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

3

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16 **Abstract**

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

39 **Keywords**

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

42 **1. Introduction**

43 Food consumption is not limited to the simple act of eating a meal three times a day and
44 repeating this act every day to fulfill the needs of energy and nutrients. Many other factors
45 including physiological, social and cultural factors, impact consumer food choices (Rozin,
46 2006). The relative weight of these factors varies with the environment in which the choices
47 are made. In particular, consumers in developing countries or low-income consumers use
48 different food choice criteria than consumers in developed countries or high-income
49 consumers (Burns et al., 2013). For example, among low-income households, food prices take
50 precedence over all other determinants (Giskes et al., 2007; Blanck et al., 2009; Steenhuis et
51 al., 2011). According to Drewnowski (2009), when financial resources become scarce,
52 consumers try to maximize food purchases by making provisions for the foods that provide
53 high calories, which often leads to the consumption of energy-dense foods. In contrast,
54 nutrient-dense and healthy foods are generally expensive and difficult to access for these
55 populations (Irala-Estévez et al., 2000; Burns et al., 2013). The geographic location as well as
56 the transport make the access to foods more difficult for a number of consumers (Dibsdall et
57 al., 2003; Story et al., 2008). For example, the price of fruits and vegetables is higher when
58 consumers need to buy food outside their area of residence (Dibsdall et al., 2003).

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

66 According to models of behavior, such as the Theory of Planned Behaviour (TPB, Ajzen,
67 1991) consumers' attitudes and beliefs about foods also influence food behavior. Attitudes
68 and beliefs are linked. Attitudes are positive or negative evaluations about people, issues, or
69 objects. Attitudes are based on cognitive, affective, and behavioral information. A belief is the
70 cognitive information that one has about an attitude object (Dejoy, 1999). Beliefs provide the
71 cognitive basis of an attitude.

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

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

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

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

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

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

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

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

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

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

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

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

145 **2. Materials and Methods**

146 2.1. Questionnaire Design

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

163 2.2. Recruitment and survey administration

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

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

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

181 2.3.Data Analysis

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

185 2.3.1. Univariate analysis

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

191 2.3.2. Multivariate analysis

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

200 Law). Chi-square tests were carried out ($\alpha = 0.05$) to characterize the identified clusters in
201 terms of demographic characteristics. Then, following Lebart et al. (2006), clusters were
202 further described by knowledge and consumption modalities using a hyper-geometric law ($\alpha =$
203 0.05) and by belief statements using Student t-tests. This was done by comparing each cluster
204 average scores with the overall average scores. Chi-square tests were performed with
205 XLSTAT software. PCA and HCA were performed with SPAD software (version 9.1, France).

206 3. Results

207 3.1. Comparison of knowledge in India and Africa

208 In order to assess their knowledge of Moringa, respondents were asked three questions (Q2-
209 Q4). In Q2, they were asked to choose between family, media, friends, health professionals, or
210 other as the first source of information about Moringa. The items “school” and “research”
211 having been often mentioned by respondents that choose the option other were added for the
212 analysis of this question. The Chi-square test showed a significant difference between African
213 and Indian respondents in terms of the sources of information about Moringa ($\chi^2 = 27.92, p <$
214 0.0001). Indian respondents chose family as the main source of information more frequently
215 than African respondents (Fig. 1a). For the latter, family was also an important source of
216 information but they also heard about Moringa from friends, media, school and research.

217 Respondents were also asked whether they considered Moringa as food, medicine or both
218 (Q3). A significant difference was observed between African and Indian respondents ($\chi^2 =$
219 $48.98, p < 0.0001$). A significantly larger number of Indian respondents considered Moringa
220 as food only compared to African respondents who considered it more often than Indian
221 respondents as either medicine only or food and medicine (Fig. 1b).

222 3.2. Comparison of consumption habits in India and Africa

223 Nine questions were asked to explore respondents' eating habits (Q6-Q14). When querying
224 about the part of Moringa consumed, a significant difference was observed between the two
225 groups of respondents ($\chi^2 = 93.58, p < 0.0001$). Most of the African respondents consumed the
226 leaves of Moringa (81%) followed by seeds while for Indians all parts of Moringa (Bark,
227 flowers, leaves, seeds) were consumed homogenously (Fig. 2a). Only Indian respondents gave
228 other responses like fruits and pods. With respect to how Moringa is eaten, Africans and
229 Indians respondents exhibited different eating habits ($\chi^2 = 123.70, p < 0.0001$). African
230 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

263 1 & 2 respondent map (Fig. 5b) shows that there is no country-of-origin segmentation (the
264 two barycenters as close to the center of the map) in terms of attitudes and beliefs toward
265 Moringa.

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

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

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

290 Respondents in cluster 2 heard about Moringa from their family more often than other
291 respondents and ate it more often for breakfast. They also tended to eat the fruit of Moringa
292 more often than other respondents did. They tended to have a more positive attitude toward
293 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

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

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

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

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

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

383 In Africa, attitude towards the consumption of vegetables can be an important factor that can
384 affect their consumption. In fact, the consumption of traditional African vegetables is low and
385 below the recommended intake (Faber et al., 2010; Shisana et al., 2013; Kimambo et al.,
386 2018). This consumption varies widely with geographical region, nationality and local
387 customs. This low consumption of traditional African vegetables could be due to the negative
388 perception where some people consider it as a food for the poor or food for those who are
389 backward in society; a notion that perhaps explains why some consumers are not positively
390 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.

421 **5. Limitations of the study**

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

432

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

443 **6. Conclusion**

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

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

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

464

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470 **Author Contributions**

471 Conceptualization, A.H., B.-E.A., G.A.O., P.A.A.-N. and D.V.; Data curation, A.H., B.-E.A.
472 and D.V.; Formal analysis, A.H., P.A.A.-N, M.K. and D.V.; Funding acquisition, F.H. and
473 D.V.; Investigation, A.H. and D.V.; Methodology, A.H., P.A.A.-N., M.K., G.A.O. and D.V.;
474 Resources, F.H. and D.V.; Supervision, F.H. and D.V.; Validation, B.-E.A and D.V.;
475 Visualization, A.H. and D.V.; Writing – original draft, A.H., P.A.A.-N., M.K. and D.V.;
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481 **Ethics approval and consent to participate**

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

485

486 **Declaration of competing interest**

487 The authors declare no conflicts of interest.

488 **Figure captions**

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

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

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

501 **Fig. 4.** Frequency counts for Moringa consumption habit questions (a) Which cooking method
502 do you use the most often to prepare Moringa? (b) In which form do you consume Moringa
503 the most? A: African countries, IN: India, NS: No Significance, $*= p < 0.05$, $**= p < 0.01$ and
504 $***= p < 0.001$ (χ^2 test).

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

Tables

510 **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

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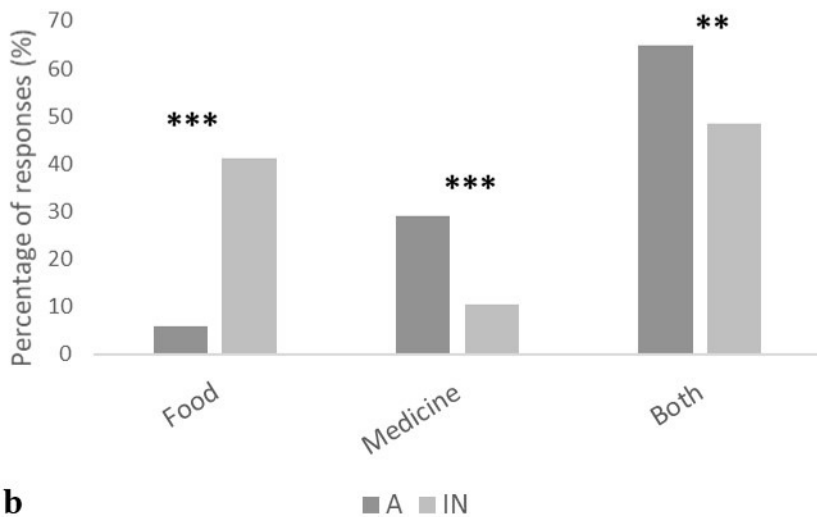
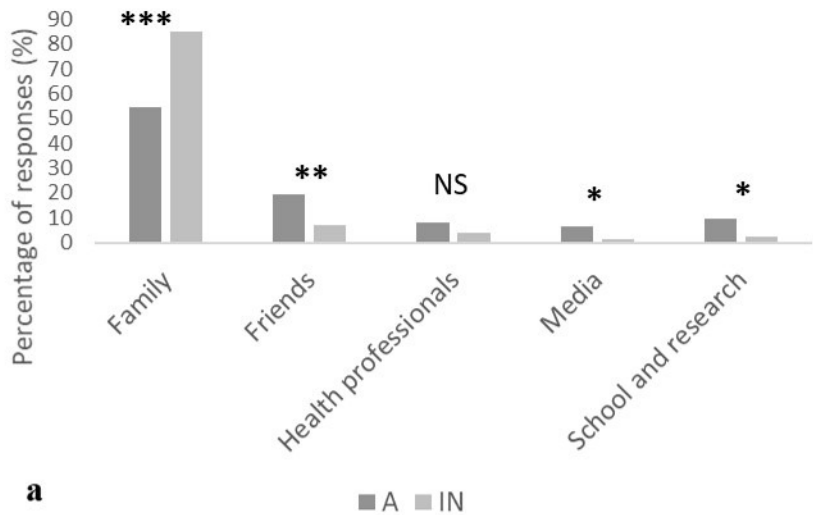
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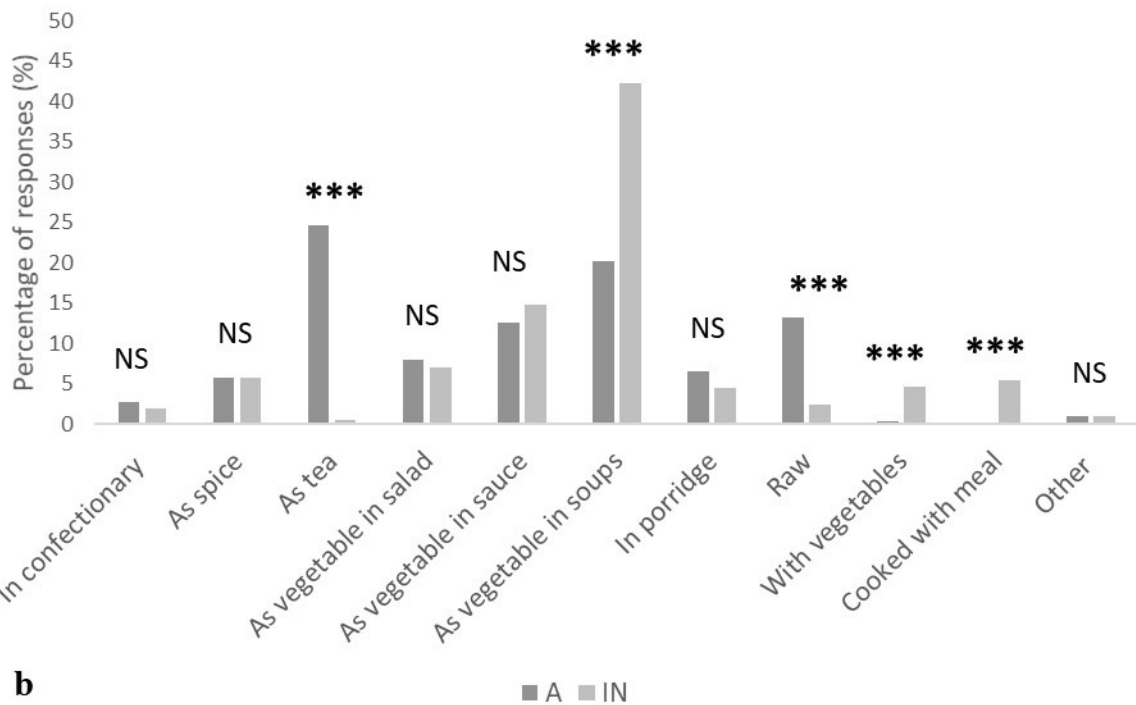
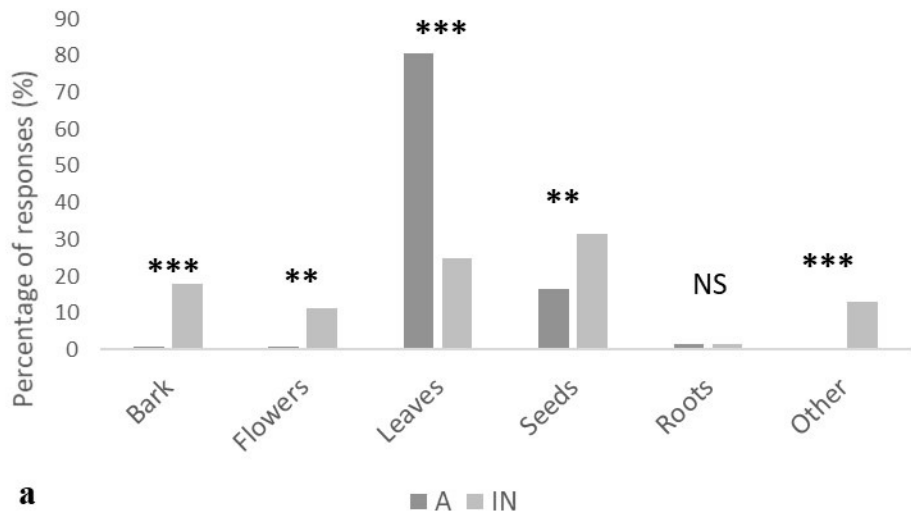
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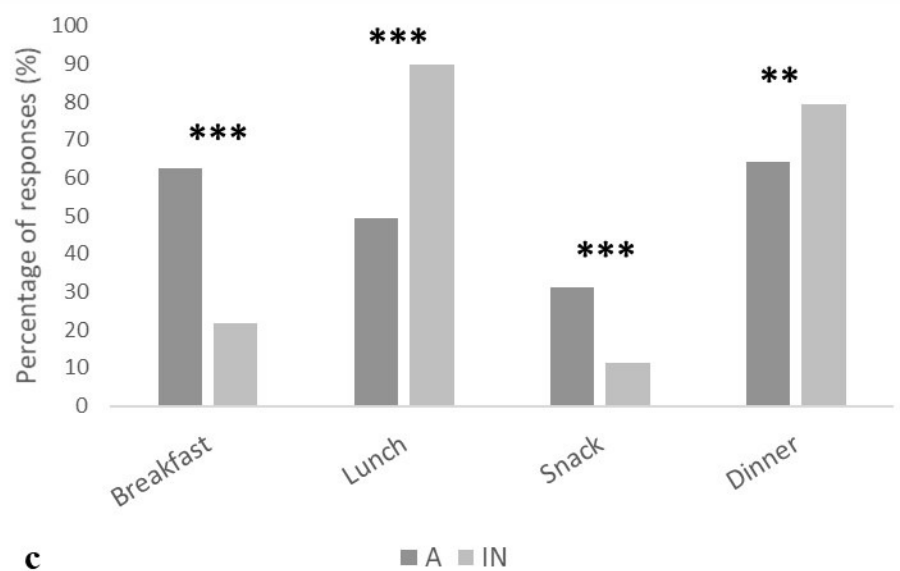
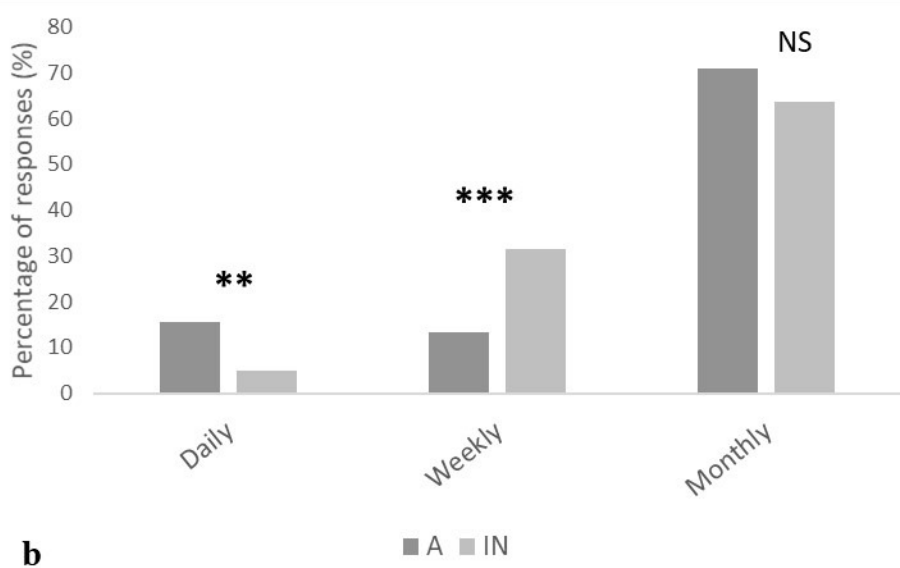
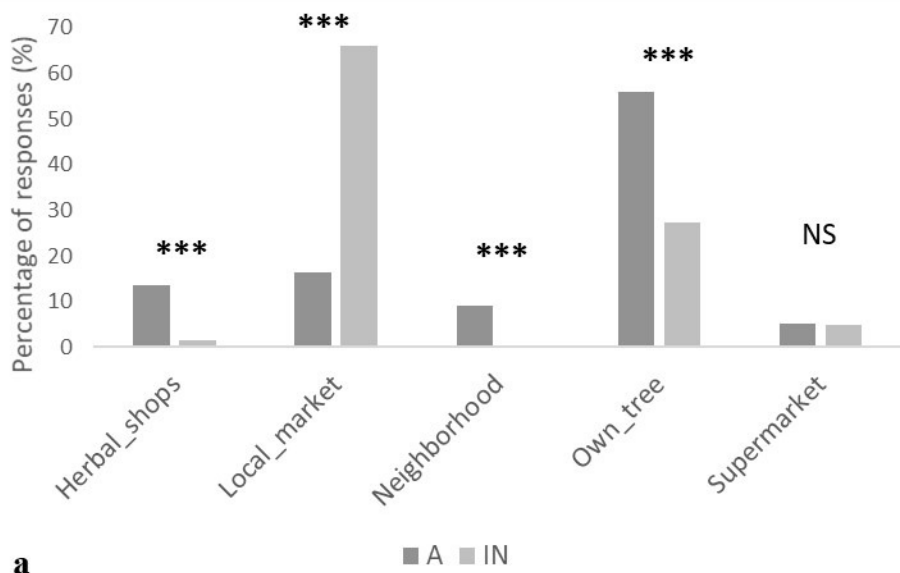
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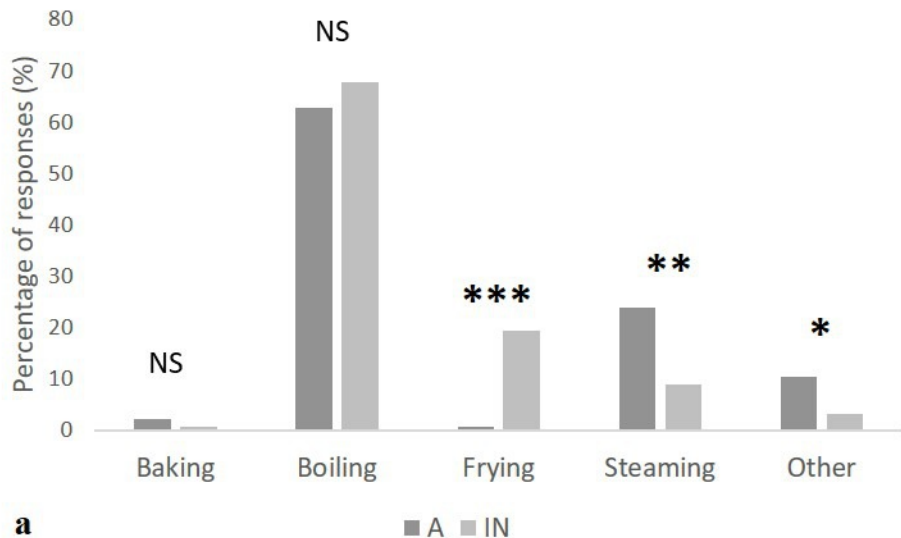
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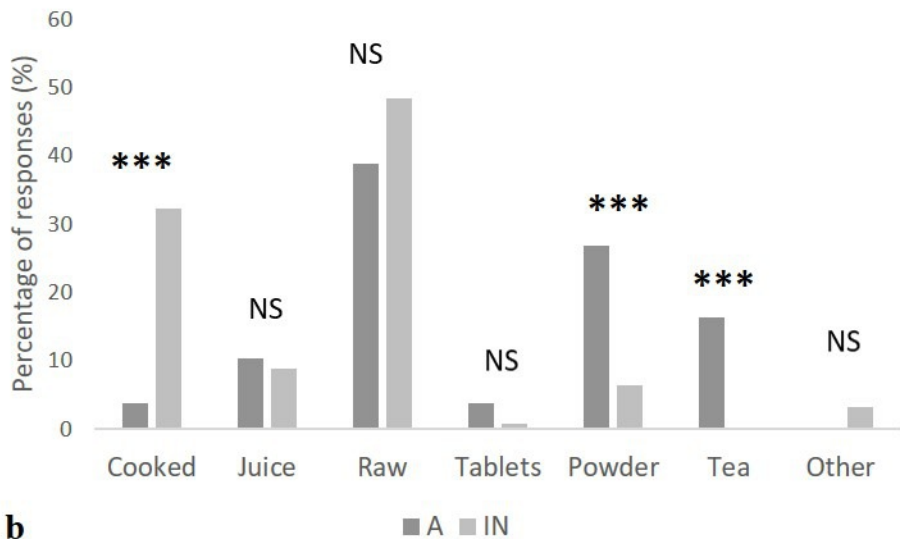






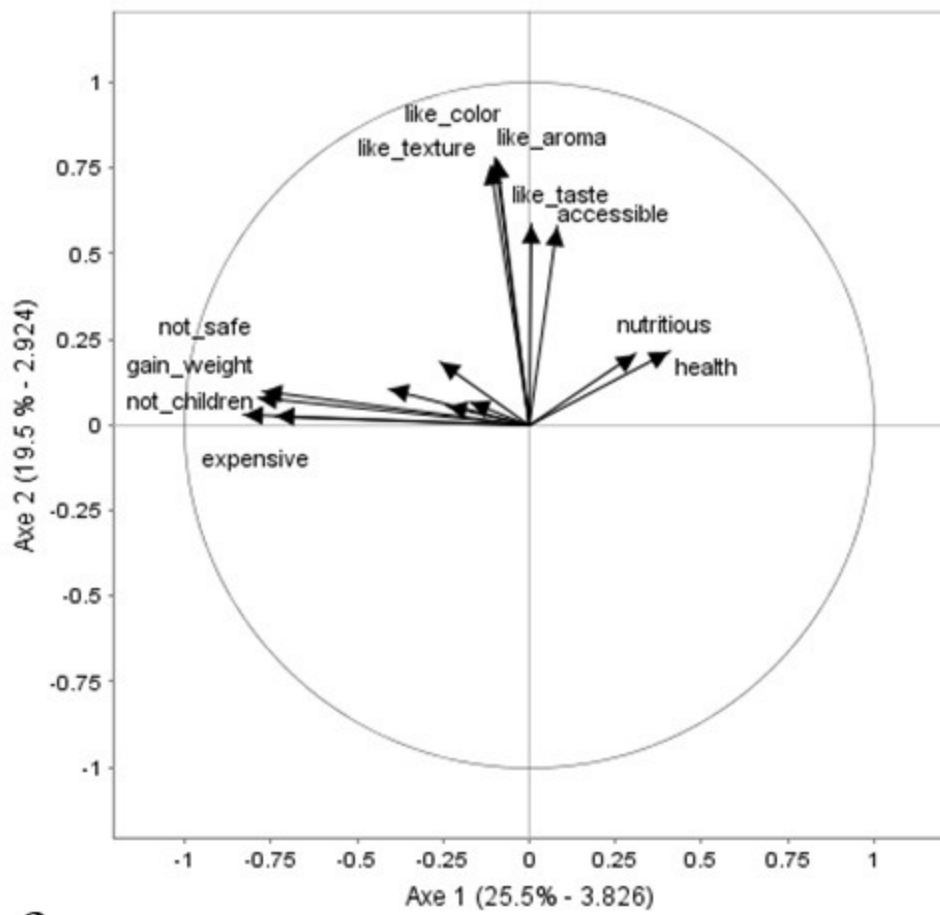


a



b

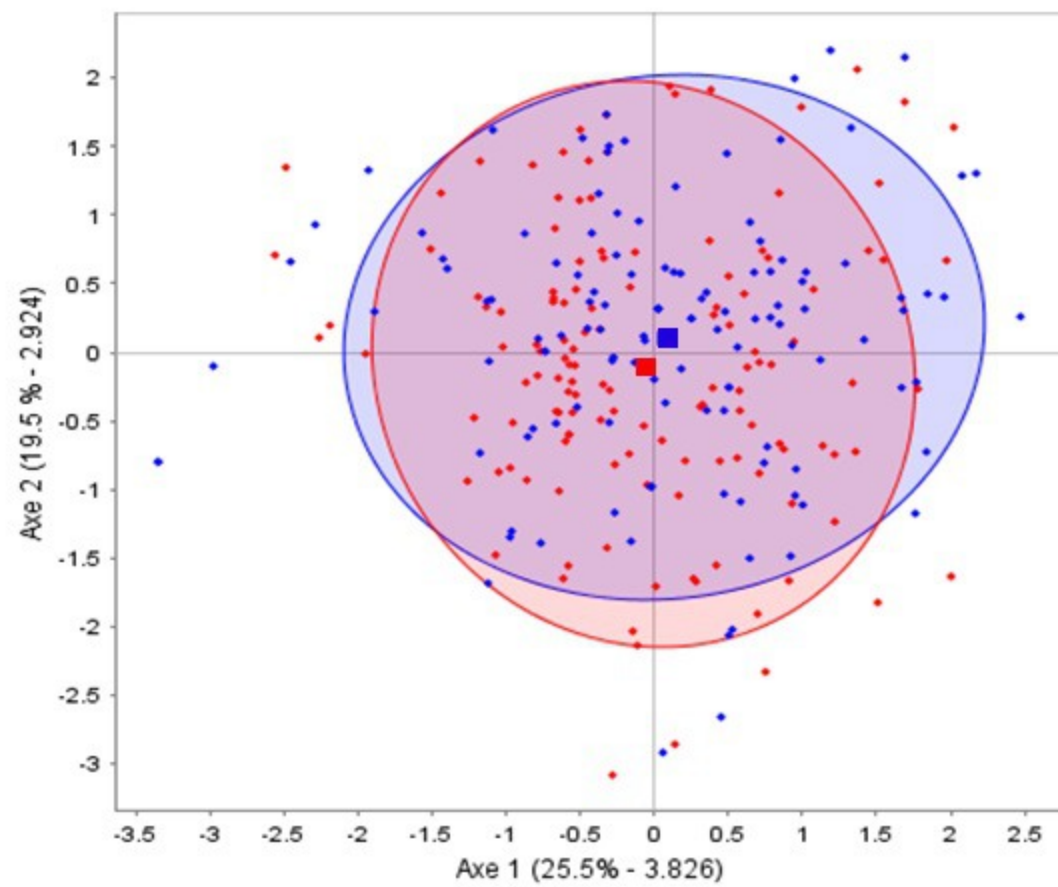
Variables - Axes 1 & 2



a

→ Continues actives

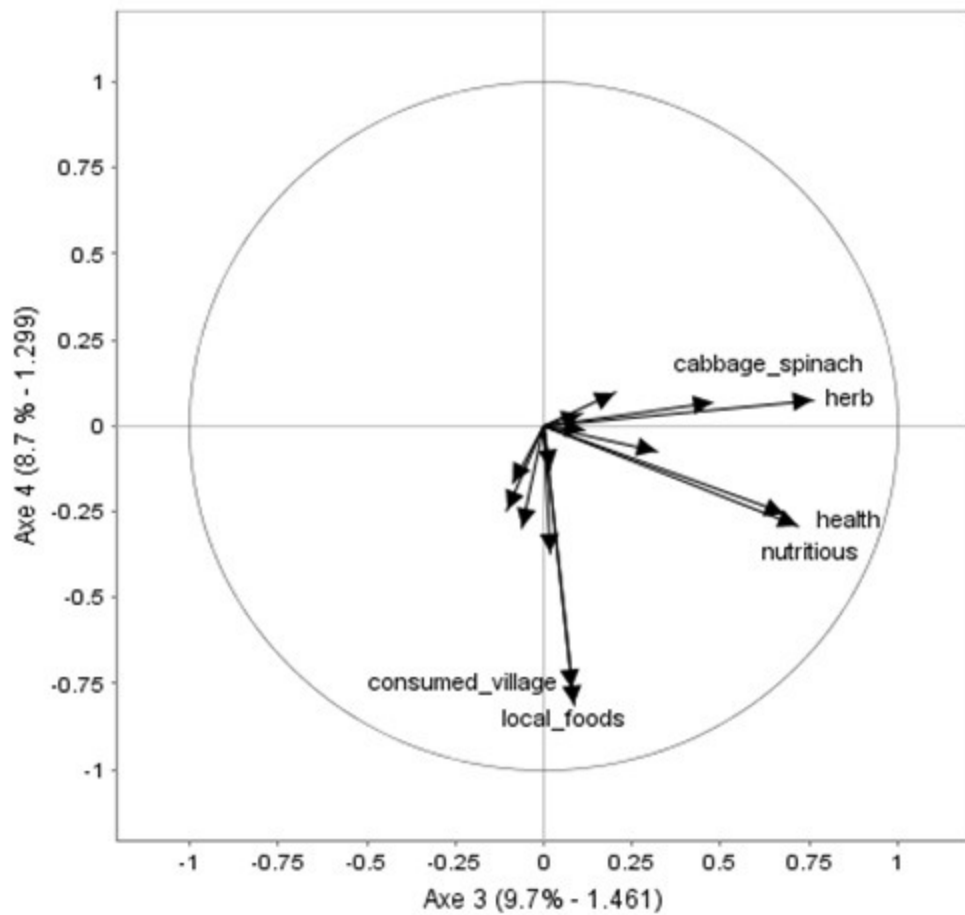
Individus - Axes 1 & 2



b

◆ Individus actifs ◆ In ◆ A

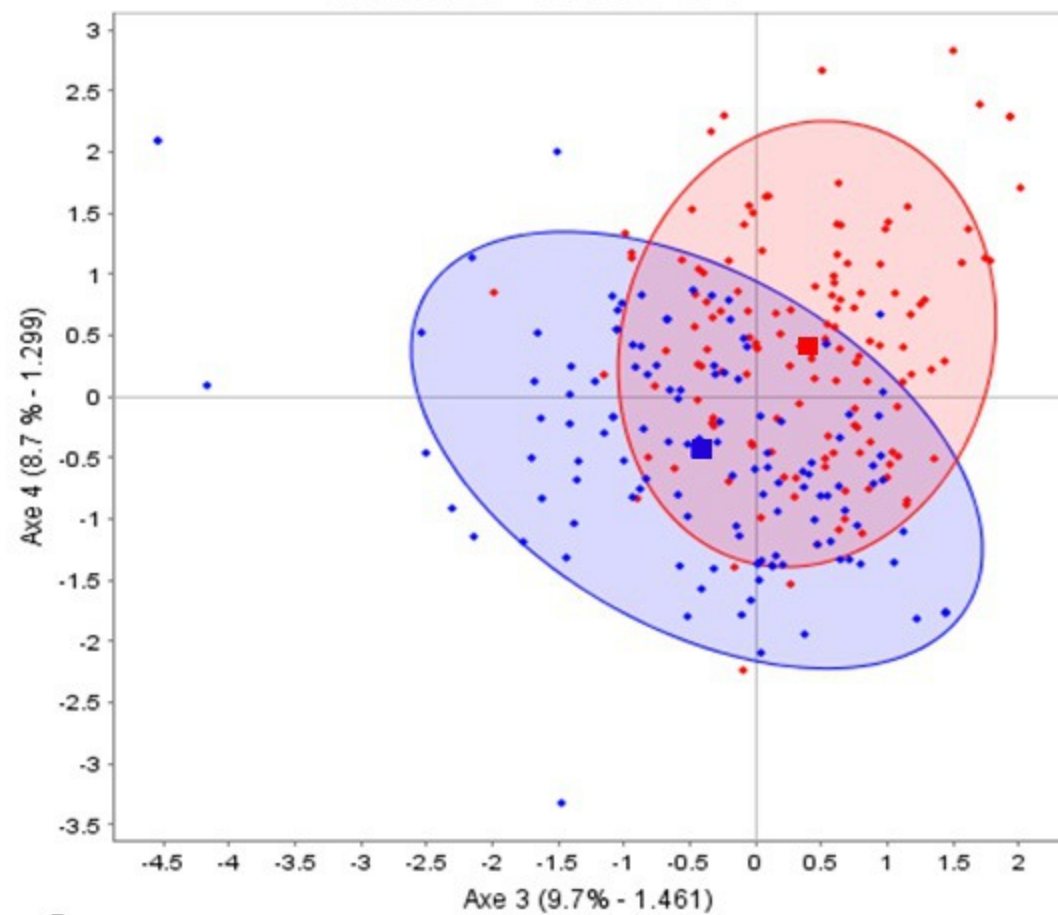
Variables - Axes 3 & 4



c

→ Continues actives

Individus - Axes 3 & 4



d

◆ Individus actifs ◆ In ◆ A