig. 5), indicated that the income status of consumers was the most important parameter to be considered to determine how the respondents find tilapia preparation prior to cooking. This was followed by their educational qualification which was 77.1 % as important as income status. Gender and age of consumers were also important with the relative importance of 66.5 % and 54.6 %, respectively, when compared to income status.

It was not surprising that, when assessing how tilapia consumers view preparation before cooking, the income status of tilapia customers emerged as the most essential feature to analyze. Most of the time, consumers in the high-income earning groups are preoccupied with work and have little free time, making it unlikely that they would have the time to prepare the laborious tilapia before cooking. It was clear from the classification tree that, a consumer of a working-class background (over 30 years old), male, and earning at least GH₵3000, would decide that prepping tilapia before cooking requires a lot of time and effort (terminal node 4, Fig. 4). Once more, consumers with higher levels of education are more likely to have high-income statuses and earn more than individuals with no formal education or only basic education. Therefore, it should come as no surprise that consumers' educational attainment was 77 % as significant as their socio-economic status in determining how they would evaluate tilapia preparation before cooking.

3.5.3. *Preference of tilapia fillets*

When respondents were given the option of a filleted tilapia that is simple to cook, 50 % of them said they would prefer that over the standard option very much, 31 % said they were undecided, and 16 % said they would not. When compared to those who claimed they would never prefer filleted tilapia, the frequency of those who stated they would, was higher ($p < 0.05$). Consumer's response to "Would you prefer filleted tilapia if available" was also modelled using the socio-demographic parameters as independent factors. The classification tree is presented in Fig. 6.

A relative importance chart of the independent variables (Fig. 7) showed that income status, ethnicity, and age of consumers are important parameters to consider in deciding if a consumer will prefer filleted tilapia or not.

If the importance of income status is 100 %, then the importance of ethnicity will be 69 % relative to income status. Likewise, the importance of age will be 55.6 % as important as income status. This affirms the findings by Dai et al. [39] on consumer perception of tilapia in China and related factors, which indicated that monthly income had a positive effect on consumer preference regarding tilapia.

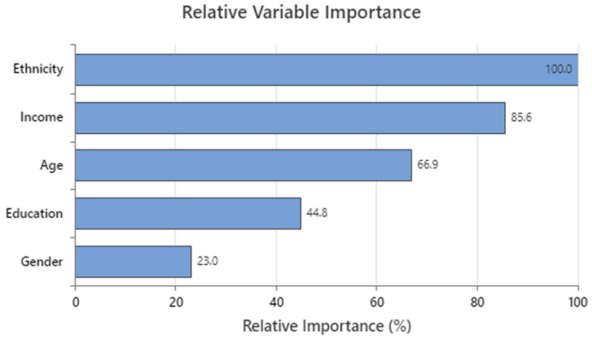

Fig. 3. A relative importance chart of predictors for monthly expenditure.

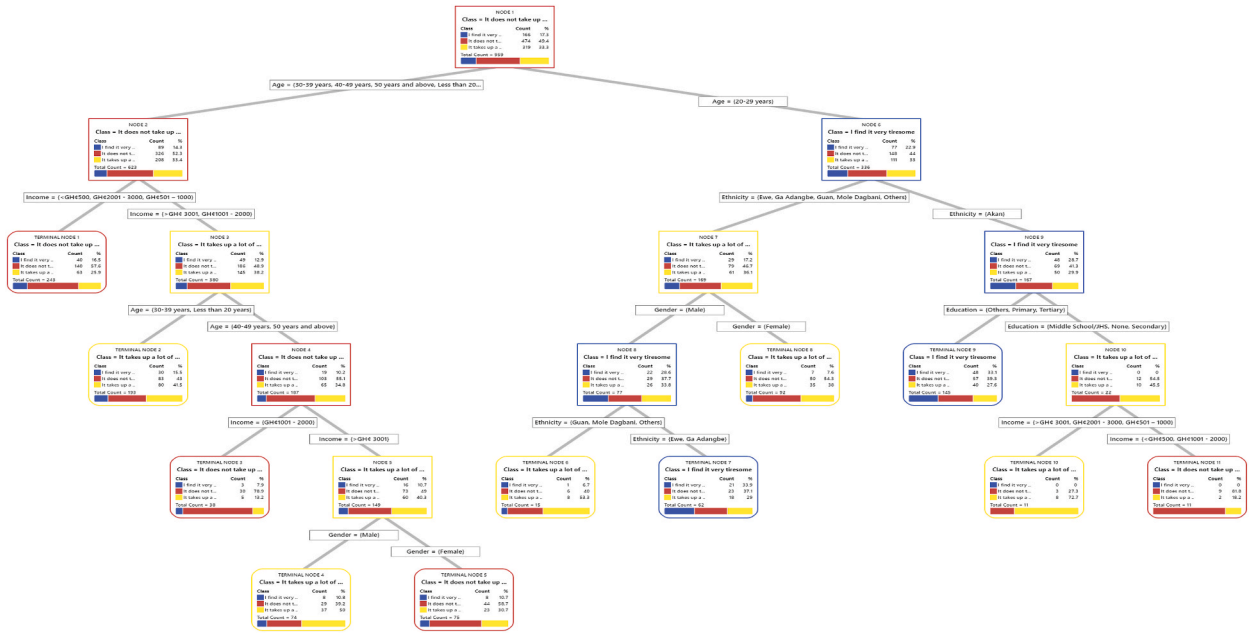

Fig. 4. An 11-terminal node CART for the response "preparation prior to cooking" as a multinomial response versus gender, age, income, ethnicity and education as categorical predictors.

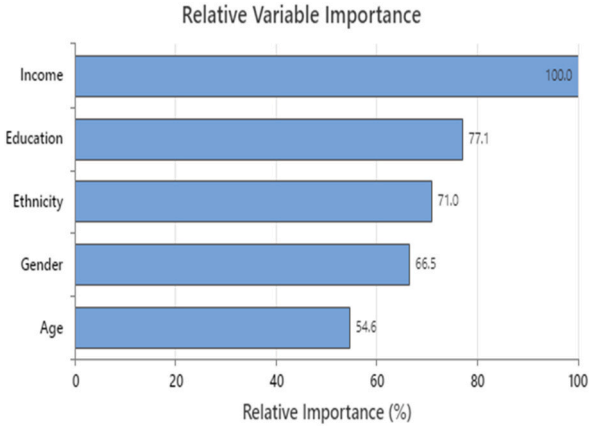

Fig. 5. A relative importance chart of predictors for "preparation of tilapia prior to cooking".

3.5.4. Willingness of consumers to buy tilapia fillets

When consumers were asked if they would buy filleted tilapia, the root node (node 1, Fig. 8) showed that most of the respondents said yes, they would buy filleted tilapia with a proportion of 78.1 %. Considering socio-demographic parameters, the root node was split based on ethnicity as it was the parameter with the least impurity when all respondents were considered. When the ethnicity of a consumer is Guan or Mole Dagbani, the decision to purchase filleted tilapia is a yes with an even higher proportion of 87.3 % (terminal node 4, Fig. 8). On the other hand, if a consumer is an Akan, Ewe, or Ga Adangbe, a decision will be made based on their age categories. When they are less than 20 years old, between 30 and 39 years, or 50 years and above, the proportion of the yes is 80.4 % (terminal node 3, Fig. 8). But an Akan, Ewe, or Ga Adangbe aged between 20 and 29 years or 40–49 years and earning an income between GH ₵2001 to 3000 or below GH₵500 will say yes at a proportion of 83.2 % (terminal node 2, Fig. 8). The proportion of yes (69.3 %) reduces when the income of consumers is between GH₵501 to 1000 (terminal node 1, Fig. 8). A relative variable importance chart (Fig. 9) showed that the income status of consumers and their ethnicity were the two most important parameters to consider in deciding if consumers will buy filleted tilapia or not. If the income status is 100 % important, then the ethnicity of consumers is 57.7 % as important as income status in determining if consumers will buy filleted tilapia or not. It was observed from the decision tree that, the probability of a consumer agreeing to buy tilapia fillets surprisingly increases when they earn between GH₵2001–3000, and less than GH₵500, rather than those that earned high incomes, greater than GH₵3000. This could be because high-income earners would

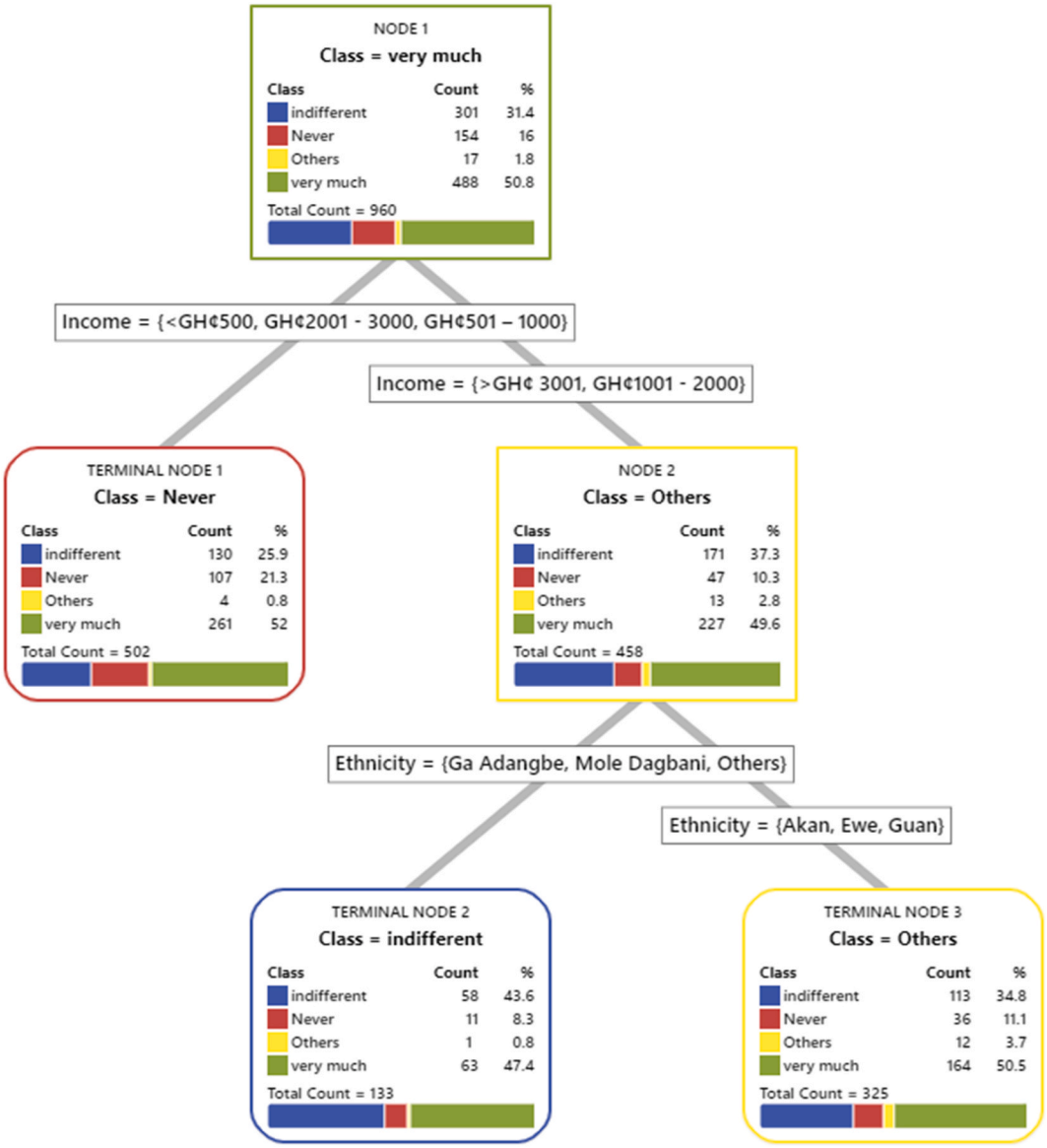

Fig. 6. A 3 terminal node CART for the response "Would you prefer filleted tilapia if available" as a multinomial response versus gender, age, income, ethnicity and education as categorical predictors.

assign their food purchasing orders to aides due to time constraints and busy schedules. As Masuda et al. [40] rightly put it, time provides unique insights into human well-being that income alone cannot capture. They found that, most often, people who are in high positions and earn more have little time to spare. According to Mingle et al. [7], fish consumption is strongly influenced by socio-economic factors and income levels.

3.5.5. Regional preferences for tilapia and socio-economic factors

At the table, cooked tilapia could be presented as a whole fish or cut into two or three parts depending on the size. For a piece that is cut into two, the head or tail regions could be served. Tilapia lovers have their preferred regions, and the survey findings indicate that the head was the most preferred region, representing almost 63 % of total respondents surveyed, consumers significantly ($p < 0.05$) chose the head region over the tail region, representing 37 % of total respondents. It was, therefore, not surprising when 70 % of consumers significantly ($p < 0.05$) indicated that the head of tilapia was important to them.

The association of socio-demographic variables with the responses (region of tilapia preference) they gave is presented in the classification tree (Fig. 10). A 6-terminal node tree was built to study this association and to make predictions. From the root node (node 1, Fig. 10), the majority indicated they prefer the head region (62.9 %). In association with socio-demographic variables, however, the age of respondents was used to split the root node. When consumers are between the ages of 30 and 49 years or below 20

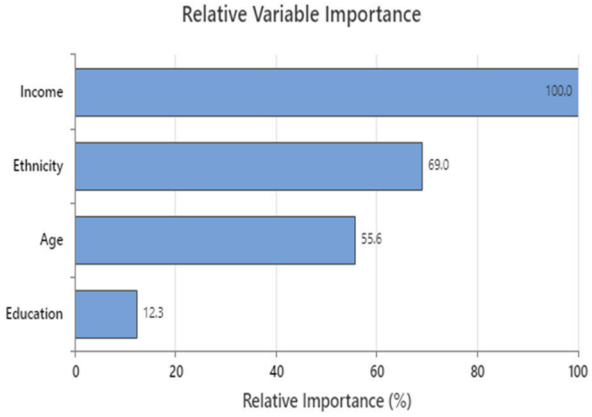

Fig. 7. A relative importance chart of predictors for the response "Would you prefer tilapia fillets if available".

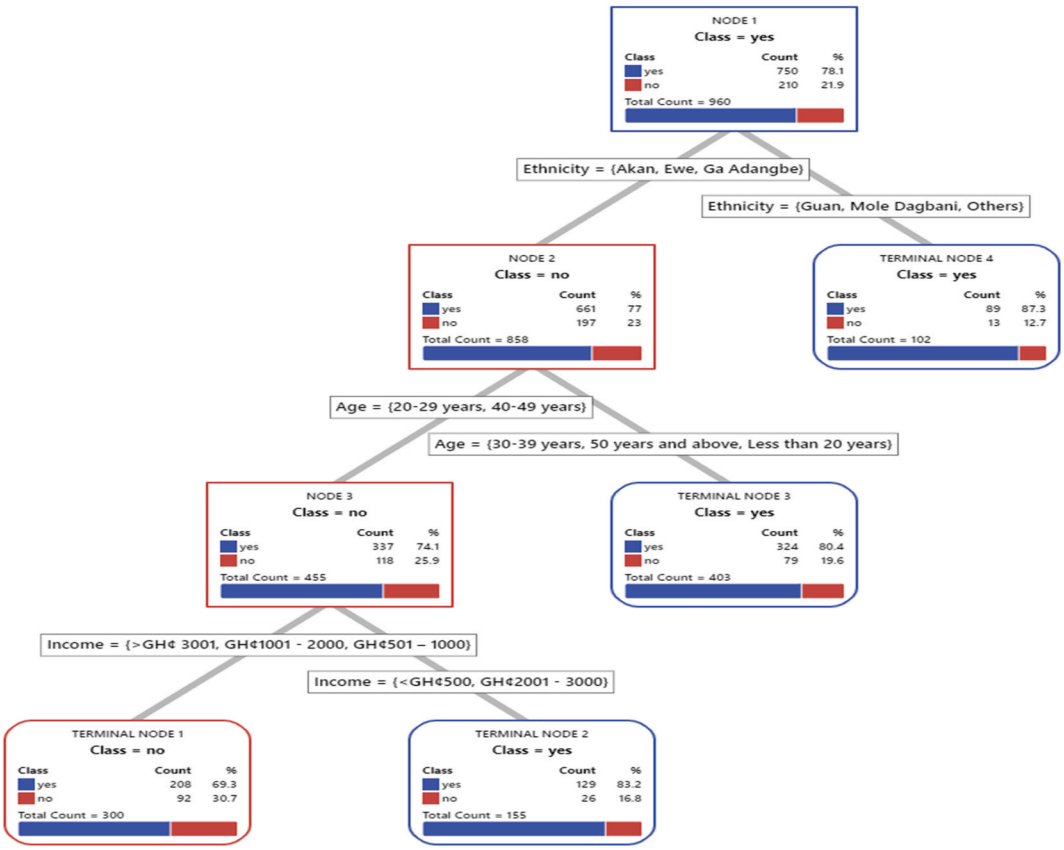

Fig. 8. A 4 terminal node CART for the binomial response "Would you buy filleted tilapia" versus gender, age, income, ethnicity and education as categorical predictors.

years (node 2, Fig. 10), knowing which part of tilapia is of importance will depend on their gender. Females will prefer the head region with a proportion of 72.7 % (terminal node 1, Fig. 10) whereas the decision of males will further depend on their ethnicity.

A Ga Adangbe, Mole Dagbani, or a Guan will prefer the tail region with a proportion of 51.6 % (terminal node 4, Fig. 10). An Akan or Ewe will prefer the head region and the proportion will depend on their age groups. An Akan or Ewe aged between 40 and 49 years or less than 20 years will highly prefer the head region (76.2 %, terminal node 2, Fig. 10) than those between 30 and 39 years of age (58.8 %, terminal node 3, Fig. 10). From the root node, when consumers are aged between 20 and 29 years or above 50 years, their educational background will determine which part of tilapia will be of importance to them. Those with no formal education, primary education, or secondary education will prefer the head region very much than those with tertiary education with respective

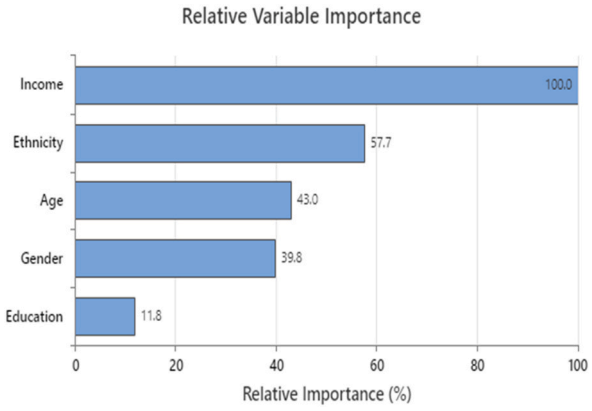

Fig. 9. A relative importance chart of predictors for the response "Would you buy tilapia fillets?"

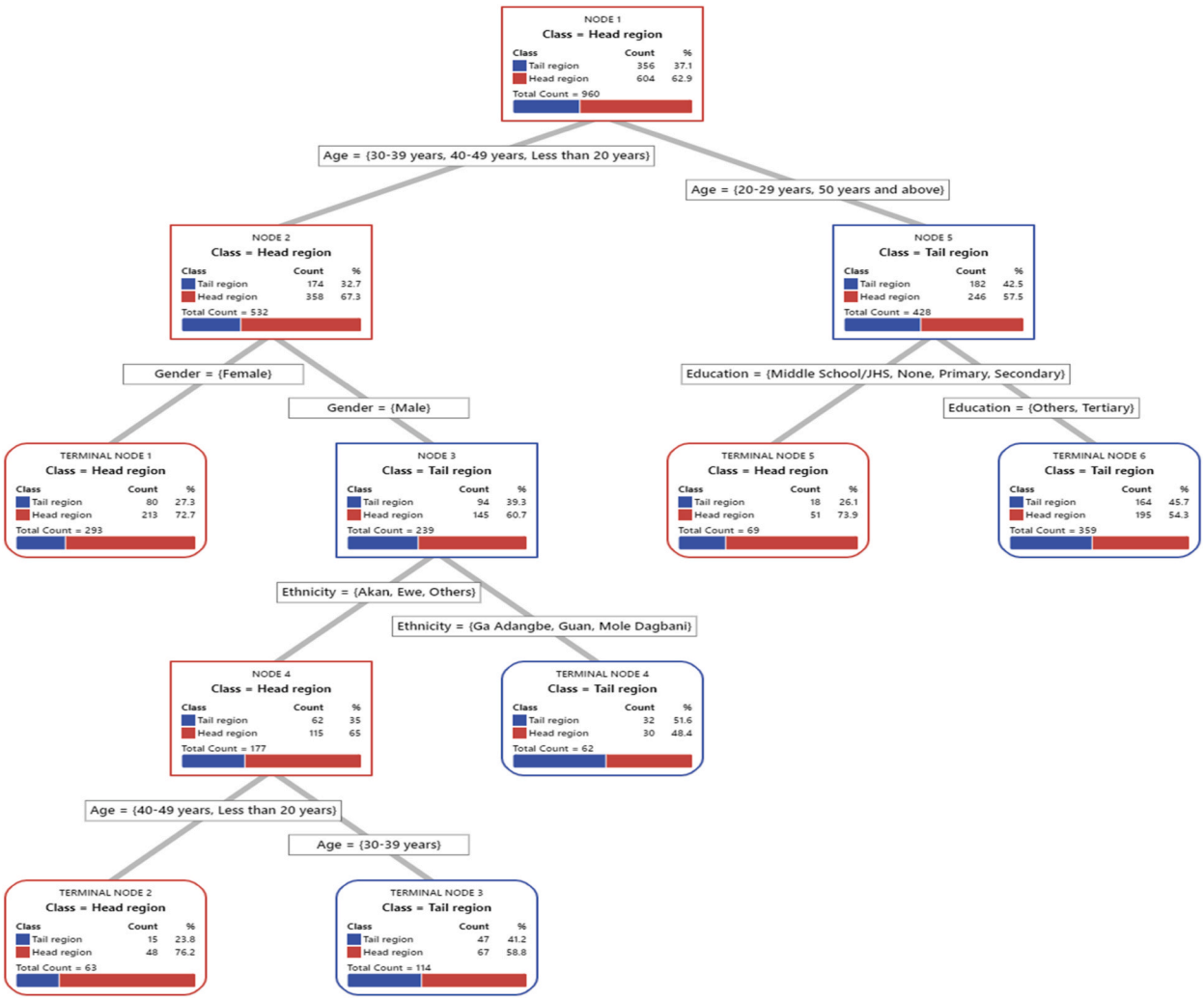

Fig. 10. A 6 terminal node CART for the binomial response "tilapia region preference" versus gender, age, income, ethnicity and education as categorical predictors.

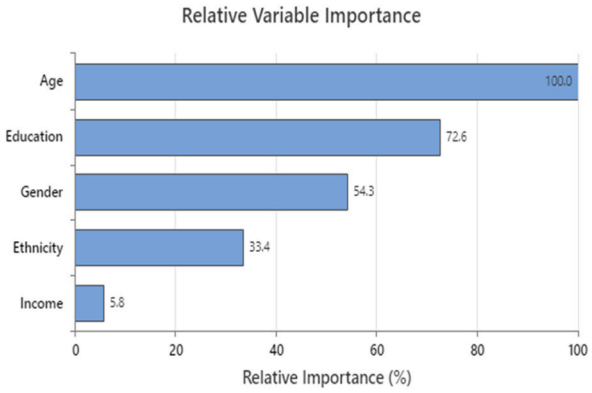

Fig. 11. A relative importance chart of predictors for the response "Tilapia region preference (Head/Tail)".

proportions of 73.9 % and 54.3 % (terminal nodes 5 and 6, Fig. 10).

A relative importance chart (Fig. 11) showed that age, education, and gender of consumers are the important parameters to be considered in deciding which part of tilapia consumers prefer. When the importance of age is 100 %, that of education, and gender are 72.6 % and 54.3 % as important as age, respectively. In Egypt [41], through a survey explored the link between aquaculture development and changes in fish demand among low-income consumers. They built logistic regression models to show that, younger women consumers with children were more likely to consume smaller tilapia sizes and preferred larger tilapia head traits. Likewise, in this study, age and gender were known to be important predictors of tilapia head or tail preference together with the educational background of consumers. Both older and younger consumers preferred the head region over the tail. However, the proportion of younger consumers (67.3 %) was more than older consumers (57.5 %). The preference for head was seen to also increase when a consumer is a female.

3.5.6. 'Buying tilapia fillets without the head and socio-economic factors

When consumers were asked if they would buy filleted tilapia without the head region, the association of socio-demographic variables and their responses was studied using classification algorithms (Fig. 12). An initial root node (node 1, Fig. 12) indicated that the majority (50.7 %) of consumers said no, they would not buy filleted tilapia without the head. However, when consumers' socio-demographics were considered, the income status of consumers was the initial important parameter to consider in splitting the root node. When consumers earned 2000 Ghana cedis and above, their decision was based on their ethnicity. Mole Dagbanis who earn above GH₵2000 will very much buy filleted tilapia without the head (terminal node 5, Fig. 12) with a proportion of 68.6 %. When they are Akan, Ewe, Ga Adangbe, or Guan and earn above GH₵2000, they will also buy filleted tilapia without the head region (terminal node 4, Fig. 12), if their age is above 50 years or between 30 and 39 years, at a lower proportion (56.9 %) when compared to the Mole Dagbani. On the other hand, if they are less than 30 years old or between 40 and 49 years, then Ewes and Ga Adangbes will not buy fillets without the head whereas Akans and Guans will buy filleted tilapia without the head (terminal nodes 2 and 3 respectively, Fig. 12). Consumers who earn below GH₵2000, however, will not buy filleted tilapia without the head (terminal node 1, Fig. 12). A relative importance chart (Fig. 13) shows that the income status and the ethnicities of respondents are to be considered in predicting whether consumers will buy filleted tilapia without the head or not. If the importance of income is pegged at 100 %, then that of ethnicity is 80.6 % relative to income.

4. Conclusion

The methods employed in this study have limitations. Consumer preference and willingness to purchase decisions are based on prevailing economic situations or changes in the market. However, such studies remain valuable tools for understanding market dynamics. The CART algorithm is a straightforward means to interpret data and is proficient at handling categorical and continuous datasets. However, it is particularly susceptible to overfitting therefore pruning is essential for CART algorithms because decision trees can become excessively large, leading to complex calculations, especially in the presence of numerous class variables.

This paper provides information linking the production of tilapia with consumption patterns and preferences in Ghana. Consumer needs are complex, and several factors come into play in determining why products are purchased and how they are used. A product fails on the market if the consumers' needs are not determined through surveys or other research methods [42].

Based on the findings, useful data is now available on the frequency of tilapia consumption and the preferences of consumers. Additionally, valuable information is available on predicted factors that influence consumer expenditure on tilapia, preferences, willingness to patronize, and purchase of tilapia fillets. The major factor that influenced consumer choices and preferences for tilapia fillets was income. However, regional preferences for tilapia are predicted by age, ethnicity, and monthly expenditure.

These findings are relevant for potential investors, fish farmers, policymakers, and stakeholders engaged in the fish value chain for improved livelihoods. This has implications for development not only in Ghana but in other developing countries where fish farming is an integral part of nutrition and livelihoods.

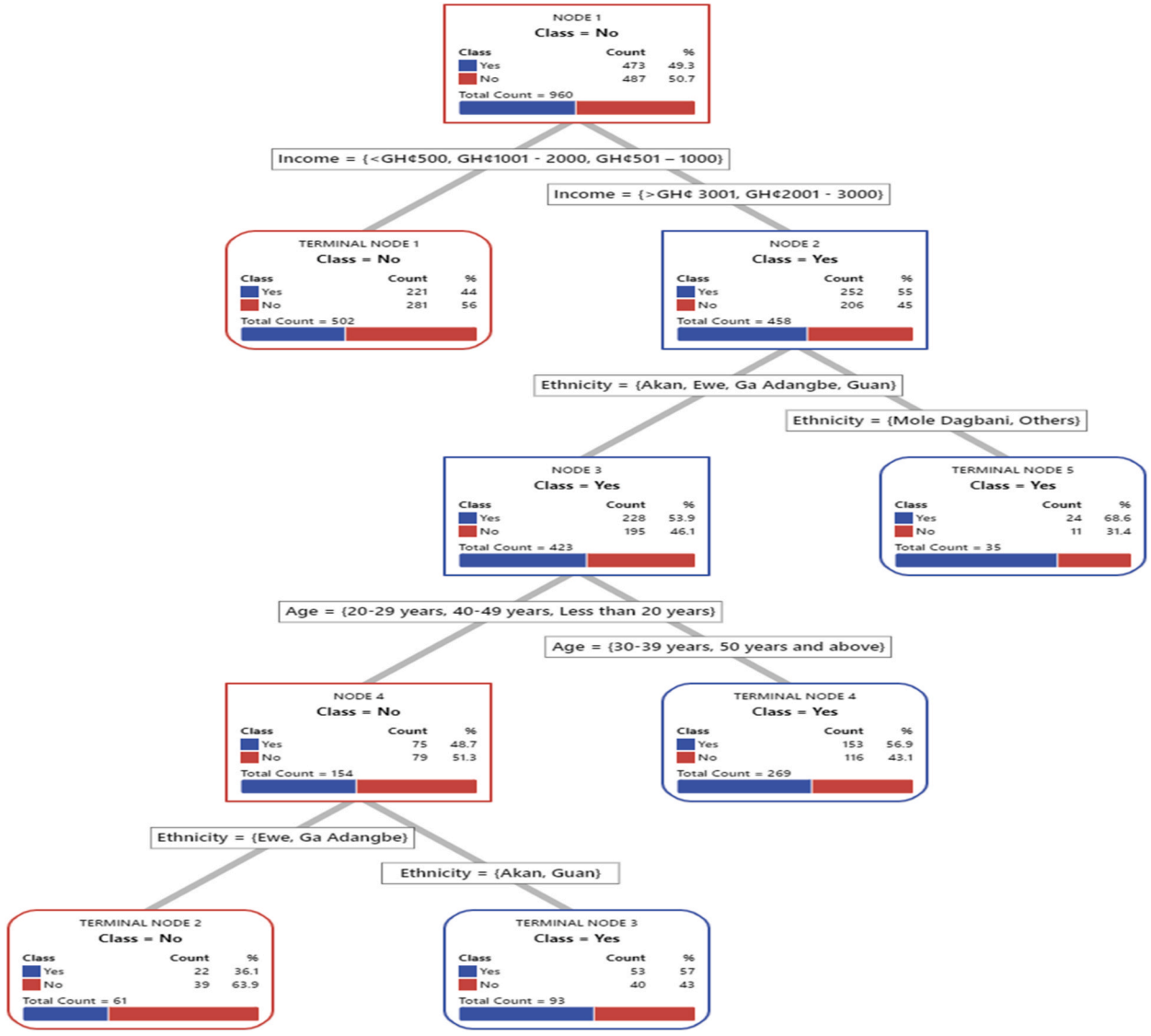

Fig. 12. A 5 terminal node CART for the binomial response "Would you buy filleted tilapia without the head" versus gender, age, income, ethnicity and education as categorical predictors.

Funding

This research was funded by the Healthy Food Africa (HFA) project, a European Union (EU) Horizon 2020 collaborative research funded by the European Union, Grant Agreement No. GA 862740.

Ethics statement

Ethical clearance for this study was sought for and granted by the Council for Scientific and Industrial Research (CSIR) Institutional Review Board, Ghana. The authors affirm that the study and data collection adhere to all ethical regulations and confirm that informed consent was obtained from the participants during data collection. Data was obtained voluntarily from respondents. The respondents gave out the information of their own free will, under no influence, and were free to opt out of the study any time they so wished.

Data availability statement

Data is included in the article, in supplementary material, or referenced in the article.
Data set available upon request.

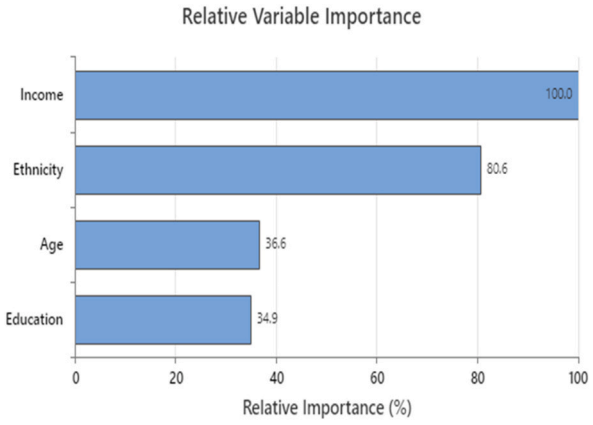

Fig. 13. A relative importance chart of predictors for the response "Would you buy tilapia fillets without the head".

CRediT authorship contribution statement

Anthonia Helga Andoh-Odoom: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Kwabena Asiedu Bugyei:** Writing – review & editing, Investigation, Formal analysis, Data curation. **Amy Atter:** Writing – review & editing, Project administration, Funding acquisition, Conceptualization. **Vincent Owusu Kyei-Baffour:** Writing – original draft, Methodology, Formal analysis, Data curation. **Angela Parry-Hanson Kunadu:** Writing – review & editing, Supervision, Conceptualization. **Firibu Kwesi Saalia:** Writing – review & editing, Supervision. **Mary Anti Chama:** Writing – review & editing, Supervision. **Youngsun Lee:** Writing – review & editing. **Hanna Maarit Koivula:** Writing – review & editing. **Wisdom Kofi Amoa-Awua:** Writing – review & editing, Supervision. **Seth Koranteng Agyakwah:** Project administration, Funding acquisition.

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.

Acknowledgement

The Natural Resources Institute Finland (LUKE).
All survey participants.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e30247.

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