

Consumption, Use and Awareness of Wheat Flour Fortification in Abidjan

Assielou Hyppolite Assielou¹, Lathro Anselme Akpro^{2*}, Bosson Jean-Aimé Assanvo³, Jean Brice Gbakayoro¹, Grodji Albarin Gbogouri¹

¹Laboratory of Nutrition and Food Safety, Faculty of Food Science and Technology, Nangui Abrogoua University, Abidjan, Côte d'Ivoire

²Marc Delorme Station, Coconut Research Station, National Agricultural Research Centre, Port-Bouët, Abidjan, Côte d'Ivoire

³Laboratory of Biocatalysis and Bioprocesses, Department of Food Science and Technology, Nangui Abrogoua University, Abidjan, Côte d'Ivoire

Email: hyppoliteassielou09@gmail.com, *akprolathroanselme@gmail.com

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Abstract

Malnutrition, particularly iron-deficiency anaemia, remains a major public health problem in Côte d'Ivoire, affecting mainly women and children. In order to reduce this burden, the fortification of wheat flour with essential micro-nutrients has been adopted as a nutritional strategy. However, the effectiveness of this intervention depends on the level of consumption of wheat-based products, as well as on the awareness of the general public and bakery stakeholders regarding flour fortification. This study therefore aimed to assess the consumption of wheat flour-based products, the use of this flour by bakeries, and the level of awareness of fortified wheat flour in four municipalities of Abidjan. This was a descriptive cross-sectional study conducted between June 2023 and September 2025 among 400 households and 120 bakery employees, who were consumers and users of wheat flour respectively. The data collected were analysed using descriptive statistics and the chi-square test. The results showed that awareness of wheat flour (87.17%) and wheat-based products (92.25%) was high among households, particularly among the most educated individuals. Bread remained the most widely consumed wheat-based product. However, awareness of flour fortification remained low (41.5%) and was significantly associated with educational attainment. Among bakery staff, who were predominantly men with secondary education, wheat flour was used universally, mainly through the GMA and Malika brands. Nevertheless, only 45% were aware of flour fortification and 31.7% knew that the flour used was fortified. All the bakeries surveyed stated that they did not carry out any checks or tests to verify the fortification of the flours used. This study highlights high con-

sumption of wheat-based products in Abidjan, but low awareness of flour fortification among both households and bakers. Strengthening information and awareness-raising initiatives appears necessary to improve the effectiveness of food fortification programmes.

Keywords

Consumption, Enrichment Levels, Wheat Flour, Abidjan

1. Introduction

In Côte d'Ivoire, malnutrition remains a major public health problem, particularly in the form of micronutrient deficiencies, often referred to as "hidden hunger" [1]. For example, anaemia affects around 51.8% of women of childbearing age in West Africa and is mainly attributed to iron deficiency, although other nutritional and infectious factors also contribute [2] [3]. Furthermore, data from the Demographic and Health Survey indicate that nearly 68% of children under five and around 66% of women suffer from anaemia, highlighting the scale of the nutritional problem in the country [4]. These deficiencies have significant consequences for health, economic productivity and human development. They primarily affect the most vulnerable populations, particularly children, pregnant or breastfeeding women and the elderly [5]-[8]. Beyond Côte d'Ivoire, anaemia is also a major public health problem globally, particularly affecting the most vulnerable groups. Indeed, around 40% of children under five and 37% of pregnant women worldwide suffer from anaemia [9]. In light of this situation, the fortification of staple foods is recognised as one of the most effective and cost-effective interventions for combating micronutrient deficiencies on a large scale [10]. The Global Nutrition Report estimates that every dollar invested in food fortification can generate up to 27 dollars in economic benefits [11]. With this in mind, the fortification of wheat flour with essential micronutrients such as iron and folic acid has been adopted in several countries, including Côte d'Ivoire, where it has been mandatory since 2007 [12] [13]. This strategy aims to improve the nutritional status of populations without requiring major changes in dietary habits [14].

Wheat flour is indeed a suitable vehicle for fortification due to its widespread consumption, particularly in urban areas. In Abidjan, the country's largest urban area, bread and bakery products play a significant role in the daily diet [15]. Recent studies indicate that dietary habits, particularly those relating to wheat-based products, have changed considerably in African urban areas over the last decade as a result of rapid urbanisation and lifestyle changes [16] [17]. This accessibility and frequency of consumption make wheat flour a strategic vehicle for micronutrient intake [18]. Indeed, although wheat is not produced locally, it plays a significant role in the dietary habits of the Ivorian population [19] [20]. However, the effectiveness of fortification programmes depends not only on the existence of a regulatory

framework, but also on the level of consumption of the products concerned, as well as the knowledge and practices of the population and stakeholders in the production and processing chain.

Recent studies show that consumers' knowledge of fortified products often remains limited, which can affect their acceptance and use [21]. Similarly, bakers' practices, particularly regarding the sourcing and use of flour, can play a significant role in the effectiveness of fortification programmes.

This raises several questions: to what extent do households and bakers in the municipalities of Abidjan consume and use wheat flour-based products? What is their level of knowledge and awareness regarding wheat flour fortification? And to what extent might these factors influence the effectiveness of this nutritional strategy in combating micronutrient deficiencies?

With this in mind, this study aims to analyze consumption patterns, usage practices and the level of knowledge regarding enriched wheat flour among households and bakers in four districts of Abidjan, in order to identify the factors likely to promote or limit the effectiveness of this nutritional intervention in urban areas of Côte d'Ivoire.

2. Materials and Methods

2.1. Study Site

This study was conducted in the city of Abidjan, the economic capital of Côte d'Ivoire, covering an area of 2119 km². It currently comprises thirteen municipalities (Abobo, Adjamé, Anyama, Attécoubé, Bingerville, Cocody, Koumassi, Marcory, Plateau, Port-Bouet, Treichville, Songon and Yopougon). According to the General Population and Housing Census [22], its population is estimated at 5,616,633 inhabitants. Economically, the District of Abidjan is home to the country's largest industrial zone and accounts for 60% of Côte d'Ivoire's gross domestic product [23].

2.2. Study Framework and Rationale for the Selection of Municipalities

The choice of Abidjan as the study area is justified by its central role in the production and distribution of wheat flour in Côte d'Ivoire. As the country's economic capital, it is home to a significant proportion of the baking industry, with more than half of the 2000 bakeries recorded nationwide [24]. It therefore provides a suitable setting for analysing the consumption and use of enriched wheat flour.

Four municipalities were selected, namely Abobo, Yopougon, Marcory and Port-Bouët. This choice is based on their demographic and socio-economic characteristics. Abobo and Yopougon, which are densely populated, feature a wide variety of household profiles, whilst Marcory and Port-Bouët are characterised by a mixed fabric, combining residential areas and economic activities. These districts are also characterised by a high concentration of bakeries, making them suitable

areas for studying the practices of stakeholders in the sector [25]. This geographical diversity thus provides a more comprehensive and nuanced picture of the levels of consumption, use and awareness of enriched wheat flour, both among households and bakers.

2.3. Type and Duration of the Study

This is a cross-sectional study with a descriptive focus, which took place from June 2023 to September 2025.

2.4. Study Population

The target population for this study consists of households (heads of households) and bakery employees (bakers) in the municipalities of the District of Abidjan.

2.4.1. Inclusion Criteria

All households and bakery employees selected to participate in this study were included.

2.4.2. Exclusion Criteria

Households absent during the study and bakers who refused to participate were excluded.

2.5. Sample Size

The sample sizes were calculated using the method described by Vessereau (1992).

$$n = \frac{Z^2 \times P(1-P)}{d^2}$$

With:

n = required sample size, $t = 1.96$ at a 95% confidence level, and P = estimated proportion of wheat-based product consumers in the population. In the absence of precise prior data, a proportion of 50% was used to obtain the maximum sample size, with d = margin of error set at 5%. The calculation yielded a minimum sample size of 384 households; to account for potential non-responses and ensure an equitable distribution among the four municipalities, the sample size was increased to 400 households, or 100 households per municipality.

With regard to bakeries, according to the available data, the city of Abidjan had 633 bakeries in 2023 [25]. A correction for the finite population was therefore applied using the following formula:

$$n_f = \frac{n}{1 + \frac{n}{N}}$$

where

n_f = adjusted sample size, n = previously calculated sample size (384), N = total population size (633). The calculation yielded a minimum sample size of 239 bakeries. However, given logistical constraints, accessibility and the refusal of certain

bakeries to participate in the survey, a sample of 120 bakeries was selected for the study.

2.6. Data Collection

Two types of survey were conducted as part of this study: one targeting consumers (households) and the other targeting users of wheat flour, namely bakeries and patisseries.

At the consumer level, a total of 400 households were surveyed, distributed evenly across the four (4) municipalities selected for the study, *i.e.* 100 households per municipality. Households were selected at random. In each household, an adult responsible for food procurement was interviewed. The aim was to gather information on socio-demographic characteristics (gender, educational level, occupation, etc.), dietary habits (forms and frequency of consumption of wheat flour-based products, place of purchase, etc.) and their level of knowledge regarding the fortification of wheat flour.

With regard to wheat flour users, a sample of 120 bakeries was selected, comprising 30 bakeries per municipality, based on a reasoned selection process that took into account the refusal of certain bakeries to participate at the time of the survey. Within these bakeries, practising bakers who had agreed to take part in the study were interviewed at random. The information collected covered their socio-demographic characteristics (gender, level of education, occupation, etc.), the characteristics of the flours used (type of flour, origin and products made), as well as their knowledge of wheat flour fortification.

The data were collected using questionnaires administered during semi-structured interviews, conducted on an individual basis after obtaining the participants' prior consent. The questionnaire comprised two categories of questions: closed questions (answers of "yes" or "no", or with a choice of predefined answers), and open questions, allowing respondents to express themselves freely. Before the survey began, the questionnaires were pre-tested with a small sample of households and bakers not included in the study to assess the clarity, comprehensibility and relevance of the questions. Observations from the pre-test enabled adjustments to be made to the content and wording of the questions. The interviews were conducted mainly in French. However, where necessary, certain questions were explained in commonly spoken local languages to aid participants' understanding. Responses to the open-ended questions were grouped into thematic categories and then coded prior to data entry and statistical analysis.

2.7. Statistical Analysis

The data were analysed using IBM SPSS Statistics version 20.0. Descriptive statistics were used to present frequencies and proportions. The chi-square test (χ^2) was used to analyse associations between variables, with a significance level set at $p < 0.05$.

3. Results and Discussion

3.1. Results

3.1.1. Sociodemographic Profile of the Households Surveyed

A total of 400 households, comprising 244 men and 156 women, were surveyed. Those with a secondary education level were the most represented group, with a total of 101 respondents. Three age groups emerge: 18 - 30 years; 31 - 45 years; and 46 - 65 years and over. The average age of the respondents is 37.64 years. The ethnic breakdown highlights the predominance of the Mandé group, which accounts for 32% of the sample. With regard to nationality, the majority of respondents are Ivorian nationals (94.75%), with a small proportion of foreign nationals (5.25%). Furthermore, trade represents the main source of income for the respondents. All of these results are listed in **Table 1**.

Table 1. Sociodemographic profile of the households surveyed.

Variable	Number	Proportion (%)
Age group	n = 400	
[18 - 30]	88	22
[31 - 45]	248	62
[46 - 65]	64	16
Gender	n = 400	
Male	244	61
Famale	156	39
Level of education	n = 400	
Literacy	77	19.25
Primary	69	17.25
Secondary	101	25.25
Higher	92	23
None	61	15.25
Nationality	n = 400	
Ivoran	379	94.75
Foreign	21	5.25
Ethnic group of Ivory Cost	n = 400	
Akan	90	22.5
Gour	104	26
Krou	57	14.25
Mandé	128	32
Autre	21	5.25
Occupation	n = 400	
Student	53	13.25
Housewife	32	8
Shopkeeper	187	46.75
Civil servant	87	21.75
Other	41	10.25

3.1.2. Levels of Knowledge about Wheat Flour According to Educational Attainment

With regard to knowledge of wheat flour, the survey results reveal a relatively good level of awareness of this product. Indeed, 87.17% of respondents stated that they were familiar with wheat flour, compared with 12.83% who were unaware of its existence. The chi-square test indicates a significant difference between respondents' educational attainment and their knowledge of wheat flour ($\chi^2 = 22.83$; $df = 4$; $p < 0.05$). The level of awareness is high among households with a secondary education level (25.25%) or higher (23%) compared to those with a literacy level (12.03%) or primary education (16.33%). Conversely, households with no formal education have a low level of knowledge of wheat flour, estimated at 10.56% (Table 2).

Table 2. Level of knowledge about wheat flour according to educational attainment.

Level of education	Knowledge of wheat flour		Chi-squared (χ^2) parameters			
	Yeah	No	Ddl	(χ^2_{obs})	(χ^2_{theo})	P
Literacy	12.03	7.22	4	22.83	9.48	<0.05
Primary	16.33	0.92				
Secondary	25.25	0				
Higher	23	0				
None	10.56	4.69				
Total	87.17	12.83				

χ^2_{obs} : hi-square observed; χ^2_{theo} : Khi-square theory; P: probability; Ddl: Degrees of freedom.

3.1.3. Level of Knowledge of Wheat Flour-Based Foods by Gender

Analysis of the level of knowledge of wheat flour-based foods shows that the vast majority, namely 92.25%, are aware of them (Table 3). The chi-square test indicates that there is no significant difference between the gender of respondents and their knowledge of these foods ($\chi^2 = 0.29$; $df = 4$; $p > 0.05$). Indeed, both men and women report being familiar with products made from wheat flour. Among men, 58.5% report being familiar with them, compared with 2.5% who are not. Among women, 33.75% are familiar with them, compared with 5.25% who report not being familiar with them.

Table 3. Level of knowledge of wheat flour-based foods by gender.

Gender	knowledge of wheat flour-based foods		Paramètres de Khi-deux (χ^2)			
	Yeah	No	Ddl	(χ^2_{obs})	(χ^2_{theo})	P
Male	58.5	2.5	1	0.29	5.99	>0.05
Female	33.75	5.25				

χ^2_{obs} : hi-square observed; χ^2_{theo} : Khi-square theory; P: probability; Ddl: Degrees of freedom.

3.1.4. Consumption Levels of Wheat Flour-Based Foods

Regarding the consumption of wheat flour-based products, the survey revealed

that all households consume them (**Table 4**). Among the forms of consumption, bread is the most commonly consumed, with 67.25% of respondents eating it between 5 and 7 times a week. Bakeries and patisseries are the main places of purchase (58.25%), and the reasons given for this choice relate mainly to product quality (38.25%), availability (24.75%) and compliance with hygiene standards (21.25%). Furthermore, 49% of households use wheat flour weekly to prepare meals at home. Doughnuts (30.75%) and cakes (16.75%) are the most common items prepared.

Table 4. Household consumption patterns of wheat flour-based foods.

Parameter	Number	Proportion (%)
Consumption of foods made from wheat flour	n = 400	
Yeah	400	100
Consumption forms	n = 400	
Bread	278	69.5
Doughnuts	65	16.25
Croissants/Pastries	44	11
Other	13	3.25
Frequency of consumption	n = 400	
1 to 2 times a week	56	14
3 to 4 times a week	75	18.75
5 to 7 times a week	269	67.25
Place of purchase	n = 400	
Shop	95	23.75
Bakery/patisserie	233	58.25
Sales assistants	72	18
Other	0	0
Reason for choosing this shop	n = 400	
Proximity	63	15.75
Product quality	153	38.25
Product availability	99	24.75
Product hygiene	85	21.25
Cooked wheat flour-based foods	n = 400	
Doughnuts	123	30.75
Cakes	67	16.75
Bread	6	1.5
None	204	51

3.1.5. Linking Education Level and Awareness of Fortified Flour

An assessment of the level of awareness regarding the fortification of wheat flour

reveals that only 41.5% of respondents are aware that it is fortified, compared with 58.5% who are not. This level of knowledge varies significantly according to the respondents' level of education ($\chi^2 = 22.88$; $df = 4$; $p < 0.05$). The level of knowledge is significantly higher among households with a higher level of education (16.25%) compared to those at other levels, which show high rates of lack of knowledge (Table 5).

Table 5. Awareness of the fortification of wheat flour with iron and folic acid by level of education.

Education level	Understanding the fortification of wheat flour with iron and folic acid		Chi-squared (χ^2) parameters			
	Yes	No	Ddl	(χ^2_{obs})	(χ^2_{theo})	P
Literacy	4.50	14.75	4	22.88	9.48	<0.05
Primary	5	12.25				
Secondary	13.75	11.50				
Higher	16.25	6.75				
None	2	13.25				
Total	41.5	58.5				

χ^2_{obs} : hi-square observed; χ^2_{theo} : Khi-square theory; P: probability; Ddl: Degrees of freedom.

3.2. Survey on the Use of Wheat Flour

3.2.1. Sociodemographic Profile of Bakers

A total of 120 peoples, comprising 103 men and 17 women, were interviewed. The age of the respondents ranged from 18 to 65 years. The educational level of the respondents was predominantly secondary school (64.2%). Furthermore, most respondents were of Ivorian nationality (76.7%) and belonged to the Aka ethnic group (30.8%) (Table 6).

Table 6. Sociodemographic profile of bakers.

Parameters	Number	Proportion (%)
Age group	n = 120	
[18 - 30]	36	30
[31 - 45]	56	46.7
[46 - 65]	28	23.3
Gender	n = 120	
Male	103	85.8
Female	17	14.2
Level of education	n = 120	
Primary	27	22.5
Secondary	77	64.2
Higher	7	5.8
None	9	7.5

Continued

Nationality	n = 120	
Ivoran	92	76.7
Foreign	28	23.3

3.2.2. Choosing Flours and Where to Buy Them

With regard to the types of cereals used, the survey revealed that wheat is the only cereal used by all the bakeries and patisseries surveyed (100%) (Table 7). Furthermore, none of them stated that they mixed wheat flour with other types of flour. GMA (47.5%) and Malika (35.8%) are the most commonly used flour brands, whilst the Abidjanaise (11.7%) and Artisan (5%) brands have relatively low usage rates. As regards the source of supply, mills are the main source of wheat flour (53.3%). The main criteria for choosing suppliers cited by respondents are product quality (43.3%), availability (27.5%) and price (21.7%).

Table 7. Knowledge and brand of flour used.

Parameters	Number	Proportion (%)
Types of cereals used	n = 120	
Wheat	120	100
Brands of flour used	n = 120	
GMA flour	57	47.5
Malika flour	43	35.8
L'Abidjanaise flour	14	11.7
L'Artisan flour	6	5
Uses of flour mixes	n = 120	
Yeah	0	0
No	120	100
Source of flour	n = 120	
Flour warehouse	36	30
Wholesale store	20	16.7
Factory	64	53.3
Reason for choosing	n = 120	
Proximity	9	7.5
Availability	33	27.5
Quality of the flour	52	43.3
Price	26	21.7

3.2.3. Storage, Shelf Life and Wheat-Based Products

As regards storage location, flour is mainly stored in the production room (64.2%) and is, for the most part, used up within a week (63.3%). As for wheat flour-based products, all the bakeries surveyed produce bread (100%). However, 30.8% focus

exclusively on bread production, whilst 69.2% also produce pastries and Viennese pastries in addition to bread. Despite this diversification, bread remains the most widely sold wheat flour-based product with the highest sales rate (52.5%) (**Table 8**).

Table 8. Storage, shelf life and by-products.

Parameter	Number	Proportion (%)
Storage location	n = 120	
Warehouse	12	10
Storage room	31	25.8
Production hall	77	64.2
Duration of use	n = 120	
Less than a week	76	63.3
1 to 2 weeks	31	26.7
3 to 4 weeks	12	10
More than a month	0	0
Products made from wheat flour	n = 120	
Bread only	37	30.8
Bread + other products (croissants, cakes, etc.)	83	69.2
Best-selling product	n = 120	
Bread	120	100
Average number sold per day	n = 120	
1 - 99	0	0
100 - 299	22	18.3
300 - 800	35	29.2
800 or more	63	52.5

3.2.4. Knowledge of Enriched Flours and Testing

With regard to respondents' knowledge of the fortification of wheat flour, the results show that only 45% of participants stated they were aware of it, compared with 51.7% who said they had not heard of it. As for the flours used, 31.7% of respondents know that they are fortified, whilst the majority (68.3%) are unaware of this. Furthermore, none of the respondents (n = 120) reported carrying out any verification tests to confirm the fortification of the flours used (**Table 9**).

Table 9. Information on wheat flour fortification and control tests carried out by bakers.

Parameter	Number	Proportion (%)
Knowledge of the enrichment of wheat flour		
Yes	54	45
No	62	51.7
No idea	4	3.3

Continued

Knowledge of the fortification of wheat flour with iron and folic acid in the flours used		
Yes	38	31.7
No	33	27.5
No idea	49	40.8
Use of tests to monitor the enrichment of the flours used		
Yes	0	0
No	120	0

4. Discussion

This study was conducted to assess the level of consumption, use and awareness of wheat flour fortification among households and bakers in four municipalities of Abidjan (Ivory Coast). The results obtained from the surveys vary.

At the household level, the socio-demographic profile reveals a study population aged between 18 and 65. The 31 - 45 age group is the most represented, accounting for 62% of respondents. This high proportion could be explained by the fact that it corresponds to a period of financial stability, which gives them a major role in managing household expenditure and food choices. These results are consistent with those reported by [26], who found a similar trend. Unlike the results obtained by [27], our study highlights a predominantly male population (61% men versus 39% women), representing a ratio of 1.6 in favour of men. These results are similar to those of [28], who reported the same trend. This situation may be explained by the fact that in Côte d'Ivoire, boys have better access to schooling than girls [29].

The educational attainment of respondents is dominated by secondary education (25.25%). However, a significant proportion of respondents have no formal education or only basic literacy skills (34.5%). Our results are similar to those of [30], who also observed a predominance of secondary education (24%). Conversely, they differ from those of [31], who found that the majority of respondents (53.33%) had not progressed beyond primary education in a study on artisanal infant cereals in Côte d'Ivoire. Furthermore, the vast majority of households (94.75%) are of Ivorian nationality and belong to various ethnic groups, among which the Mandé are the most represented (32%). This ethnic diversity illustrates the multicultural character of the city of Abidjan, characterised by the coexistence of numerous communities. Our results, however, differ from those of [27], who reported a predominance of Krou people among households in the Abidjan district. Trade constitutes the main source of income for the households surveyed (23.5%, 46.75%). This could be explained by current socio-economic realities, where the informal sector and entrepreneurial activities constitute the main sources of income. Similar findings have been reported in studies, which have highlighted the significant presence of women, particularly in the informal sector

in Abidjan [32].

The results of this study reveal that wheat flour and its derivatives are well known to the households surveyed. This awareness of wheat flour varies significantly according to the educational level of the households surveyed. Indeed, households with secondary education (25.25%) or higher (23%) have a better understanding of wheat flour, unlike those with a low level of education. The findings are consistent with those of Nomel and her collaborators, who highlighted a significant relationship between households' educational level and the choice of cereals used in the preparation of *toh* [33]. In their study, the authors observed that households with a secondary school education prefer millet over yellow maize for the preparation of this dish. Furthermore, a study conducted by the CNSA (2022) [34] also highlighted the influence of the head of household's level of education on access to food. Indeed, the study revealed that the proportion of households reporting frequent food shortages is significantly lower when the head of household has a university education (2%) than when they have no formal education (16%). However, no significant difference was observed between men and women regarding knowledge of products made from wheat flour. Households headed by men (39%, 58.5%) and those headed by women (53.25%, 33.75%) alike reported being familiar with these products. Similar studies where found no significant association between the gender of the head of household and food security in a survey conducted in Bangladesh [35]. According to these authors, this lack of disparity could be explained by a relatively favourable socio-cultural context, thereby allowing women to participate freely in the labour market.

In addition to assessing awareness, the survey also examined consumption levels of products made from wheat flour. The study found that these products are consumed by all the households surveyed (100%). Among the various ways in which wheat flour is consumed, bread is the main form, with nearly 68% of respondents eating it regularly (5 to 7 times a week). This high prevalence of bread consumption reflects the importance of cereals in West African diets, where they account for over 60% of daily energy intake [36]. These findings corroborate those of Niang *et al.* (2017) [37], who also highlighted the central role of cereals in the diets of households in Senegal. In our study, the high consumption of bread could be explained by the fact that it is a staple food, easily accessible and widely available [19]. The same case was reported in Ghana, where more than half of respondents (54.4%) consumed bread daily, with nearly 27.9% consuming it twice or more per week [38].

Similarly, Adino *et al.* (2024) [39] obtained similar results in their study of dietary habits and preferences regarding bakery products among urban dwellers in Ethiopia. They found that 38% of respondents consumed bread every day. Bakeries and patisseries appear to be the main sources of wheat flour-based products. The majority of households surveyed justified their choices based on criteria related to product quality, availability and hygiene standards. This trend was also

reported by [40], who found that growth in the bakery products market is primarily driven by affordability, product variety and the nutritional benefits perceived by consumers. Furthermore, the study highlights the weekly use of wheat flour within households, particularly for the preparation of various dishes. Doughnuts and cakes are the main home-made dishes made with wheat flour. These findings are consistent with those of Keller International [41], who highlighted the common use of wheat flour in the preparation of doughnuts and cakes by households in Côte d'Ivoire.

However, although they regularly consume products made from wheat flour, few households are aware that this flour is rich in iron and folic acid. In fact, only 41.5% are aware of this. Awareness of wheat flour fortification varies significantly according to educational level. Thus, households with the highest level of education (39.25%) have a better understanding of this practice than those with other levels of education. This highlights the important role of education in understanding dietary practices. The low awareness observed in this study corroborates the findings of [42], who showed in a survey conducted in Burkina Faso that more than half of the respondents had never heard of fortified foods. Similarly, a study carried out in Bangladesh on the level of knowledge regarding the fortification of edible oils with vitamin A and rice revealed that Bangladeshi consumers were insufficiently informed on this subject. Only 15% of participants knew that edible oils were fortified with vitamin A, whilst only 3% knew that rice was also fortified [43].

With regard to the use of wheat flour in bakeries and patisseries, our study shows that in Côte d'Ivoire this is a predominantly male-dominated sector (85.8%). The low representation of women could be explained both by the physically demanding nature of the profession and by certain socio-cultural considerations. This male predominance is consistent with the observations of Mbatchou Ngahane *et al.* (2015) [44], who reported a majority of men among bakery employees in Cameroon. Furthermore, nearly half (46.7%) are aged between 31 and 45, indicating a relatively young population at the peak of their professional maturity. Similar results were reported by Mohammed Lawal *et al.* (2022) [45], who highlighted this same trend in a study of bakers in Ghana. The majority of respondents have completed secondary education (64.2%). This relatively high level of education could be an asset in fostering a better understanding of hygiene and quality standards. These findings are consistent with those of Abong *et al.* (2021) [46], who highlighted a high level of education among bakery workers in Kenya.

Wheat is the only cereal used in all the bakeries and patisseries surveyed, confirming its central role as the primary raw material used in bread-making [47]. The GMA and Malika brands largely dominate the market among the bakeries and patisseries surveyed, accounting for over 80% of the flour used. The low usage of other brands, notably Artisan and Abidjanaise, could be explained by their recent arrival on the market, which still limits their brand recognition. Bakers source their supplies mainly from large mills, which are considered the main suppliers of

flour in Côte d'Ivoire. The criteria determining this choice are based primarily on the quality of the products offered, their availability and their price. These results highlight the importance of logistical and economic factors in the choice of supply chains by stakeholders in the bakery sector. Similar findings were reported by OCIS (2022) [48] in a study on the determinants of bread prices in Benin, which found that large mills accounted for 67.4% of wheat flour supply sources for bakeries. In the majority of bakeries surveyed, flour is stored directly in the production room for preservation. It is used by 63.3% of bakers within less than a week. Our findings corroborate those of Bossou *et al.* (2022) [49], who reported in a study conducted in Benin that 93% of bakers stored their flour for a period of 3 to 6 days. Furthermore, the study also shows that all the bakeries surveyed produce bread. However, some specialise exclusively in bread production, whilst others diversify their output by offering, in addition to bread, pastries and Viennese pastries. Nevertheless, bread remains the main product sold, with a production volume exceeding 800 loaves per day. Similar results were reported by ANSSA (2014) [50], which showed in a study conducted in Bamako that the majority of urban bakeries produce between 400 and 4900 loaves per day.

However, the survey revealed that awareness of the fortification of wheat flour with iron and folic acid remains limited among the bakers surveyed. Indeed, only 45% of respondents are aware of this practice, compared with 55% who are unaware of it. Furthermore, barely 31.7% of respondents stated that they were aware of the fortification of the flours they use, whilst the majority were unaware of it, even though the 50 kg woven polypropylene sacks in which these flours are packaged carry relevant information. This attitude of ignorance or trivialisation of the information could persist. This is all the more likely given that consumers themselves pay little attention to the nutritional information on packaging [51]. The low level of awareness observed in this study is consistent with the findings of Helen Keller International [41], who showed that in Côte d'Ivoire, the population's level of knowledge about fortified foods remains very low. Indeed, in a survey assessing household coverage of refined vegetable oil fortified with vitamin A and soft wheat flour fortified with iron and folic acid, these authors found that only 16% of participants had ever heard of fortified foods, and that the fortification of flour (14%) and salt (5%) appeared to be less well known.

This study has certain limitations that should be borne in mind when interpreting the results. Firstly, its cross-sectional nature does not allow for the establishment of causal relationships between the variables studied. Secondly, the data were based primarily on participants' self-reports regarding their consumption and use of wheat flour products, which may introduce recall bias or social desirability bias. Furthermore, the study was limited to four municipalities in Abidjan and the bakeries were selected in a targeted manner, which may restrict the generalisability of the results to the entire population. Finally, no direct verification of the actual fortification of the flour used was carried out at the bakeries or on the products consumed.

5. Conclusion

This study assessed the consumption habits and level of knowledge among the population of Abidjan regarding wheat flour and its fortification with iron and folic acid. It also examined how bakers and pastry chefs use this flour and their awareness of its fortification. The results show that wheat flour-based products, particularly bread, play a significant role in the diets of the households surveyed. However, knowledge of the fortification of this flour remains limited among both consumers and those involved in processing. Indeed, fewer than half of the households and bakers are aware that the wheat flour sold in Côte d'Ivoire is fortified with micronutrients. Furthermore, all the bakeries surveyed stated that they do not carry out checks or tests to verify the fortification of the flours used. These results essentially reflect the participants' levels of awareness and reported practices. However, they do not allow for conclusions to be drawn regarding actual compliance with the fortification standards for the flours used. It is therefore necessary to strengthen awareness campaigns targeting consumers and bakery professionals, as well as to improve the mechanisms for monitoring and controlling the quality of fortified wheat flour in Côte d'Ivoire.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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