Moringa oleifera Lam.: A comparative survey on consumer knowledge, usage, attitude and belief in Africa and India

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Abstract

Native to India, *Moringa oleifera* Lam. is a plant with high nutritional value, which is now grown across the world, especially in tropical and subtropical regions. This study determined the knowledge, consumption, attitudes and beliefs toward *Moringa oleifera* in some African countries (Nigeria, Ghana, and South Africa) and in India to gain a better understanding of why this plant is widely consumed in India but less so in Africa. An online survey was conducted using a snowball sampling procedure with 258 respondents who are consumers of Moringa (124 are Indians and 134 are Africans; 54% are Male and 46% are Female). We hypothesized that the differences in patterns of Moringa consumption in India and Africa might be due to differences in knowledge, attitudes and beliefs towards Moringa. In particular, we expected Indian respondents to have a better knowledge and more positive attitudes and beliefs towards Moringa than African respondents. Based on our study sample, we observed differences in terms of knowledge and consumption of Moringa between Indian and African respondents. However, these differences could not be explained in terms of beliefs and attitudes: No significant difference was found between African and Indian respondents' beliefs towards Moringa. Having positive attitudes and beliefs is not enough to change Moringa consumption behavior. Past behavior seems to be a better predictor of Moringa consumption behavior. As Moringa is not yet anchored in African families and cultural practices, especially in South Africa, providing only nutritional and health information is not enough to promote Moringa consumption in Africa. A better option would be to increase the familiarity of Moringa by incorporating it into familiar local foods with a high satiating power. Family also seems to be an important driver of Moringa consumption that needs to be taken into account.

Keywords

Moringa oleifera; Online survey; Consumer knowledge; Usage; Attitudes and Beliefs; India; Africa

1. Introduction

Food consumption is not limited to the simple act of eating a meal three times a day and repeating this act every day to fulfill the needs of energy and nutrients. Many other factors including physiological, social and cultural factors, impact consumer food choices (Rozin, 2006). The relative weight of these factors varies with the environment in which the choices are made. In particular, consumers in developing countries or low-income consumers use different food choice criteria than consumers in developed countries or high-income consumers (Burns et al., 2013). For example, among low-income households, food prices take precedence over all other determinants (Giskes et al., 2007; Blanck et al., 2009; Steenhuis et al., 2011). According to Drewnowski (2009), when financial resources become scarce, consumers try to maximize food purchases by making provisions for the foods that provide high calories, which often leads to the consumption of energy-dense foods. In contrast, nutrient-dense and healthy foods are generally expensive and difficult to access for these populations (Irala-Estévez et al., 2000; Burns et al., 2013). The geographic location as well as the transport make the access to foods more difficult for a number of consumers (Dibsdall et al., 2003; Story et al., 2008). For example, the price of fruits and vegetables is higher when consumers need to buy food outside their area of residence (Dibsdall et al., 2003).

Besides economic factors (i.e., price, availability, accessibility), other factors such as food sensory attributes related to preference and liking and physiological attributes related to intrinsic properties of food like satiating power play an important role in food choices (Murray and Vickers, 2009). The satiating power of a food is a very important factor in making food choices among low-income populations. Burns et al. (2013) described a satiating food in terms of amount and supply of energy needed for physical activities. In their study, satiation was associated with carbohydrates and starchy foods such as bread, rice, and potato.

According to models of behavior, such as the Theory of Planned Behaviour (TPB, Ajzen, 1991) consumers' attitudes and beliefs about foods also influence food behavior. Attitudes and beliefs are linked. Attitudes are positive or negative evaluations about people, issues, or objects. Attitudes are based on cognitive, affective, and behavioral information. A belief is the cognitive information that one has about an attitude object (Dejoy, 1999). Beliefs provide the cognitive basis of an attitude.

Bech-Larsen and Grunert (2003) in a study evaluating consumers' response towards orange juice, yoghurt and spread enriched with omega 3-fatty acids and oligosaccharides showed that the effect of a health claim depends on the product base. The effect is stronger for the spread,

a product perceived as inherently unhealthy, than for orange juice and yoghurt, naturally perceived as healthy. Although TPB has proved to be a powerful model to explain human behavior, attitudes and beliefs are not the sole predictors of food behavior. Among the additional constructs that could improve the predictive value of TPB, past behavior (i.e. actions or reactions of a person in response to external or internal stimuli in the past) and habits (goal oriented automatic behavior) are of particular importance (de Bruijn et al., 2008).

While the different factors listed above have been extensively studied in developed countries only a few studies have been carried out in developing countries (Burns et al., 2013; Hough and Sosa, 2015). Yet, there is a crucial need for such studies to understand the problem of chronic malnutrition in these countries. Although geographical or economical limited access to food is one of the causes of malnutrition, it is not the only one. For example, despite being a country rich in natural resources like fruits, legumes and leaf vegetables, Madagascar is severely affected by child malnutrition. According to Ramaroson et al. (2015), the origin of this paradox can be found both in the food history of the country and in consumers' habits, knowledge, and belief structures about food properties.

For the majority of developing countries and low-income populations, some varieties of food are unaffordable or seasonally unavailable. In the tropics for instance, meals are generally built around one staple food rich in carbohydrates but very poor nutritionally, such as a dough made from yam, maize or cassava (Dhakar et al., 2011; Ramota et al., 2013). This kind of restrictive diet consumed every day leads to chronic malnutrition (Dhakar et al., 2011).

In order to solve this problem, several studies on the usage of plants rich in nutrients and locally grown in some developing countries, have been implemented. Fuglie (2001) showed that the regions most burdened by malnutrition in Africa, Asia and Latin America share the ability to grow and utilize an edible plant, Moringa, commonly referred to as “The Miracle Tree” due to its high nutritional value.

Moringa oleifera, Lam., is a naturally cultivated variety of the genus Moringa belonging to the *Moringaceae* family. It is a medium sized tree species indigenous to northwest India (Ramachandran et al., 1980; Mughal et al., 1999). It has also been cultivated and naturalized in other parts of India, Pakistan, Afghanistan, Bangladesh, Southeast Asia, West Asia, East and West Africa (Mahmood et al., 2010). The Moringa tree is known by several regional names such as Horseradish tree, Marango, Mulangay, Saijihan and Sajna (Fahey, 2005) . This plant is considered as one of the world’s most useful trees because almost all its parts can be

consumed as food, medicine and animal forage, as well as for water purification (Fahey, 2005; Khalafalla et al., 2010; Saini et al., 2016; Ma et al., 2020) .

Because the plant is native to India, the value of Moringa is well known in this country since immemorial time (Ramachandran et al., 1980). In this country, fruits of Moringa, leaves, pods and seed oil are used for different purposes. Very young pods, which taste like asparagus are commonly consumed as vegetables and for other culinary preparations. Mature pods are used in the preparation of soups and stews (Pandey et al., 2011). Young leaves are commonly prepared like spinach or as soups and salads, while in some areas, immature seeds are consumed raw or cooked (Mishra et al., 2012).

In contrast, Moringa is not native to Africa and was introduced only in the early 20th century (Foidl et al., 2001). Although less consumed than in India, Moringa leaves are incorporated to some African dishes. For example, Moringa leaves are used in preparing a Nigerian soup called “Egusi” made from melon and spinach (Babayeju et al., 2014). In Kenya, the fresh leaves of Moringa are used as vegetables and tea and the leaf powder are mixed with other foods (Kumssa et al., 2017). In Ghana, a study carried out by Glover-Amengor et al. (2017) showed that Moringa leaves was used to fortify different school lunch menu in order to improve the vitamin A and minerals contents of dishes of children from 4 to 12 years old.

Despite the abundant benefits of this plant, it seems that there is a lack of awareness and/or an unwillingness to exploit it (Farinola et al., 2014). In Nigeria, Popoola and Obembe (2013) mentioned that there is unequal indigenous knowledge concerning plant use among the Nigerian population attributed to differences in ecological regions, ethnicities, gender, age, professions, religion, cultural beliefs, abundance and usefulness of the species. Another study carried out in northern South Africa reports that although the people of Hammanskraal (a town in Gauteng province) have heard about the uses and benefits of Moringa, they never consumed it, whereas the people of Lebowakgomo (a town in Limpopo province) often consume this plant (Ntila et al., 2018).

The goal of this study is to comparatively explore the knowledge, consumption, attitudes and beliefs about *Moringa oleifera* in Africa and India to gain a better understanding of why this plant is widely consumed in India but less in African countries. Our hypothesis was that differences in patterns of consumption might be due to differences in terms of knowledge, attitudes and beliefs. In specific, we expected Indian respondents to have a better knowledge and more positive attitudes and beliefs towards Moringa than African respondents.

We conducted an online survey in India and three African countries. The African countries, were chosen based on the different levels of consumption of Moringa: Ghana where Moringa is consumed by humans through fortifying some local foods (Glover-Amengor et al., 2017); Nigeria where Moringa is mostly used as medicine, food and for nutritional supplementation purposes (Popoola and Obembe, 2013); and South Africa where it is mostly used for animal feeding (Mabapa et al., 2017).

2. Materials and Methods

2.1. Questionnaire Design

The questionnaire was written in English, since this is a common language in Ghana, Nigeria, South Africa and India where the online survey was conducted. A pilot online survey was initially carried out in the four countries before we implemented the main survey. This led to the reduction or addition of questions and changes in the wordings of the questions in order to make them more understandable. The final questionnaire (Table 1) included 20 questions structured into four sections: 1) knowledge of Moringa (Q1 –Q4), 2) consumption of Moringa (Q5 – Q14), 3) attitudes and beliefs towards Moringa (Q15) followed by five socio-demographic questions (Q16-Q20) in section four. The knowledge and consumption sections included yes/no, single-choice, and check-all-that-apply (CATA) questions. The CATA lists for each question were based on previous literature (Pandey et al., 2011; Mishra, Singh, & Singh, 2012; Babayeju et al., 2014; Kumssa et al., 2017). The belief section included 15 belief statements evaluated with 5-point Likert scales. The statements were also based on previous literature to span different belief dimensions such as health, taste, practicality, affordability and nutrition. As Indian populations do not use the term Moringa in everyday life but refer to it as drumstick plant, the term Moringa was replaced with the term drumstick plant throughout the questionnaire to collect data in India.

2.2. Recruitment and survey administration

Data were collected by means of an online survey using Google Form software. Respondents in the four countries were recruited using the snowball technique via email. They received e-mails sent to e-mail groups and individual contacts and were asked to forward the link to their acquaintances in order to recruit additional participants. The survey was also advertised on social media platforms (WhatsApp). Before answering the survey, respondents were informed of the purpose and background of the study and asked to sign a consent form. The survey was

conducted in African countries from August 2019 to February 2020 and in India from February 2020 to March 2020.

A total of 513 respondents filled out the questionnaire: 83 in South Africa (16%), 129 in Ghana (25%), 105 in Nigeria (21%) and 196 in India (38%). Among the 513 respondents, 255 declared that they do not consume Moringa, while 258 (134 are African and 124 are Indian) affirmed to consume it. Since this study focused on consumer knowledge, usage, attitude and belief, only the data from the 258 respondents who have consumed Moringa at least once in the past were analyzed. The rationale for this decision was premised on the fact that the study aimed to gain an understanding of the motivation behind the consumption of Moringa based on the experiential knowledge of Moringa consumers in the four countries. The demographic characteristics of the Moringa respondents are summarized in Table 2.

2.3.Data Analysis

To analyze the data collected, we compared respondents' knowledge, consumption, attitudes and beliefs about Moringa between India and African countries (Ghana, Nigeria and South Africa).

2.3.1. Univariate analysis

In order to understand the extent of knowledge, consumption, attitudes and beliefs about Moringa in India and Africa, univariate analysis on the Yes/No, single-choice and CATA questions using frequency counts was carried out. Chi-square tests were performed to highlight the differences between participants' responses to each variable. All analyses were performed with XLSTAT software (version 2020.2.3, France).

2.3.2. Multivariate analysis

The responses to the 15 belief statements were coded directly from the 5-points Likert-scale used by respondents, ranging from 1 for "strongly disagree" to 5 for "strongly agree". A varimax rotated Principal Component Analysis (PCA) was performed on the attitudes and beliefs statements (Q15) as active variables and respondents as observations. Participant continent of residence (India or Africa) was projected as supplementary variable in the PCA. A segmentation of the participants was then obtained by performing a Hierarchical Cluster Analysis (HCA) with Euclidean distances and Ward aggregation criteria on the coordinates of the respondents on the Principal Component (PC) with an eigenvalue greater than 1 (Kaiser

Law). Chi-square tests were carried out ($\alpha = 0.05$) to characterize the identified clusters in terms of demographic characteristics. Then, following Lebart et al. (2006), clusters were further described by knowledge and consumption modalities using a hyper-geometric law ($\alpha = 0.05$) and by belief statements using Student t-tests. This was done by comparing each cluster average scores with the overall average scores. Chi-square tests were performed with XLSTAT software. PCA and HCA were performed with SPAD software (version 9.1, France).

3. **Results**

3.1. Comparison of knowledge in India and Africa

In order to assess their knowledge of Moringa, respondents were asked three questions (Q2-Q4). In Q2, they were asked to choose between family, media, friends, health professionals, or other as the first source of information about Moringa. The items "school" and "research" having been often mentioned by respondents that choose the option other were added for the analysis of this question. The Chi-square test showed a significant difference between African and Indian respondents in terms of the sources of information about Moringa ($\chi^2 = 27.92$, $p < 0.0001$). Indian respondents chose family as the main source of information more frequently than African respondents (Fig. 1a). For the latter, family was also an important source of information but they also heard about Moringa from friends, media, school and research.

Respondents were also asked whether they considered Moringa as food, medicine or both (Q3). A significant difference was observed between African and Indian respondents ($\chi^2 = 48.98$, $p < 0.0001$). A significantly larger number of Indian respondents considered Moringa as food only compared to African respondents who considered it more often than Indian respondents as either medicine only or food and medicine (Fig. 1b).

3.2. Comparison of consumption habits in India and Africa

Nine questions were asked to explore respondents' eating habits (Q6-Q14). When querying about the part of Moringa consumed, a significant difference was observed between the two groups of respondents ($\chi^2 = 93.58$, $p < 0.0001$). Most of the African respondents consumed the leaves of Moringa (81%) followed by seeds while for Indians all parts of Moringa (Bark, flowers, leaves, seeds) were consumed homogenously (Fig. 2a). Only Indian respondents gave other responses like fruits and pods. With respect to how Moringa is eaten, Africans and Indians respondents exhibited different eating habits ($\chi^2 = 123.70$, $p < 0.0001$). African respondents consumed Moringa as tea (26%) and in raw form more often than Indian

231 respondents who consumed it more often in a cooked form, as vegetables in soups (45%), in
232 sauce and in salad (Fig. 2b).

233 A significant difference was also observed between African and Indian respondents for the
234 sources of Moringa ($\chi^2 = 74.63$, $p < 0.0001$). Whereas African respondents mostly harvested
235 Moringa directly from their yard (56%) and from their neighborhood, Indian respondents
236 often purchased Moringa from the local market (66%) or herbal shops (Fig. 3a). The
237 frequency at which African respondents used Moringa as a cooking ingredient was
238 significantly different from that of Indian respondents (χ^2 test = 17.18, $p < 0.000$). While most
239 African and Indian respondents declared using Moringa monthly (71% and 64% respectively)
240 more African respondents used it daily than Indian respondents who used it more often on a
241 weekly basis (Fig. 3b). Most African respondents predominantly consumed Moringa dishes
242 for breakfast and dinner, whereas Indian respondents declared consuming them for lunch and
243 dinner (Fig. 3c).

244 When asked about the methods used for cooking Moringa, African and Indian respondents
245 showed a significant difference ($\chi^2 = 37.64$, $p < 0.0001$). The majority of African and Indian
246 respondents declared boiling Moringa (63% and 68% respectively). However, Indian
247 respondents used more frequently the frying method than African respondents who used
248 steaming more often (Fig. 4a).

249 The last question in this section concerned the form in which respondents declared consuming
250 Moringa. Both African and Indian respondents consumed mostly Moringa in its raw form
251 (Fig. 4b). The main difference between the two groups of respondents was that Indian
252 respondents consumed Moringa in a cooked form more often than African respondents who
253 consumed it more often in a powder form ($\chi^2 = 74.36$, $p < 0.0001$).

254 3.3. Comparison of belief statements in India and Africa

255 A varimax rotated PCA was applied to the belief statements (Q15). Following Kaiser law
256 (eigenvalue > 1) the first four PC explaining 63.4% of total variance were kept for the
257 analysis (Fig. 5). To facilitate the interpretation of the PC, only statements with contribution
258 greater than the average contribution were considered in the analysis. As shown Fig 5a, PC 1
259 (25.5%) opposed positive attitudes and beliefs (health, nutritious) to negative ones (not safe,
260 not good for children, gain-weight, expensive). All attitude and belief statements related to
261 liking (like color, like taste, like aroma, like texture) and accessibility are positively correlated
262 to PC 2 (19.5%). The projection of the barycenter of African and Indian respondents onto PC

1 & 2 respondent map (Fig. 5b) shows that there is no country-of-origin segmentation (the two barycenters as close to the center of the map) in terms of attitudes and beliefs toward Moringa.

The third PC (9.7%) is positively correlated with the statements Moringa is like a cabbage or spinach, Moringa is an herb, Moringa is healthy and nutritious. The fourth PC (8.7%) is negatively correlated with the statements Moringa is consumed with local food and it is consumed in the village. The projection of the barycenter of African and Indian respondents onto these two PCs (Fig. 5b) shows a segmentation in terms of country of origin. On average, African respondents agreed more with the statements Moringa is like cabbage or spinach and it is like a herb, than Indian respondents. On the opposite, Indian respondents agreed more with the beliefs that Moringa is most consumed in villages and with local foods than African respondents.

The HCA carried out on respondents' coordinates on the first four PCs separated respondents into three clusters. Chi-square tests (α-risk= 5%) performed on demographic characteristics showed no significant difference in terms of countries of origin, age and sex (Table 3). In contrast, the three clusters differed in terms of knowledge and consumption habits and patterns of attitudes and beliefs (Table 4).

Respondents in Cluster 1 heard about Moringa from teachers and researchers in school more often than other respondents did. They ate Moringa less often and found it less easy to prepare than other respondents. Their knowledge of other usages of Moringa than human consumption was lower than that of other respondents. Globally they tended to disagree more than other respondents did with all belief statements. In particular, they disagreed more with the idea that Moringa is a local food consumed in the village, that this is an herb more than a vegetable and that it is like cabbage or spinach. They also tended to like less Moringa than other respondents but even though their scores were lower than that of other respondents they believed in the heath and nutritional value of Moringa as their average scores for these items were above four.

Respondents in cluster 2 heard about Moringa from their family more often that other respondents and ate it more often for breakfast. They also tended to eat the fruit of Moringa more often than other respondents did. They tended to have a more positive attitude toward the taste, health and nutrition dimension of Moringa than other respondents did. They also

294 believed that Moringa is accessible and did not think that it is an expensive or local product
295 consumed in villages nor that it is similar to cabbage or spinach.

296 Respondents in cluster 3 heard about Moringa from health professionals more often than other
297 respondents, they found it easier to prepare than other respondents and their knowledge of
298 uses other than food consumption is higher than that of other respondents especially for water
299 purification. They tended to agree more with all belief statements than other respondents
300 whether positively or negatively. The difference with other respondents was, however, higher
301 for negative statements such as it makes me gain weight, it is not safe to consume, it is very
302 expensive and it is not for children. They also agreed more on the fact that it is consumed by
303 people in the village, that it is only consumed with local foods, that it is like cabbage or
304 spinach and that it is more a herb than a vegetable. Despite these somewhat negative attitudes
305 and beliefs towards Moringa they still agreed more than other respondents did on the fact that
306 they like Moringa and that it has health and nutritional values. The difference with other
307 respondents is, however, lower for these last items and may be in part due to a tendency to
308 agree with all statements.

309 **4. Discussion**

310 The aim of this paper was to gain some understanding into why the *Moringa oleifera* plant
311 known for its nutritional benefits is widely consumed in India but less so in African countries.
312 Our hypothesis was that Indian respondents would have a better knowledge and more positive
313 attitudes towards Moringa than African respondents and that this difference in knowledge
314 attitudes and beliefs would explain the difference in consumption.

315 Based on our study sampling procedure, we observed a difference in terms of consumption
316 between Indian and African respondents, which is in agreement with our *a priori* expectation
317 based on previous literature (Pandey et al., 2011; Mishra et al., 2012; Babayeju et al., 2014;
318 Kumssa et al., 2017). The first remarkable difference was noticed between the number of
319 respondents who declared knowing and consuming Moringa. In India, only 37 % of the total
320 respondents had not heard about Moringa and/or have not consumed it before. On the other
321 hand, more than half (57%) of African respondents declared not to have heard about Moringa
322 and/or have consumed it before. Most of these respondents were from South Africa (76%),
323 followed by Nigeria (53%), then Ghana (45%). These different patterns of responses can be
324 explained through food habits and cultural differences. In India, Moringa is mostly known
325 through family members, which is in line with the coevolution of food habits and Moringa

cultivation in India since Moringa is native to this area. Most Indian families have known and consumed this plant since time immemorial (Ramachandran et al., 1980). On the other hand, African respondents especially in South Africa mentioned other sources of knowledge besides family including friends, media, and school/research. Moringa was introduced to Africa only in the early 20th century, hence, it is not yet anchored in the family and cultural practices. The fact that sources like media, school and research have been mentioned in South Africa suggests that information about this plant is still in the diffusion and exploitation stage as illustrated by the increase of scientific research on Moringa (Fahey, 2005) in this country. The strong link between Moringa and food in India is also reflected by the fact that about 40% of Indian respondents perceived Moringa only as food. Despite Moringa usage in some African dishes (Yaméogo et al., 2011), the majority of African respondents from our study considered it as both food and medicine, and a remarkable number of African respondents considered it only as a medicine.

Differences were also noted on the parts of the plant consumed in Africa and India. Based on what we found from our study population in India, respondents used almost all parts of Moringa in their food preparation and this is a finding which is in agreement with Pandey et al. (2011) and Mishra et al. (2012). The usage of the plant as food is much more limited in Africa. In the three African countries, most of our study participants declared eating only the leaves. In agreement with this observation, most scientific publications describing the use of Moringa as a food in African countries mentioned dishes made with Moringa leaves (Abioye and Mo, 2015; Ntila et al., 2020). This absence of diversification of Moringa usage shows that this plant is not yet as anchored in African cuisine and food repertory as it is in Indian dishes. In agreement with this interpretation, most Indian respondents declared incorporating Moringa in their meals as a vegetable in soups, salad, sauce or with meat, while African respondents tended to consume it in a raw form or as tea. Likewise, most Indian respondents bought Moringa in local market like other foods and ate it during lunch and dinner, whereas, most African respondents got their Moringa from their own tree or from herbal shops. These differences can be attributed to the difference in terms of availability and accessibility of the Moringa plant in both countries. Although *Moringa oleifera* shows diversification into many characters and high morphological variability, the main factor limiting productivity is the absence of elite varieties adapted to the local conditions of each area.

Contrary to our expectation, almost no significant difference in attitude and beliefs was found between African and Indian respondents based on our study participants. The only difference

observed was that Indian respondents were more likely to consider Moringa as a traditional food (eaten in the village, with local foods) different from herbs, cabbage or spinach than African respondents. No effect of country was observed on the sensory, nutritional and health beliefs. Regardless of the country of origin, age or sex, respondents were segmented into three clusters. The first cluster included respondents with rather low consumption and low knowledge of Moringa. These respondents tended to disagree more with all belief statements than other respondents did. They heard of Moringa from school and researchers more often than other respondents and came more often from South Africa than in the other clusters. The second cluster included respondents who heard of Moringa from their family more than other respondents. These respondents tended to have a more positive attitude towards Moringa. The third cluster included respondents who heard of Moringa from health professionals more than other respondents. Even though these respondents believed in the health and nutritional value of Moringa they also had a negative attitude concerning its usage. Despite this segmentation in terms of attitudes and beliefs towards Moringa we did not find a clear link between beliefs and consumption patterns.

This result suggests that contrary to what we expected from the TPB theory, attitudes and beliefs are not a driving force in the Moringa consumption behavior. Past behavior seems to be a better predictor: people who have behaved in a certain way at one point in time are likely to do so again. In India, Moringa appears to be part of the culinary repertory and people's attitudes towards health and nutritional benefits were not different from that of other respondents. Therefore, their motivation to eat Moringa might have come more from their habits and the habits of their family than from their attitudes and beliefs towards Moringa. This weight of past behaviors makes it difficult to change food behaviors. Having positive attitudes and beliefs is not enough to change these habits.

In Africa, attitude towards the consumption of vegetables can be an important factor that can affect their consumption. In fact, the consumption of traditional African vegetables is low and below the recommended intake (Faber et al., 2010; Shisana et al., 2013; Kimambo et al., 2018). This consumption varies widely with geographical region, nationality and local customs. This low consumption of traditional African vegetables could be due to the negative perception where some people consider it as a food for the poor or food for those who are backward in society; a notion that perhaps explains why some consumers are not positively inclined to eating them (Vorster Ineke et al., 2007). Moreover, Mwangi and Kimathi (2006)

391 also showed that some young consumers with some exposure to African leafy vegetables
392 reflected a negative attitude and image and viewed them not trendy as compared to fast foods.

393 The consumption of leafy vegetable is different from one country to another. For example, in
394 Ghana, green leafy vegetables such as African spinach, amaranth, leafy eggplant, tossa, and
395 Moringa leaves are cultivated all year round (Glover-Amengor et al., 2017). Glover-Amengor
396 and Vowotor (2013), indicated that *Moringa oleifera* is grown and sparingly consumed in the
397 district, and could be used as food. In South Africa, a focus group study conducted in the rural
398 Limpopo site and in the rural KwaZulu-Natal site showed that the most popular leaves were
399 amaranth *(Amaranthus spp), spider plant (Cleome gynandra),* wild watermelon *(Citrullus*
400 *lanatus) and blackjack (Bidens spinosa).* In Limpopo, leaves were dried and stored for
401 consumption during winter. KwaZulu-Natal households considered African leafy vegetables
402 as food for low income population (Faber et al., 2010).

403 Familiarity was also considered as an important factor that can determine the food choice. In
404 particular, familiarity with leafy vegetable can change from one African country to another.
405 Despite Moringa being described as one of the leafy vegetables consumed in Ghana (Glover-
406 Amengor and Vowotor, 2013), it was not mentioned among the most consumed leafy
407 vegetables in South Africa (Faber et al., 2010) which probably explain why South African
408 households are less familiar with the plant. Furthermore, a study conducted in the University
409 of KwaZulu-Natal about the acceptability of Moringa beverage further showed that the
410 majority of households interviewed were not familiar with *Moringa oleifera* because it was
411 not considered as food (Olusanya et al., 2018).

412 Additionally, other factors seem more important in the modulation of food choice among low-
413 income populations. These factors are related to the physiological consequences of the
414 intrinsic characteristics of the product such as satiating power. A study carried out by
415 Ramaroson et al. (2015) in Madagascar showed that despite the belief that cassava is not good
416 nutritionally (low protein content, lack of vitamins and minerals), Malagasy people still
417 widely consume it. The reason for this is because cassava has a high satiating power and is
418 widely available. In the same study, the authors report that the opposite behavior is observed
419 for Moringa: Although they know, through governmental nutritional programs, that Moringa
420 is good nutritionally they do not consume it because of its lack of satiating power.

5. Limitations of the study

It is important to note that this study suffers from a few limitations. First, the study used structured questionnaire written in English and administered using online platforms which probably lead to self-selection bias of young, educated respondents with modest economic means. Although this cohort may not be representative of the population of India and Africa, it generates useful insights for comparing consumer knowledge, usage, attitude, which is the objective of the study. Moreover, the structured questionnaire can sometimes be restrictive and limit respondents' responses to survey questions and make it difficult for participants to fully explain themselves. To minimize this limitation, we piloted the survey with a subset of the target population who were not part of the study participants in the main survey, and we used the results of the pilot survey to refine questionnaire questions for clarity and brevity.

Second, the study adopts a non-probability snowball sampling procedure which is non-representative of the study target population. Since the aim of the study is to compare consumer knowledge, usage, attitude and believe in Africa and India, this limitation has no serious implication for the study because we do not attempt to claim external validity or generalize the findings from the study to entire population in Africa and India. Lastly, the study employed multivariate Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA), which often require large sample of data to give robust results. Although concerted efforts were made to recruit large number of participants for the survey, only 513 respondents with complete information were analyzed in the study, hence, the study findings were interpreted with caution while taking this limitation into consideration.

6. Conclusion

The main aim of this study was to compare the knowledge, usage, attitudes and beliefs about Moringa oleifera among Indian and African respondents. The majority of the respondents had a university education which is explained by the fact that getting response from all category of the population was quite challenging in these countries in addition to internet access which is sometime unavailable.

This study showed that knowledge and consumption habits of Moringa were different among Indian and African respondents. This difference seems to stem from the fact that through historical evolution, Moringa is strongly anchored in the Indian culinary repertory whereas it is seen more as a food supplement in Africa. Despite these differences, Indian and African

respondents shared the same attitudes and beliefs towards Moringa especially in terms of nutritional and health benefits. This suggests that attitudes and beliefs are not powerful enough to impact Moringa food consumption in low-income societies. In order to improve Moringa consumption and by consequence to improve food security, creating more awareness about Moringa nutritional benefits especially among African population is not enough. A better option would be to increase the familiarity of Moringa by incorporating it into familiar local foods with a high satiating power. The family seems also to be an important driver of Moringa consumption that needs to be taken into account. Finally, in our study, we chose to examine the motivations of respondents who consume Moringa. While this approach has the advantage of focusing on motivation behind Moringa consumption, it would also be interesting to look at the motivations of people who do not consume Moringa.

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Author Contributions

Conceptualization, A.H., B.-E.A., G.A.O., P.A.A.-N. and D.V.; Data curation, A.H., B.-E.A. and D.V.; Formal analysis, A.H., P.A.A.-N, M.K. and D.V.; Funding acquisition, F.H. and D.V.; Investigation, A.H. and D.V.; Methodology, A.H., P.A.A.-N., M.K., G.A.O. and D.V.; Resources, F.H. and D.V.; Supervision, F.H. and D.V.; Validation, B.-E.A and D.V.; Visualization, A.H. and D.V.; Writing – original draft, A.H., P.A.A.-N., M.K. and D.V.; Writing – review & editing, B.-E.A., G.A.O., F.H., and D.V. All authors have read and agreed to the published version of the manuscript.

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Ethics approval and consent to participate

Following the ethical clearance number AFO 001 of the University of Fort Hare, participants were informed of the goal and content of the survey and asked to sign an informed consent form prior to start the survey

Declaration of competing interest

The authors declare no conflicts of interest.

Figure captions

Fig.1. Frequency counts for knowledge of Moringa questions (a) Where did you hear about Moringa for the first time? (b) For you, what is Moringa? A: African countries, IN: India, NS: No Significance, *= $p < 0.05$, **= $p < 0.01$ and ***= $p < 0.001$ (χ^2 test).

Fig. 2. Frequency counts for Moringa consumption habit questions (a) Which parts of the Moringa tree listed below do you consume? (b) How do you eat Moringa? A: African countries, IN: India, NS: No Significance, *= $p < 0.05$, **= $p < 0.01$ and ***= $p < 0.001$ (χ^2 test).

Fig. 3. Frequency counts for Moringa consumption habit questions (a) Where do you most frequently find your Moringa? (b) How often do you use Moringa as an ingredient in your cooking *(*c) At what time during the day do you eat dishes containing Moringa? A: African countries, IN: India, NS: No Significance, *= $p < 0.05$, **= $p < 0.01$ and ***= $p < 0.001$ (χ^2 test).

Fig. 4. Frequency counts for Moringa consumption habit questions (a) Which cooking method do you use the most often to prepare Moringa? (b) In which form do you consume Moringa the most? A: African countries, IN: India, NS: No Significance, *= $p < 0.05$, **= $p < 0.01$ and ***= $p < 0.001$ (χ^2 test).

Fig. 5. PCA performed on the attitude and belief statements by respondents table (a) Correlation circle for PC 1 and 2 (b) projection of the respondents on PC 1 and 2 (c) Correlation circle for PC 3 and 4 (d) projection of the respondents on PC 3 and 4. The squares and the 95% ellipses on the respondent maps represent the barycenter of respondent origin (India vs Africa).

Tables

Table 1 Questionnaire on the knowledge, consumption, attitudes and beliefs about Moringa.

Q1. 1. Have you heard of Moringa?[b]	Q2. Where did you hear about Moringa for the first time?[a] (family, media, friends, health professionals, other)
Q3. For you, what is Moringa?[a] (a medicine, a food, both)	Q4. What other uses of Moringa do you know?[c] (water purification, household cleaning agent, fence, animal feed, I don't know, other)
Q5. Do you consume Moringa?[b]	Q6. Which parts of the Moringa tree listed below do you consume?[c] (roots, leaves, flowers, seeds, bark, other)
Q7. Among the parts you selected in Q6, which one do you consume the most?[a] (roots, leaves, flowers, seeds, bark, other)	Q8. Where do you most frequently find your Moringa?[a] (I buy it from the herbal shops, I buy it from the local market, I buy it from the supermarket, from my own Moringa tree, other)
Q9. How do you eat Moringa?[c] (as vegetable in soups, as spice, as tea, raw, in porridge, as vegetable in salad, in confectionary, as vegetable in sauce, other)	Q10. How often do you use Moringa as an ingredient in your cooking?[a] (more than once daily, once daily, more than once weekly, once weekly, 1-2 times a month, less than 1-2 times a month)
Q11. Which cooking method do you use the most often to prepare Moringa?[a] (boiling, steaming, frying, baking, other)	Q12. How difficult is it for you to prepare meals with Moringa?[a] (extremely easy, easy, neither easy nor difficult, difficult, extremely difficult)
Q13. At what time during the day do you eat dishes containing Moringa?[a] (for breakfast, for lunch, as a snack, for dinner)	Q14. In which form do you consume Moringa the most?[a] (raw, dry powder, juice, tea bag, capsule, tablets, other)
Q15. Do you agree with the following statements: I like the taste of Moringa/ It is like cabbage or spinach/It is an herb more than a vegetable/ It is consumed by people in the village/ It is nutritious/ It is good for health/ It is only consumed with local foods/It cannot be given to children/ It makes me gain weight/ It is not safe to consume/ I like it's aroma/ It is very expensive/ I like the texture/ It is easily accessible/ I like its color	
Q16-Q20 Demographic information (sex, age, nationality, education level, profession)[a]	

[a] Single-choice questions; [b] Yes/No questions; [c] CATA ; [d] 5-points Likert scale questions

511 **Table 2** Demographic characteristics of respondents included in the study (N = 258).

	Ghana	Nigeria	South Africa	India	Total
Sex					
Male	35	28	5	70	138
Female	23	28	15	54	120
Total	58	56	20	124	258
Age					
18-24	11	14	7	32	64
25-34	34	22	12	26	94
35-44	4	10	1	28	43
45-54	8	9	0	26	43
≥55	1	1	0	12	14
Total	58	56	20	124	258
Education level					
University	51	52	19	117	239
Secondary education	6	0	1	4	11
No formal education	0	1	0	0	1
Other	1	3	0	3	7
Total	58	56	20	124	258
Profession					
Student	9	8	6	24	47
Self employed	1	5	3	2	11
Scientist/Research	1	7	4	9	21
Administrator/ office worker	33	19	5	64	121
Teacher	10	8	2	4	24
Health officer	4	7	0	5	16
Unemployed	0	2	0	16	18
Total	58	56	20	124	258

512 **Table 3** Demographic characteristics of the respondents in each cluster.

	Cluster 1	**Cluster 2**	**Cluster 3**
Origin			
Africa	45	38	51
India	40	38	46
Sex			
Male	48	38	52
Female	37	38	45
Age			
18-34 years	51	44	63
35-60 years	34	32	34

513 **Table 4** Characterization of clusters by active attitudes and beliefs statements using a bilateral
514 student *t* test comparing the average score in the cluster and the overall average score.

Characteristic variables	Mean in cluster	Overall mean	P-value
Cluster 1			
cabbage_spinach	2,941	3,198	0,003
consumed_village	2,871	3,326	0,000
local_foods	2,729	3,217	0,000
Herb	3,529	3,977	0,000
Health	4,106	4,562	0,000
like_taste	3,624	4,159	0,000
like_aroma	3,200	3,829	0,000
like_color	3,365	3,965	0,000
Accessible	3,318	3,977	0,000
like_texture	3,165	3,771	0,000
Nutritious	4,012	4,527	0,000
Cluster 2			
Nutritious	4,882	4,527	0,000
Health	4,895	4,562	0,000
like_taste	4,421	4,159	0,000
Accessible	4,263	3,977	0,000
like_color	4,197	3,965	0,002
consumed_village	2,947	3,326	0,001
local_foods	2,855	3,217	0,001
cabbage_spinach	2,816	3,198	0,000
Expensive	1,908	2,597	0,000
not_safe	1,645	2,453	0,000
gain_weight	1,882	2,609	0,000
not_children	1,737	2,547	0,000
Cluster 3			
gain_weight	3,320	2,609	0,000
not_safe	3,258	2,453	0,000
Expensive	3,289	2,597	0,000
not_children	3,206	2,547	0,000
local_foods	3,928	3,217	0,000
consumed_village	4,021	3,326	0,000
like_texture	4,186	3,771	0,000
cabbage_spinach	3,722	3,198	0,000
Herb	4,464	3,977	0,000
like_aroma	4,247	3,829	0,000
like_color	4,309	3,965	0,000
Accessible	4,330	3,977	0,000
like_taste	4,423	4,159	0,000
Nutritious	4,701	4,527	0,001
Health	4,701	4,562	0,007

References

Abioye, V. F., Mo, A. 2015. Proximate composition and sensory properties of Moringa fortified maize-ogi. Journal of Nutrition & Food Sciences, S12, 001.

Ajzen, I. 1991. The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50, 179-211. https://doi.org/10.1016/0749-5978(91)90020-T

Babayeju, A., Gbadebo, C., Obalowu, M., Otunola, G., Nmom, I., Kayode, R., Toye, A., Ojo, F. 2014. Comparison of organoleptic properties of egusi and efo riro soup blends produced with Moringa and spinach leaves. Food Science and Quality Management**,** 28.

Bech-Larsen, T., Grunert, K. G. 2003. The perceived healthiness of functional foods: A conjoint study of Danish, Finnish and American consumers' perception of functional foods. Appetite, 40, 9-14.

Blanck, H. M., Yaroch, A. L., Audie, A. A., Sarah, L. Y., Zhang, J., Mâsse, L. C. 2009. Factors influencing lunchtime food choices among working Americans. Health Education & Behavior, 36, 289-301.

Burns, C., Cook, K., Mavoa, H. 2013. Role of expendable income and price in food choice by low-income families. *Appetite*, 71, 209-217. https://doi.org/10.1016/j.appet.2013.08.018

de Bruijn, G., Kroeze, W., Oenema, A. Brug, J. 2008. Saturated fat consumption and the theory of planned behaviour: Exploring additive and interactive effects of habit strength. Appetite, 51, 318-323.

Dejoy, D. M. 1999. Attitudes and beliefs. In : Wogalter, M. S., DeJoy, D., Laughery. K. R. (Eds). Warnings and Risk Communication. CRC Press. pp. 186-216.

Dhakar, R. C., Pooniya, B., Bairwa, N., Gupta, M., Sanwarmal. 2011. Moringa : The herbal gold to combat malnutrition. Chronicles of Young Scientists, 2, 119-125.

Dibsdall, L. A., Lambert, N., Bobbin, R. F., Frewer, L. J. 2003. Low-income consumers' attitudes and behavior towards access, availability and motivation to eat fruit and vegetables. Public Health Nutrition, 6, 159-168.

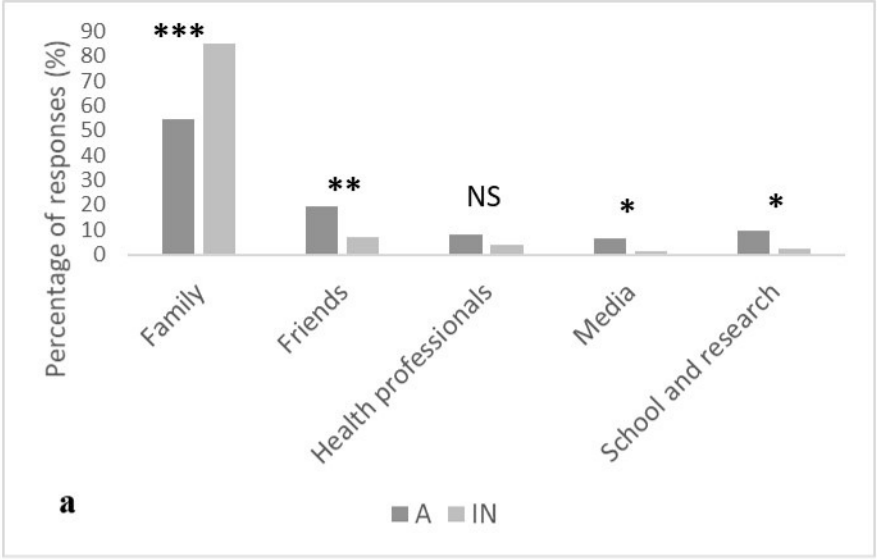
Drewnowski, A. 2009. Obesity, diets, and social inequalities. Nutrition Reviews, 67, 36-39.

553 Faber, M., Van Jaarsveld, P. J., Wenhold, F. M., van Rensburg, J. 2010. African leafy
554 vegetables consumed by households in the Limpopo and KwaZulu-Natal provinces in South
555 Africa. South African Journal of Clinical Nutrition, 23, 30-38.
556
557 Fahey, J. 2005. *Moringa oleifera*: A Review of the medical evidence for its nutritional,
558 therapeutic, and prophylactic properties. Trees for Life Journal, 1, 5.
559
560 Farinola, L. A., Famuyide, O. O., Adio, A. F., Ewolor, A. S. 2014. Households' perception,
561 awareness and willingness to pay for *Moringa oleifera* Lam. powder in Oyo state. Journal of
562 Agricultural and Crop Research, 2, 94-103.
563
564 Foidl, N., Makkar, H.P.S., Becker, K. 2001. Potentiel de *Moringa oleifera* en agriculture et
565 dans l'industrie. In international workshop on development potential for Moringa products,
566 CIRAD, Montpellier.
567
568 Fuglie, L. J. 2001. The Miracle Tree: The multiple attributes of Moringa, Pulisher: Church
569 World Service, West Africa Regional Office, Dakar, pp. 85.
570
571 Giskes, K., Van Lenthe, F. J., Brug, J., Mackenbach, J. P., Turrell, G. 2007. Socioeconomic
572 inequalities in food purchasing: The contribution of respondent-perceived and actual
573 (Objectively Measured) price and availability of foods. Preventive Medicine, 45, 41-48.
574
575 Glover-Amengor, M., Vowotor, K. A. 2013. Survey on consumption of vegetables and fruits
576 in a Coastal District in Ghana. Journal of Natural Sciences Research, 3, 84–89.
577
578 Glover-Amengor, M., Aryeetey, R., Afari, E., Nyarko, A. 2017. Micronutrient composition
579 and acceptability of *Moringa oleifera* leaf-fortified dishes by children in Ada-East District,
580 Ghana. Food Science & Nutrition, 5, 317-323.
581
582 Hough, G., Sosa, M. 2015. Food choice in low-income populations – A Review. Food Quality
583 and Preference, 40, 334-342.
584
585 Irala-Estévez, J. D., Groth, M., Johansson, L., Oltersdorf, U., Prättälä, R., Martínez-González,
586 M. A. 2000. A systematic review of socio-economic differences in food habits in Europe:
587 Consumption of fruit and vegetables. European Journal of Clinical Nutrition, 54, 706-714.
588
589 Khalafalla, M., Abdellatef, E., Dafalla, H. M., Nassrallah, A., Aboul-Enein, A., Lightfoot, D.
590 A., El-Deeb, F., El-Shemy, H. 2010. Active principle from *Moringa oleifera* Lam. leaves
591 effective against two leukemias and a hepatocarcinoma. African Journal of Biotechnology, 9,
592 8467-8471.
593
594 Kimambo, J.J., Kavoi, M.M., Macharia, J., Nenguwo N. 2018. Assessment of factors
595 influencing farmers' nutrition knowledge and intake of traditional African vegetables in
596 Tanzania. African Journal of Food, Agriculture, Nutrition, and Development, 18, 13353-
597 13371.
598

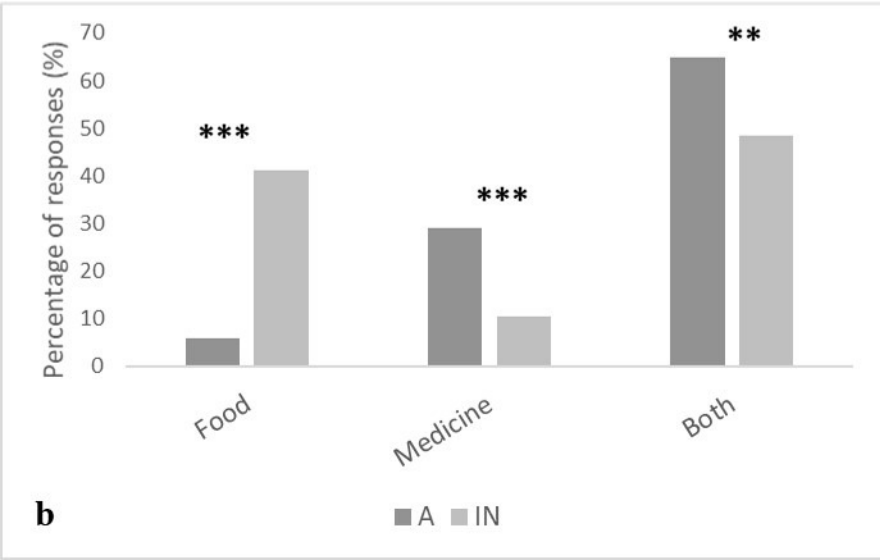
599 Kumssa, D. B., Joy, E. J. M., Young, S. D., Odee, D. W., Louise Ander, E., Magare, C., Gitu,
600 J., Broadley, M. R. 2017. Challenges and opportunities for Moringa growers in Southern
601 Ethiopia and Kenya. PloS One, 12, 11.
602
603 Lebart, L., Piron, M., Morineau, A. 2006. Statistique exploratoire multidimensionnelle, fourth
604 ed, Visualisation et inférence en fouille de données. Dunod.
605
606 Ma, Z. F., Ahmad, J., Zhang, H., Khan, I., Muhammad, S. 2020. Evaluation of phytochemical
607 and medicinal properties of Moringa (*Moringa oleifera*) as a potential functional food. South
608 African Journal of Botany, 129, 40-46.
609
610 Mabapa, M. P., Ayisi, K. K., Mariga, I. K., Mohlabi, R. C., Chuene, R. S. 2017. Production
611 and utilization of Moringa by farmers in Limpopo Province, South Africa. International
612 Journal of Agricultural Research**,** 12, 160-171.
613
614 Mahmood, K.T., Mugal, T., Haq, I.U. 2010. *Moringa oleifera*: A natural gift-a review.
615 Journal of Pharmaceutical Sciences and Research*,* 2, 775-781.
616
617 Mishra, S. P., Singh, P., Singh, S. 2012. Processing of *Moringa oleifera* leaves for human
618 consumption. Bulletin of Environment Pharmacology and Life Sciences, 2, 28-31.
619
620 Mughal, M. H., Gayoor, A., Srivastava, P. S., Iqbal, M. 1999. Improvement of drumstick
621 (*Moringa* Pterygosperma Gaertn.) a unique source of food and medicine through tissue
622 culture. Hamdard Medicus*,* 42, 37-42.
623
624 Murray, M., Vickers, Z. 2009. Consumer views of hunger and fullness. A qualitative
625 approach. Appetite, 53, 174-182.
626
627 Mwangi, S., Kimathi, M. 2006. African leafy vegetables evolves from underutilized species to
628 commercial cash crops. Research Workshop on Collective Action and Market Access for
629 Smallholders, Cali, Colombia
630
631 Ntila, S., Ndhlala, A. R., Kolanisi, U., Abdelgadir, H., Siwela, M. 2018. Acceptability of a
632 Moringa added complementary soft porridge to caregivers in Hammanskraal, Gauteng
633 province and Lebowakgomo, Limpopo province, South Africa. South African Journal of
634 Clinical Nutrition, 32, 51-57.
635
636 Ntila, S., Ndhlala, A. R., Mashela, P. W., Kolanisi, U., Siwela, M. 2020. Supplementation of a
637 complementary white maize soft porridge with *Moringa oleifera* powder as a promising
638 strategy to increase nutritional and phytochemical values: A research note. South African
639 Journal of Botany, 129, 238-242.
640

641 Olusanya, R. N. 2018. The Nutritional Composition and Acceptability of Moringa Oleifera
642 Leaf Powder (MOLP)-Supplemented Mahewu: A Maize Meal-Based Beverage for Improved
643 Food and Nutrition Security. Thesis in University of KwaZulu-Natal.Chapter 5, pp. 86-112
644
645 Pandey, A., Pradheep, K., Gupta, R., Roshini Nayar, E., Bhandari, D. C. 2011. Drumstick
646 Tree' (*Moringa oleifera* Lam.): A multipurpose potential species in India. Genetic Resources
647 and Crop Evolution, 58, 453-460.
648
649 Popoola, J. O., Olawole, O. O. 2013. Local knowledge, use pattern and geographical
650 distribution of *Moringa oleifera* Lam. (*Moringa*ceae) in Nigeria. Journal of
651 Ethnopharmacology, 150, 682-691.
652
653 Ramachandran, C., Peter, K. V., Gopalakrishnan, P. K. 1980. Drumstick (*Moringa oleifera*):
654 A multipurpose indian vegetable. Economic Botany, 34, 276-283.
655
656 Ramaroson, R. V., Valentin, D., Arvisenet, G. 2015. How to use local resources to fight
657 malnutrition in Madagascar? A study combining a survey and a consumer test. Appetite, 95,
658 533-543.
659
660 Ramota, K. O., Monday Ojo, K. R., Adeoye, O. S., Adewumi Toyin, O. 2013. Proximate,
661 mineral and sensory qualities of 'Amala' prepared from Yam flour fortified with Moringa leaf
662 powder. Food Science and Quality Management, 12, 10-23.
663
664 Rozin, P. 2006. The integration of biological, social, cultural and psychological influences
665 onfood choice. in: Shepherd, R., Raats M. (Eds.),The psychology of food choice, Guildford,
666 UK: CABI, pp. 19-40.
667
668 Saini, R. K., Sivanesan, I., Keum, Y. 2016. Phytochemicals of *Moringa oleifera*: A review of
669 their nutritional, therapeutic and industrial significance. 3 Biotech, 6, 203-217.
670
671 Shisana, O., Labadarios, D., Rehle, T., Simbayi, L., Zuma, K., Dhansay, A., Reddy, P.,
672 Parker, W., Hoosain, E., Naidoo, P., Hongoro, C., Mchiza, Z., Steyn, N.P., Dwane, N.,
673 Makoae, M., Maluleke, T., Ramlagan, S., Zungu, N., Evans, M.G., Jacobs, L., Faber, M.,
674 SANHANES-1 Team. 2014. The South African National Health and Nutrition Examination
675 Survey, 2012: SANHANES-1: the health and nutritional status of the nation. 2014ed. Cape
676 Town: HSRC Press.
677
678 Steenhuis, I., Waterlander, W. E., de Mul, A. 2011. Consumer food choices: The role of price
679 and pricing strategies. Public Health Nutrition, 14, 2220-2226.
680
681 Story, M., Kaphingst, K. M., Robinson-O'Brien, R., Glanz, K. 2008. Creating healthy food
682 and eating environments: Policy and environmental approaches. Annual Review of Public
683 Health, 29, 253-272.
684

685 Voster Ineke, H. J., Jansen van Rensburg, W., Van Zijl, J. J. B., Venter Sonja, L. 2007. The
686 importance of traditional leafy vegetables in South Africa. African Journal of Food,
687 Agriculture, Nutrition and Development, 7, 1-13.
688
689 Yaméogo, C., Bengaly, M. D., Savadogo, A., Nikiema, P. A., Traore, A. 2011. Determination
690 of chemical composition and nutritional values of *Moringa oleifera* leaves. Pakistan Journal
691 of Nutrition, 10, 264-268.


***
**
NS
*
*
90
80
70
60
50
40
30
20
10
0
Percentage of responses (%)
Family
Friends
Health professionals
Media
School and research
A
IN

a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40
30
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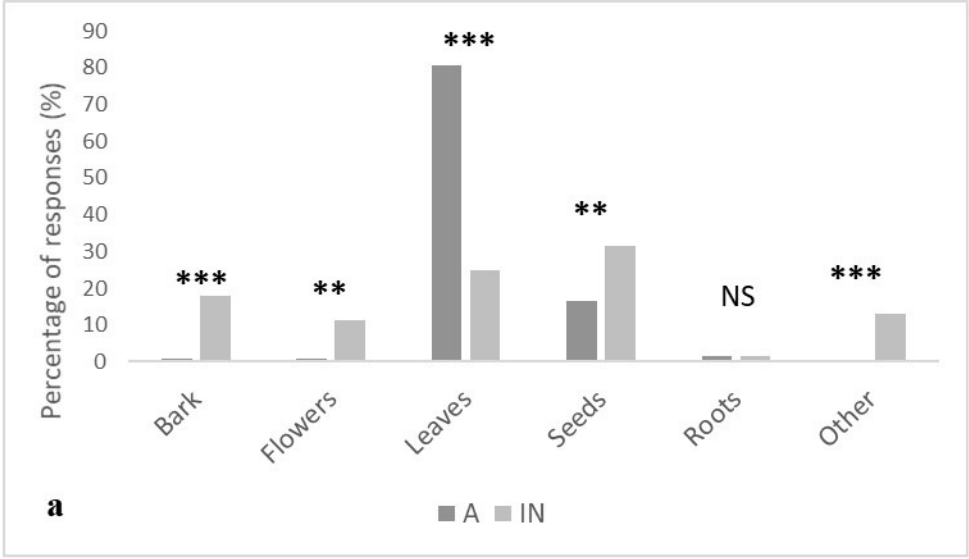
Percentage of responses (%)
Food
Medicine
Both
A
IN

b


Percentage of responses (%)
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80
70
60
50
40
30
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NS
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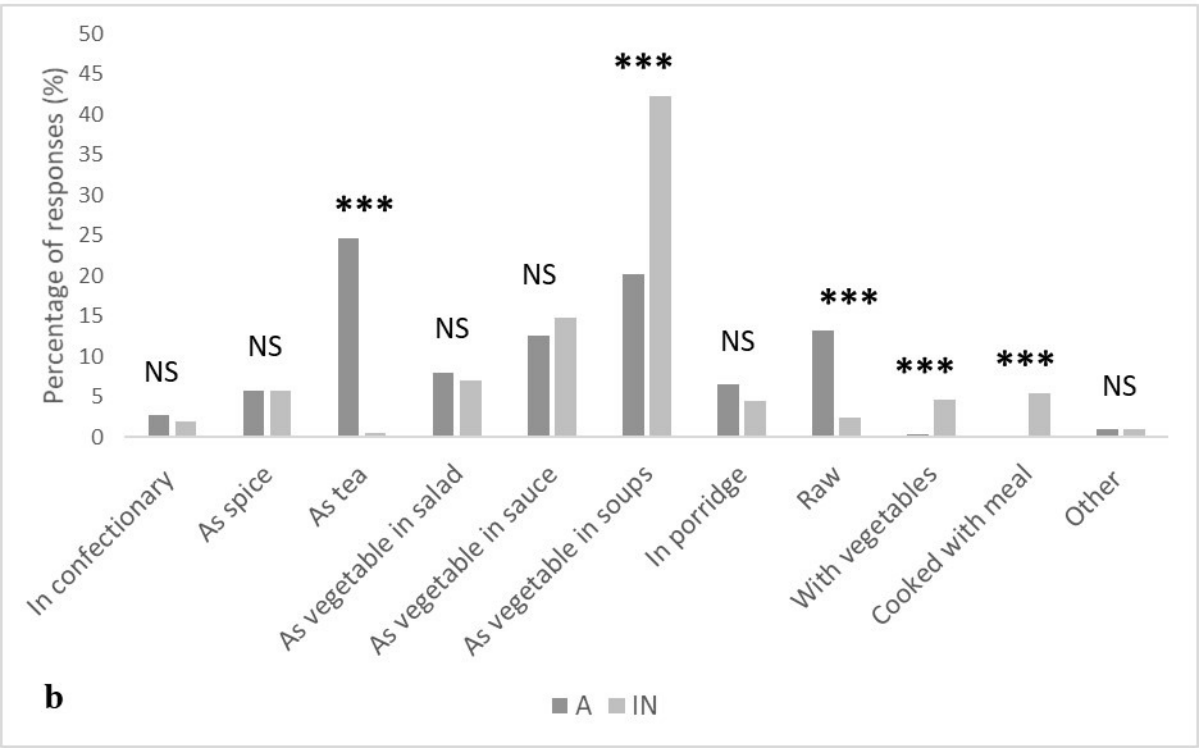
Bark
Flowers
Leaves
Seeds
Roots
Other
A
IN

a


Percentage of responses (%)
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45
40
35
30
25
20
15
10
5
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NS
NS
***
NS
NS
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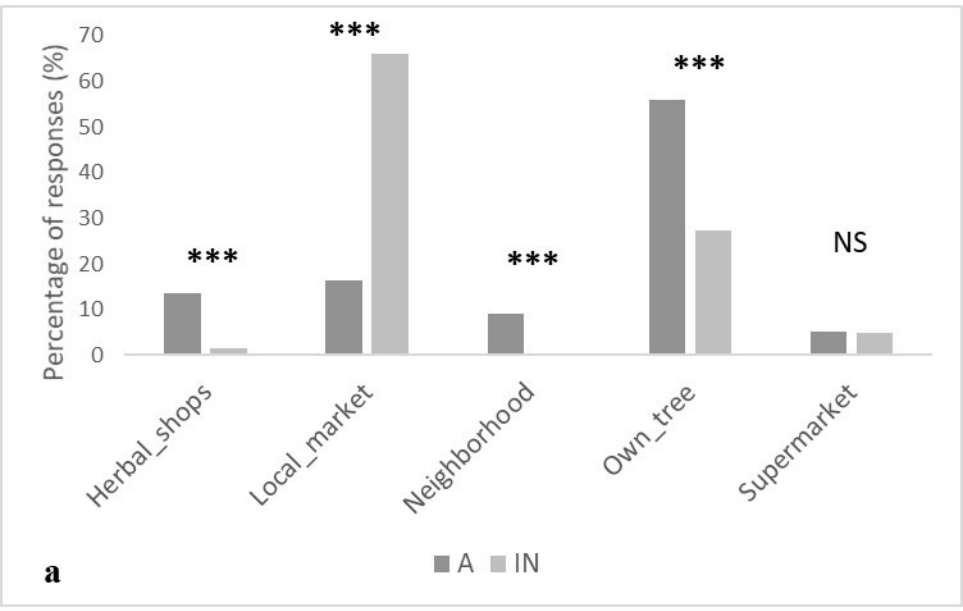
NS
***
***
***
NS
In confectionary
As spice
As tea
As vegetable in salad
As vegetable in sauce
As vegetable in soups
In porridge
Raw
With vegetables
Cooked with meal
Other
A
IN

b


Percentage of responses (%)
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60
50
40
30
20
10
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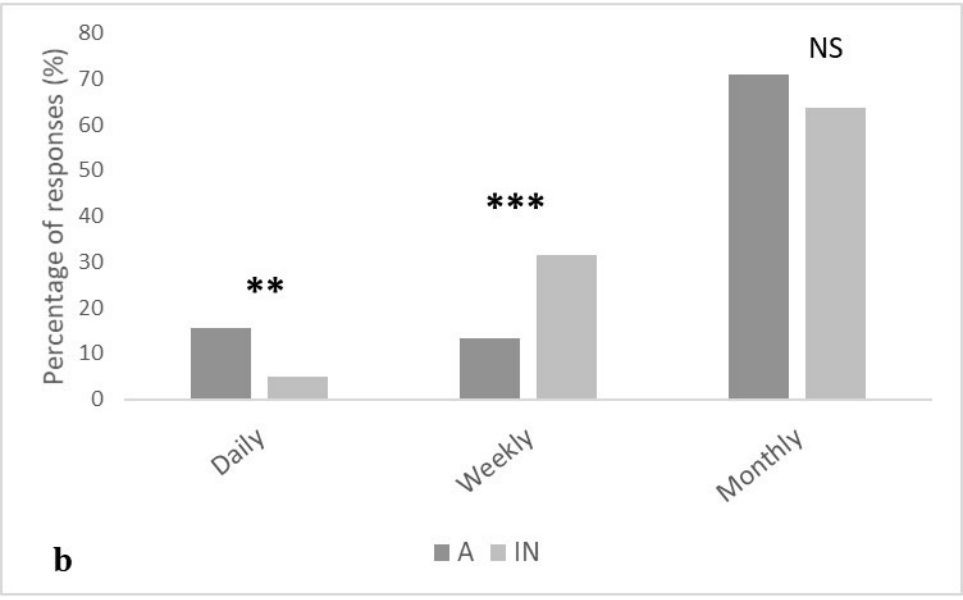
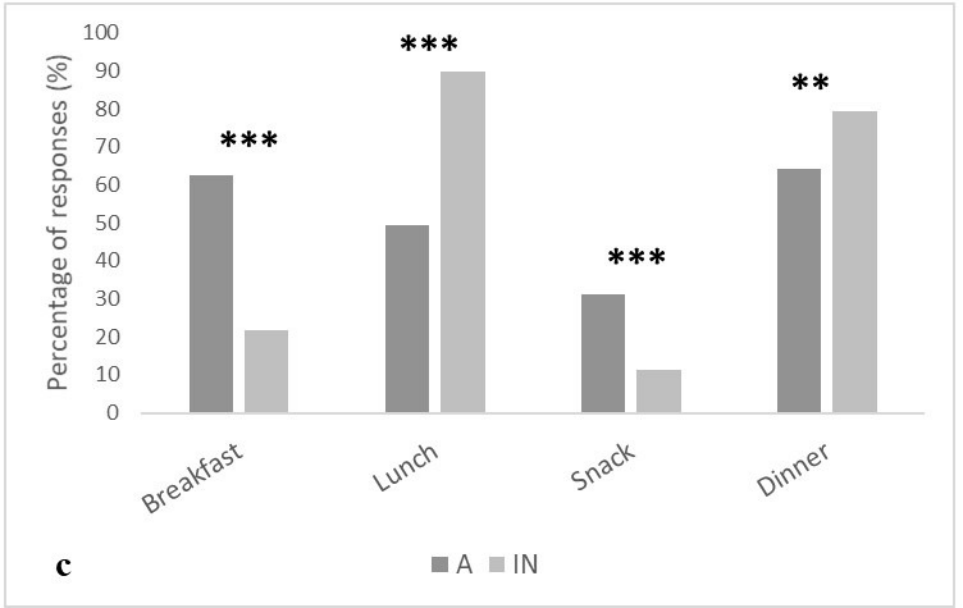
NS
Herbal_shops
Local_market
Neighborhood
Own_tree
Supermarket
A
IN

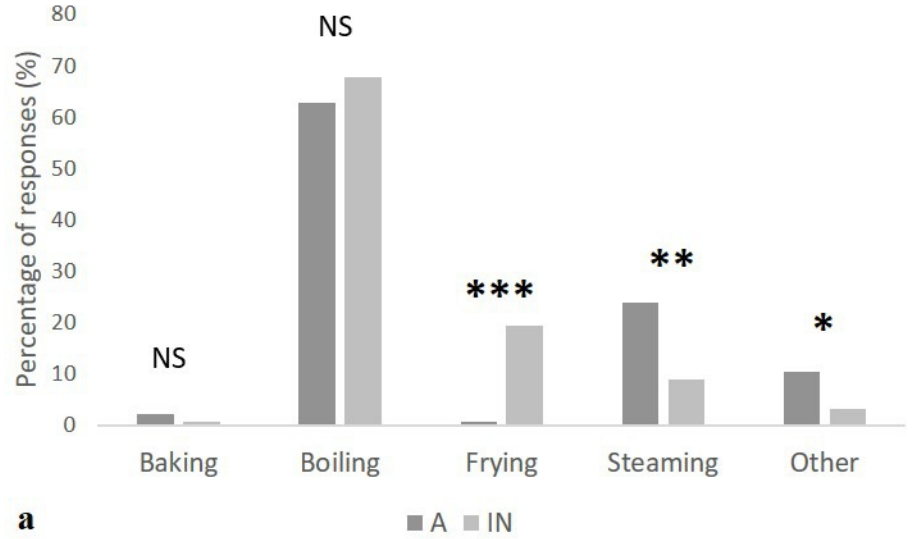
a


Percentage of responses (%)
80
70
60
50
40
30
20
10
0
**
***
NS
Daily
Weekly
Monthly
A
IN

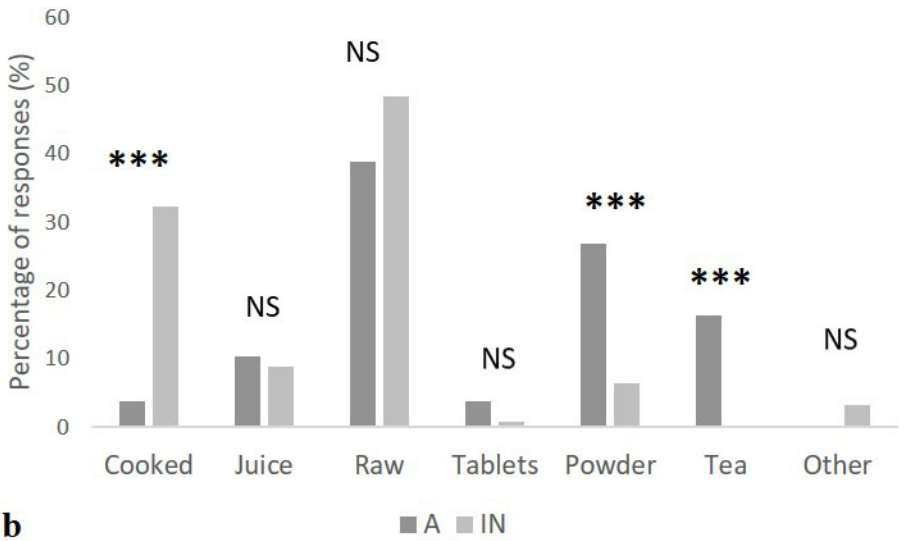
b


Percentage of responses (%)
100
90
80
70
60
50
40
30
20
10
0
***
***
***
**
Breakfast
Lunch
Snack
Dinner
A
IN

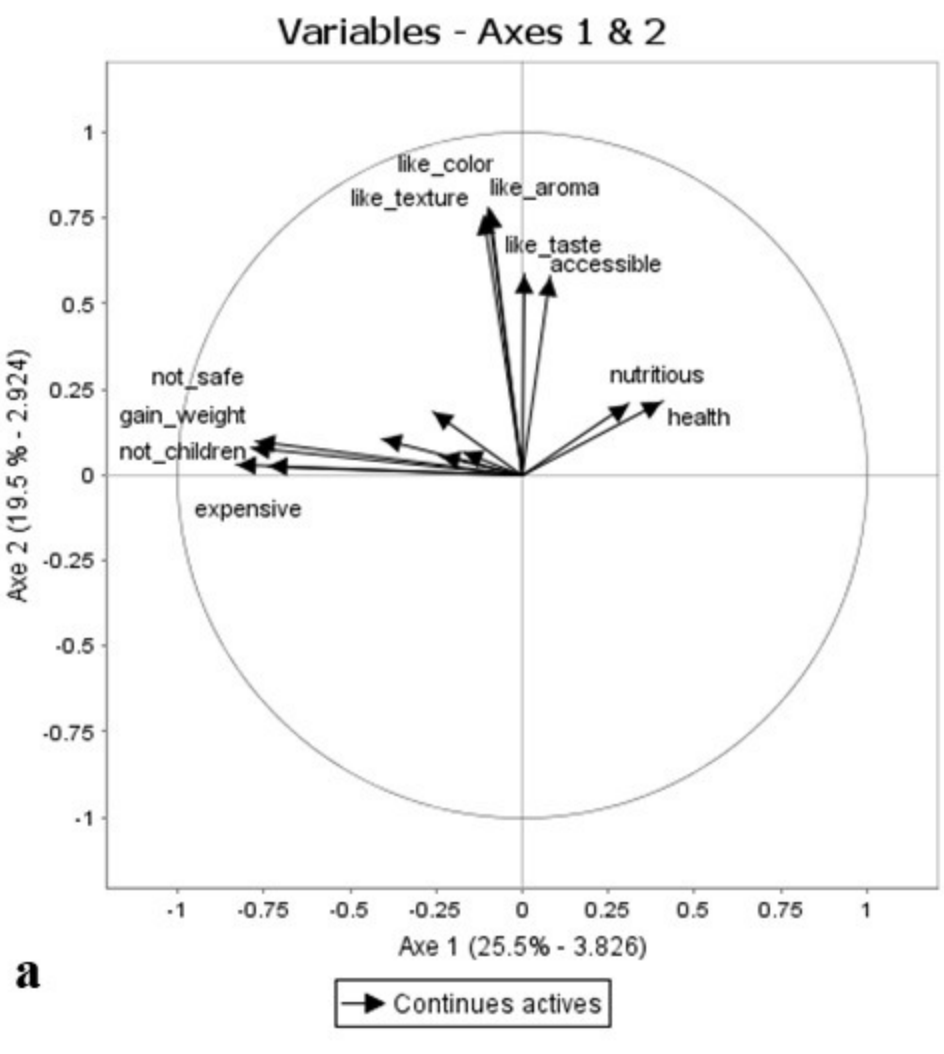
c


80
70
60
50
40
30
20
10
0
Percentage of responses (%)
NS
NS
***
**
*
Baking
Boiling
Frying
Steaming
Other
A
IN

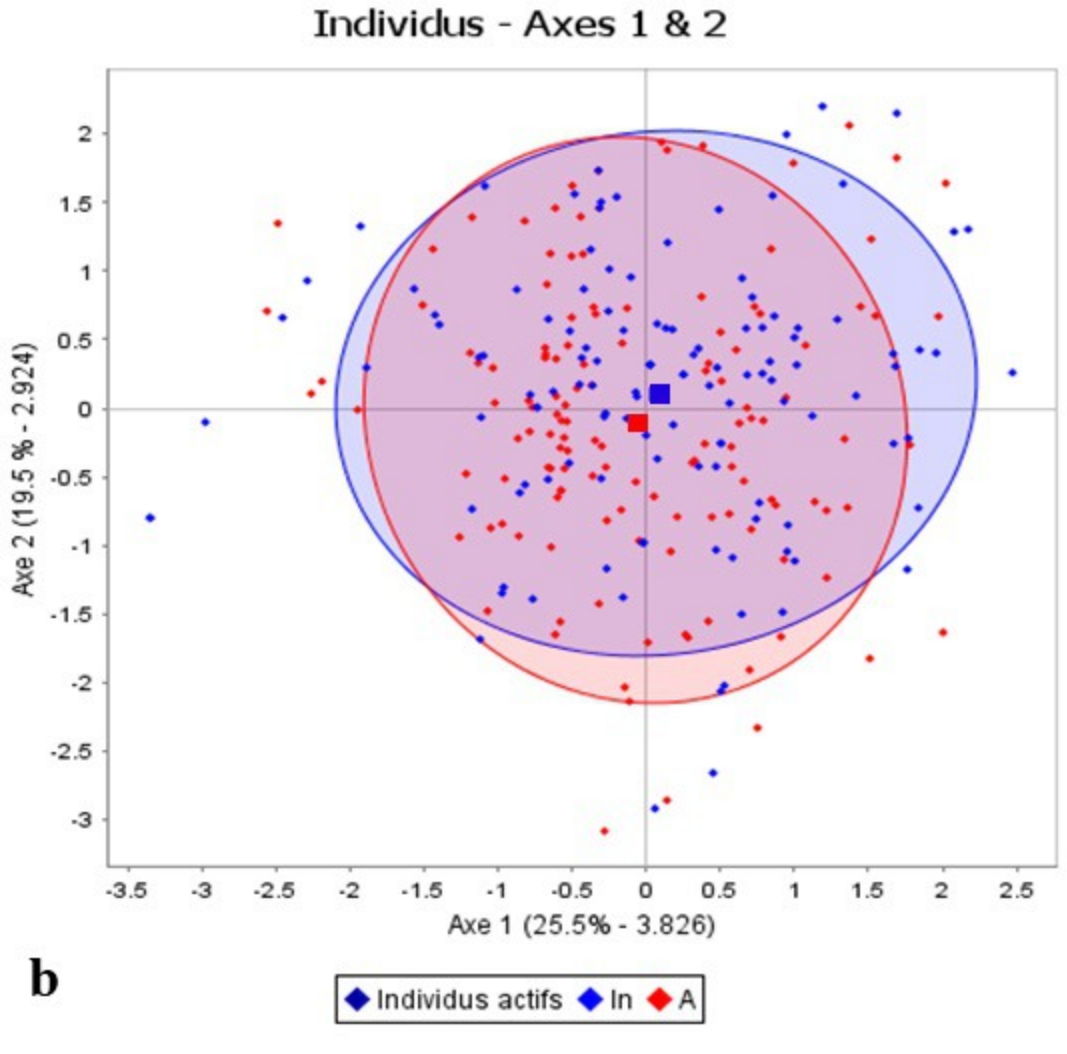
a


60
50
40
30
20
10
0
Percentage of responses (%)
***
NS
NS
NS
***
***
NS
Cooked
Juice
Raw
Tablets
Powder
Tea
Other
A
IN

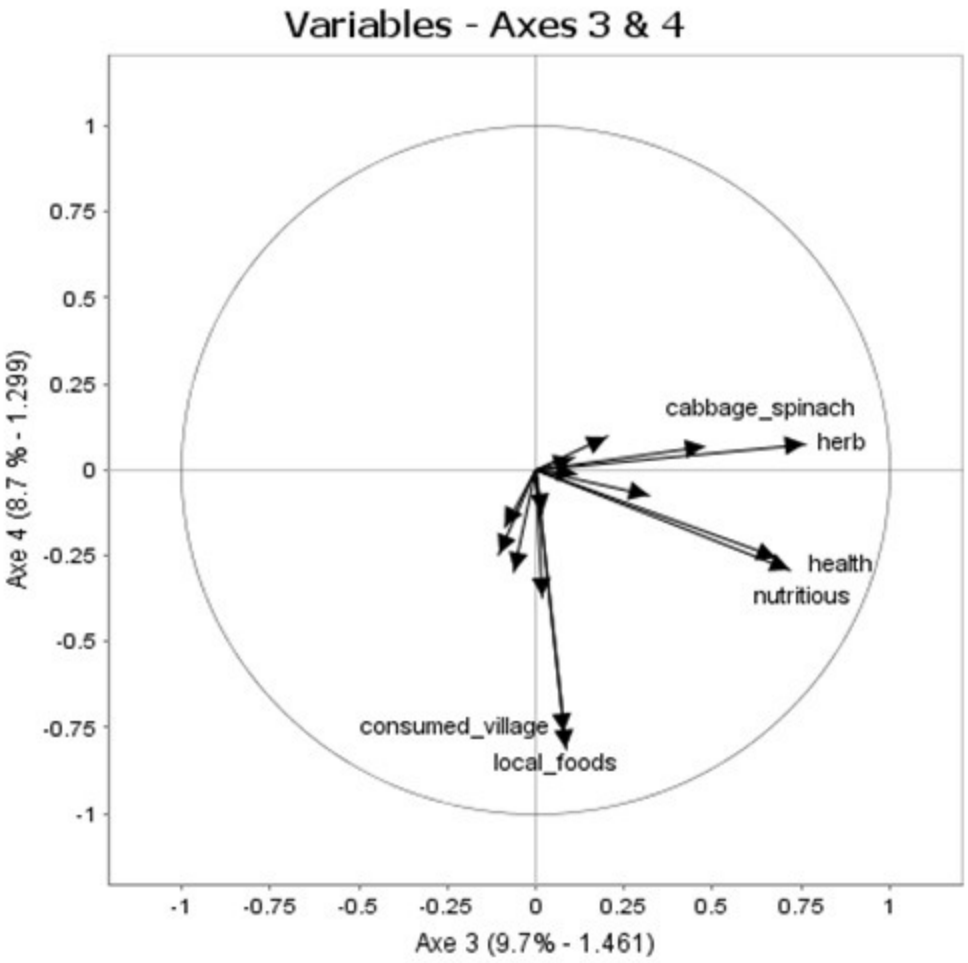
b


Variables - Axes 1 & 2
like_color
like_texture
like_aroma
like_taste
accessible
not_safe
gain_weight
not_children
expensive
nutritious
health
Axe 2 (19.5 % - 2.924)
Axe 1 (25.5% - 3.826)
Continues actives

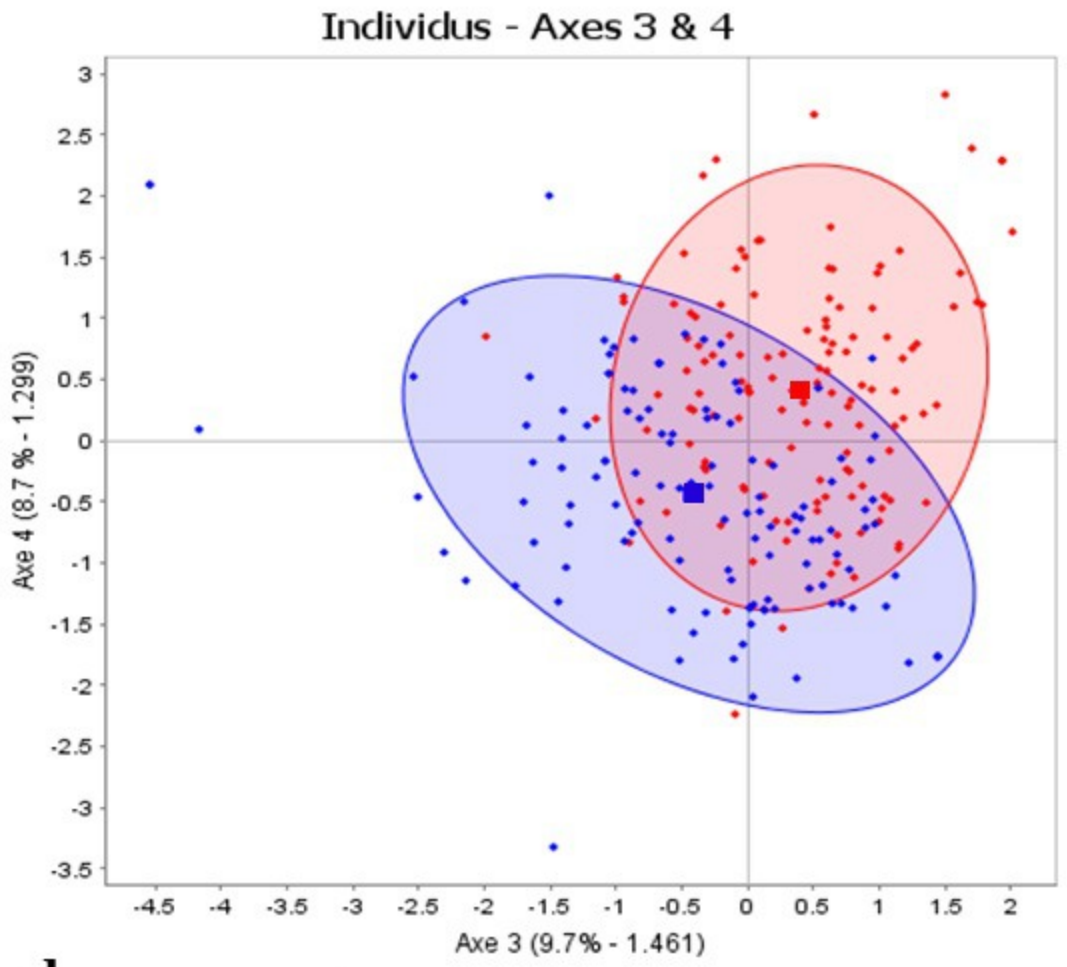
a


Individus - Axes 1 & 2
Axe 2 (19.5 % - 2.924)
Axe 1 (25.5% - 3.826)
Individus actifs
In
A

b


Variables - Axes 3 & 4
cabbage_spinach
herb
health
nutritious
consumed_village
local_foods
Axe 4 (8.7 % - 1.299)
Axe 3 (9.7% - 1.461)
Continues actives

c


Individus - Axes 3 & 4
Axe 4 (8.7 % - 1.299)
Axe 3 (9.7% - 1.461)
Individus actifs
In
A

d