**TRICOT REPORT FOR NORTHERN AND SOUTHERN GHANA**

**INTRODUCTION**

The overall aim of breeders is to ensure novel varieties developed are adopted and utilized by end users. Frontline users of breeders’ work are farmers who work with seeds developed by breeders. However, understanding farmer preferred varieties has been challenging for breeders since farmers rely on feedbacks from consumers before production. Hence focused has been shifted from farmer preferred traits to consumer preferred traits in an attempt to drive demand along the value chain. Participatory farmer selection has often been employed by breeders to help advance and release varieties during breeding process (Baafi et al., 2015). During participatory farmer selection, limited number of farmers is used to assist in selecting materials based on phenotypic and agronomic traits. Important culinary properties are therefore overlooked during the processes which adversely affect adoption and utilization. Limited number of farmers used also makes it statistically difficult to relate results to the general population. Participatory farmer selection also allow for only limited set of materials to be evaluated. Therefore, selections of early stage trials with more materials for advancement are primarily done by breeders only. Some materials with key consumer traits might be left unselected. A novel approach to avert the challenges of participatory farmer selection approach is the use of the tricot tool. Tricot design is based on the assumption that all varieties has the same probability of being selected or rejected. Each assessor is presented with three different set of materials to evaluate by using designed serving order. This simplified approach makes it possible to be used when evaluating planting materials or roots by farmers or consumers respectively. The importance of consumers in driving adoption has therefore made the tool relevant in sensory surveys.

Sensory is a form of marketing that engages consumers’ senses and affect their behavior (Krishna, 2011). Over the years, sensory has been used by food scientist to assist breeding works (Amyotte et al., 2017; Bowen et al., 2019; Bugaud et al., 2009; lauriet et al., 2012; Leighton et al., 2010). Hedonic ratings, ranking and pair wise comparison has frequently been used to assist food scientist rate preferences for a particular variety. However, limitations of these rating scales have often the quality of results and interpretation. Consumers often fail to use hedonic scales appropriately due to lack of training. Hedonic scales are also subjected to the mood of the consumer. Multiple pairwise comparisons also lead to fatigue due to the quantity of samples usually evaluated by each consumer. Best-worst scaling method (often called maxdiff method) has therefor been developed to simplify preference choices (Jaeger et al al., 2008, Adamsen et al., 2013). The method employs a person to select best and worst option in available set of samples. This method has been used in food safety research but yet to be used in breeding efforts and together with tricot tool could be essential in selecting relevant varieties during breeding.

Rapid breeding has received attention owing to global population increase. The world’s population is estimated to reach 9 billion by 2050 and food production will need to grow by 70% (FAO, 2011). Therefore underutilized crops such as sweetpotatoes will be important in combating hunger of all forms whiles alleviating poverty. Sweetpotatoes has unlimited benefits and very essential in sub-Saharan countries. In Ghana, the crop is deemed underutilized and its potential is gradually been revealed through efficient breeding and market awareness. International potato center in collaboration with CSIR-CRI and CSIR-SARI have over the years released several varieties but has received limited adoption. This in part has been due to lack of consumer participation in varietal selection and awareness creation of the crop. Therefore a new approached is sorted to include consumers in varietal selection. This report therefore seeks to highlight the importance of tricot tool in selecting preferred varieties across Ghana.

**MATERIAL AND METHODOLOGY**

**Samples**

**Northern sector:** Two (2) set of trials (advance trial and varietal trial) were used across 9 central locations in Northern, Upper East and Upper West regions. Advance materials (AT) were made of seven (7) genotypes and six (6) checks whiles VTs were made of eight (8) genotypes and five (5) checks. VT materials included PGN16030-30, PGN16130-4, PGN16203-18, PGN16024-27, PGN16024-28, PGN16092-6, PGA14011-24 and PGN16021-39 with checks including Nan, Apomuden, Purple (Diedi), Ligri, Obare. AT material used included PG17140-N2, PG171412-N2, PG17206-N5, PG17265-N1, PG17362-N1, PG17305-N1, PG173136-N1 with checks including Nan, Apomuden, Obare, CIP442126, Purple (Diedi) and Ligri. Genotypes and checks were selected to have variations in dry matter, sweetness and flesh colour. Flesh colours included orange, cream and purple.

**Southern sector:** Five genotypes were used across 3 different locations in the south. Checks used however did not yield and hence were excluded from the survey work. They included PGA12010-15, PGA12151-73, PGA14008-15, PGA14011-13 and PGA14229-2.

|  |  |  |  |
| --- | --- | --- | --- |
| **Northern AT** | **Flesh colour** | **Northern VT** | **Flesh colour** |
| CIP442162 | Pale yellow | PGN16021-39 | Light orange |
| PG17362-N1 | Intermediate orange | Obare | White |
| PG17265-N1 | Deep orange | PGN16203-18 | Light orange |
| PG17206-N5 | Deep cream | PGN16130-4 | Purple |
| PG17412-N2 | Intermediate orange | Nan | Deep orange |
| PG17136-N1 | White | PGN16030-30 | Intermediate orange |
| PG17305-N1 | Pale cream | PGA14011-24 | Deep orange |
| Apomuden | Intermediate orange | Ligri | Pale cream |
| Obare | White | PGN16092-6 | Light yellow |
| PG17140-N2 | Pale yellow | Tu-purple | Purple |
| Tu-Purple (Diedi) | Purple | PGN16024-28 | Cream with purple spot |
| Nan | Light orange | Apomuden | Light orange |
| Ligri | Pale cream | PGN16024-27 | Orange with purple spot |

**Locations**

**Northern sector:** Nine market centers were selected for the exercise. The areas selected have been known for sweetpotatoe activities and consumption. Locations included Katinga (Tali), Waribogu (Tolon), Nyankpala (Tolon) and Kumbungu in the Northern region, Bongo, Bawku and Navrongo in the Upper East region, and Gwolllu (Tumu) and Wa in the Upper West region. A total of 455 respondents were used for the AT materials and another 455 respondents used for VT materials. Respondents were interviewed at a central location close to sweetpotato sales points in order to intercept sweetptotato buyers.

**Southern Sector:** samples were given to individual respondents to be evaluated at home with the help of a field agent. Respondents were given enough samples to enable individual’s household to participate in the evaluation. Three communities in central, Eastern and Volta regions were selected for the work over a period of one week.

**Sample Preparation**

Samples were washed and boiled in groups of six. Four (4) medium sized roots from each variety was put in separate transparent polythene bags. Incisions were made on each root before putting in polythene bag to allow heat penetration. Root edges were also cut to remove the meristematic parts which affect taste. Perforations were also made on polythene bag before placing them in a pot containing boiling water. Samples were boiled for an average of 20 mins.

**Design of Experiment**

A tricot design using a best-worst scaling method was employed. In this design, samples were randomized in such a way that, each variety was evaluated the same number of times and appeared in similar positions the same number of times as others. This was done to ensure balance and avoid biasness. A serving order generated using design of experiment (DOE) in XLSTAT is as shown in appendix B. Each sample was evaluated 35 times by 455 individuals across the three northern regions for ATs and the same number times was repeated for the northern VTs. For the southern materials, random serving order was generated manually due to limited time and resource, hence, the number of respondents were lesser. Each respondent was required to taste three different set of genotypes and choose which ones were preferred best and best. They were again asked to give reasons as to why a given genotype was preferred most or least as well as describe the taste of each selected genotype. A sample questionnaire has been shown in appendix A.

**Data Analysis**

**Choice Analysis:** A modified version of the best-worst scale as described by Jaeger et al., (2008) and Lawless and Heymann (1998) was used with each respondent served a single combination of the genotype set. A simple two step approach was used to interprete the data. The first step was to count the number of times a particular genotype is chosen as best and subtract from the number of times it was selected as worst for respondents. The second step was to find the aggregate scores for each of the genotypes. This approach was also used by Jaeger et al., (2008) and Adamsen et al., (2013). Alternative approach is to measure the choice probability of each genotype compared to the most important genotype. This approach was not used because of the numerous checks used.

**Text Analysis:** An approach used by Symoneaux et al., (2012) was employed for analyzing text data. Since respondents were guided with choice options, texts were recoded into single letters for each like and dislike comment under each variety. Number of like and dislike comments were then counted and subjected to chi-square analysis. However, it was realized most of the comment had had less than 5% mention, hence a global chi-square was used instead of per cell chi-square. A similar approach was used in analyzing data for taste comments.

**FINDINGS (RESULTS AND DISCUSSIONS)**

**Northern Sector:** Results from the best-worst scale showed different categories of genotypes. For the ATs (Fig 1), seven (7) genotypes were preferred, one (1) genotype neither liked nor disliked with six (6) genotypes disliked. Obare (check) was the most preferred among all genotypes with PG17140-N2 most disliked. PG173136-N1 was the most preferred AT and was preferred more than all the other checks apart from Obare. Obare and Nan are commercial varieties common in Northern and Upper East regions hence its appearance and taste are well known by the people. Therefore PG173136-N1 has high possibility of been adopted when released. Other acceptable AT materials included PG17305-N1, CIP44216 and PG17362-N1 which performed better than other checks like Ligri, Purple (Diedi) and Apomuden. PG17206-N5 was disliked but performed better than two checks (Purple and Apomuden). Apomuden has often been rejected by consumers due to its low dry matter content making it watery during cooking. According to unpublished works by CIP, Purple (Diedi) has often been rejected due to its flesh colour. Most consumers are used to cream or white fleshed materials with orange fleshed materials gaining prominence just recently. This could have been one of the major reasons for being disliked.

Fig 1. A graph showing preference for Northern AT genotypes using Best-Worst scale

However, consumer reasons for their best and worst choices were heavily based on taste attributes (Fig 4A and B). Ability of genotype to satisfy and firmness are functions of dry matter and are the next best attributes cited by consumers (Fig 4B). This indicates that, taste is the most important criteria in selecting a particular variety followed by texture and appearance. According to Magwaza and Opara, (2015), appearance can only attract consumers to taste products but sustained consumption depends on internal attributes such as taste and texture. Appearance however seems to be the next important criteria in rejecting a particular. Discolouration and unfamiliar flesh colours seem to contribute to undesired appearance and could have been the reason why Purple (Diedi) was rejected (Appendix C). Moderately sweet to high sweet seems to be the desired taste with low to non sweet taste being undesired in genotypes. Obare, PG173136-N1 and Nan were all found to be moderate to high sweet (Appendix B). Other desirable taste traits included yam like taste with limited percentage prfering low sweet taste. However, high sweet taste has dual purpose role in consumer choice. High percentage of consumers perceived high sweet taste as a positive attribute as well as negative attribute. Other undesirable taste parameters include salty, bitterness, bitter aftertaste and sour taste. The greater emphasis on taste could also mean a lack of appropriate descriptors for sweetpotatoes (Lawless and Heymann, 1998; Chambers et al., 2014), hence the need for trained sensory panel. Chi-square analysis also showed no association between attributes and varieties indicating varieties had no influence on attributes used to describe them. There was a high association between taste attributes and AT genotypes (Appendix C )

Fig 2. A graph showing preference for Northern VT genotypes using Best-Worst scale

A similar trend was also observed in the preferences for VT genotypes. However, three of the leading genotypes were all checks (Nan, Obare and Ligri) (Fig 2). It was also observed that, most of the VT materials were disliked by consumers. PGN16021-39 was the only preferred VT genotype with PGN16092-6 and PGA14011-24 neither liked nor disliked. PGN16030-30 was the least preferred genotype largely due to its perceived low sweetness. Desired attributes and taste pattern for VTs were similar to that observed in ATs.

Fig 3 A graph showing preference for Southern AT genotypes using Best-Worst scale

**Southern Sector:** Checks for southern ATs had poor yields, hence was not included in the survey work. Two (2) of the five genotypes were liked by consumers with PGA14008-15 being the most preferred and PGA14229-2 least preferred. Like northern consumers, taste and appearance were the key desirable attributes used to select the best genotype (Fig 5A). However, southern consumers identified fibrousness as part of the undesirable attributes (Fig 5B). In terms of taste parameters, consumers either did not understand the terminology or could not find suitable descriptors. Descriptors such as appearance, firmness, fibrousness, bad taste, no flavour, which do not describe taste, were cited as taste parameters (5C-D). However sweetness seems to play major role in consumer choices as well as yamlike taste. Most consumers cited bad taste a criteria for rejecting a particular genotype. Other undesirable taste attributes included moist (tasteless) and low sweet nature of genotypes.

Generally it can be deduced that, perception about a product greatly impact choices. Sweetpotatoes are generally perceived as white/cream, sweet and should be firm when boiled or crispy when fried. Recent breeding efforts have introduced other flesh colours like purple and orange. However, awareness about the nutritional benefits of orange fleshed types in certain areas such as Bawku, Navrongo and Kumbungu has led to acceptability of this flesh colour. Limited knowledge about the purple types seems to be hampering their acceptability even though other quality attributes are similar or superior to well-known varieties on the markets. As a result of these perceptions, changes to any of the sensory traits without awareness creation will limit adoption. From this survey, sweet taste seems to be the driving force behind most consumer choices with differences existing between the different levels of sweetness. Majority of consumers however, seem to favour moderately sweet sweetpotatoes over their low sweet or nonsweet counterparts. This could be due to the perception that sweetpotatoes are sweet, hence low sweet or non sweet types are not regarded as sweetpotatoes. However a limited minority also prefers these low sweet to non sweet types.

A B

C D

E F

G H

Fig 4(A-H). Graphs showing key attributes and taste parameters cited by Northern consumers

A B

C D

Fig 5A-D. Graphs showing key attributes and taste parameters cited by Southern consumers

Texture has been reported in several literatures to be very important attribute for consumer preference. It however wasn’t as important as taste and appearance in choosing a particular variety. This could be due to either most of the genotypes had similar textural properties or consumers lacked the appropriate vocabularies to describe them. Appearance was also a key attribute due to the power of vision in attracting consumers. Aside flesh colours, appearance is also affected by distortions such as ununiform colour patterns, fibrousness, discolourations due to browning during cooking and even distribution of moisture in the sample. This could have been one of the reasons behind genotypes of similar flesh colours having different ratings. Genotypes with high darkening or fibrous appearance were generally disliked. Most orange fleshed varieties are low dry matter but are mostly liked due to their bright orange colours. This could be one of the reasons why Nan was rated highest among the best varieties.

Eventhough differences exist between north and south culturally, consumers of sweetpotatoes seems to have similar reasons for their choices. This is because sweetpotatoes is not peculiar to a particular tribe and the mode of preparation is similar across different cultures. However, southern consumers seem to be concern about fibrousness, which they view as an undesirable trait.

**CONCLUSION**

Sweetpotato is still underutilized in Ghana with consumers lacking knowledge on its nutritional and culinary properties. Existing varieties such Nan, Obare are widely accepted and offers a benchmark for measuring future varieties in breeding lines. PGN16021-39, PG17362-N1, CIP442162, PG17305-N1, PG173136-N1 have huge prospects of being adopted when released in the North whiles PGA140113-23 and PGA14008-15 will be acceptable in the south. Taste is the major criteria used by consumers to make sweetpotato choices with consumers preferring moderately sweet genotypes. Appearance and texture were also found to play key roles in consumer preferences. However, most consumers were limited in terms of vocabularies to describe sweetpotatoes’

It is therefore recommended that, the research be repeated to test the robustness of the data. Further research on combining sensory panel data with the tricot work should also be carried out in order to understand what drives consumer preferences.

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**APPENDIX A. SAMPLE QUESTIONNAIRE**

**QUESTIONNAIRE – Community Tasting**

Household number (if applicable)……………………………………..

Name of participant: …………………………………….

Age: ………………………………………………..

Gender: ………………………………………………………..

**Instructions**

Please taste each sample and answer the questions below. (use a tick or X)

1.Which sweetpotato is the **best** according to you?

Code A………… Code B…………. Code C…………..

What **attributes** of the sweetpotato make you say it is the best? (CATA)

Colour/Appearance………………. Taste …………………. Firmness……………… mealiness ………………..satisfying…………………. Other (please specify)…………………..

In your own words, **describe the taste** of the sweetpotato

……………………………………………………………………………………………………………………….

2. Which sweetpotato is the **worst** according to you?

Code A………… Code B………….Code C…………..

What **attributes** of the sweetpotato make it the worst?

Colour/Appearance………………. Taste …………………. Other (please specify)…………………..

In your own words, **describe the taste** of the sweetpotato

……………………………………………………………………………………………………………………….

3. Which **cooking method** do you commonly use for sweetpotato in your household?

Boiling ……………… Steaming ……………….. Frying………………… Baking……………….. Other ………………………….

4. Do you **plant** sweetpotato in your field?

Yes ……………. No……………………

If yes, **how many varieties** do you plant per growing season?

One …………… Two………………. Three…………….. More than 3 …………………………

Which factors influenced your **choice of variety planted**? (tick all applicable)

Availability of planting material ………………………….

Taste of the roots ……………………………

Duration to maturity ……………………….

Cooking time ……………………………….

Colour of the roots ……………………….

Market for selling ………………………….

Other (please specify) ………………………..

5. Do you **purchase** sweetpotato from the market?

Yes………… No……… Sometimes ………

**If yes**, what criteria do you use to choose the variety purchased?

Price…………………. Size of root……………….. Colour of root…………………. Familiarity…………………. Vendor……………. Other (please specify)…………………………..

APPENDIX B. SERVING ORDER USED FOR THE WORK

|  |  |  |  |
| --- | --- | --- | --- |
| JUDGES | Var1 | Var2 | Var3 |
| J1 | A | L | M |
| J2 | M | B | A |
| J3 | C | A | B |
| J4 | C | B | D |
| J5 | E | C | D |
| J6 | D | E | F |
| J7 | F | E | G |
| J8 | G | F | H |
| J9 | H | G | I |
| J10 | I | J | H |
| J11 | J | K | I |
| J12 | L | J | K |
| J13 | K | M | L |
| J14 | D | A | M |
| J15 | A | E | B |
| J16 | B | F | C |
| J17 | D | G | C |
| J18 | D | H | E |
| J19 | F | I | E |
| J20 | J | F | G |
| J21 | G | K | H |
| J22 | H | I | L |
| J23 | M | J | I |
| J24 | K | A | J |
| J25 | L | B | K |
| J26 | L | C | M |
| J27 | I | A | E |
| J28 | J | F | B |
| J29 | C | G | K |
| J30 | L | H | D |
| J31 | M | I | E |
| J32 | J | A | F |
| J33 | K | G | B |
| J34 | L | H | C |
| J35 | M | D | I |
| J36 | E | J | A |
| J37 | K | F | B |
| J38 | G | C | L |
| J39 | D | H | M |
| J40 | I | A | B |
| J41 | J | C | B |
| J42 | K | C | D |
| J43 | E | L | D |
| J44 | E | M | F |
| J45 | G | F | A |
| J46 | B | G | H |
| J47 | H | C | I |
| J48 | J | D | I |
| J49 | J | K | E |
| J50 | L | K | F |
| J51 | L | G | M |
| J52 | A | M | H |
| J53 | A | H | G |
| J54 | I | H | B |
| J55 | C | J | I |
| J56 | D | J | K |
| J57 | E | K | L |
| J58 | F | M | L |
| J59 | M | A | G |
| J60 | A | B | H |
| J61 | B | I | C |
| J62 | D | J | C |
| J63 | K | D | E |
| J64 | L | E | F |
| J65 | G | M | F |
| J66 | A | H | F |
| J67 | B | I | G |
| J68 | H | C | J |
| J69 | K | I | D |
| J70 | E | J | L |
| J71 | F | M | K |
| J72 | G | L | A |
| J73 | B | M | H |
| J74 | I | A | C |
| J75 | D | B | J |
| J76 | E | K | C |
| J77 | F | D | L |
| J78 | G | M | E |
| J79 | H | E | A |
| J80 | I | F | B |
| J81 | C | J | G |
| J82 | H | K | D |
| J83 | E | L | I |
| J84 | J | F | M |
| J85 | A | K | G |
| J86 | B | H | L |
| J87 | I | M | C |
| J88 | D | J | A |
| J89 | E | B | K |
| J90 | C | F | L |
| J91 | G | M | D |
| J92 | A | D | H |
| J93 | B | E | I |
| J94 | F | J | C |
| J95 | G | K | D |
| J96 | E | H | L |
| J97 | F | I | M |
| J98 | G | A | J |
| J99 | K | B | H |
| J100 | I | L | C |
| J101 | J | M | D |
| J102 | A | K | E |
| J103 | B | L | F |
| J104 | M | C | G |
| J105 | C | H | A |
| J106 | I | B | D |
| J107 | C | E | J |
| J108 | F | K | D |
| J109 | L | E | G |
| J110 | F | H | M |
| J111 | G | A | I |
| J112 | H | J | B |
| J113 | K | C | I |
| J114 | J | D | L |
| J115 | M | E | K |
| J116 | A | F | L |
| J117 | M | B | G |
| J118 | H | B | A |
| J119 | C | B | I |
| J120 | C | D | J |
| J121 | D | K | E |
| J122 | L | F | E |
| J123 | F | G | M |
| J124 | G | A | H |
| J125 | I | H | B |
| J126 | J | C | I |
| J127 | J | D | K |
| J128 | E | L | K |
| J129 | M | F | L |
| J130 | A | M | G |
| J131 | F | G | A |
| J132 | G | B | H |
| J133 | H | I | C |
| J134 | D | I | J |
| J135 | J | E | K |
| J136 | K | L | F |
| J137 | M | L | G |
| J138 | M | H | A |
| J139 | A | I | B |
| J140 | J | B | C |
| J141 | K | C | D |
| J142 | L | E | D |
| J143 | F | E | M |
| J144 | G | E | A |
| J145 | H | B | F |
| J146 | G | I | C |
| J147 | H | J | D |
| J148 | I | K | E |
| J149 | J | L | F |
| J150 | K | M | G |
| J151 | L | A | H |
| J152 | M | I | B |
| J153 | C | J | A |
| J154 | B | D | K |
| J155 | C | E | L |
| J156 | D | M | F |
| J157 | A | G | D |
| J158 | H | E | B |
| J159 | C | I | F |
| J160 | D | G | J |
| J161 | K | H | E |
| J162 | F | L | I |
| J163 | G | J | M |
| J164 | H | A | K |
| J165 | B | L | I |
| J166 | C | M | J |
| J167 | D | A | K |
| J168 | B | L | E |
| J169 | F | C | M |
| J170 | A | G | C |
| J171 | B | H | D |
| J172 | E | I | C |
| J173 | D | F | J |
| J174 | G | E | K |
| J175 | L | F | H |
| J176 | M | G | I |
| J177 | A | H | J |
| J178 | K | B | I |
| J179 | L | C | J |
| J180 | K | D | M |
| J181 | E | A | L |
| J182 | B | M | F |
| J183 | B | A | G |
| J184 | H | B | C |
| J185 | I | D | C |
| J186 | D | J | E |
| J187 | K | F | E |
| J188 | F | L | G |
| J189 | H | M | G |
| J190 | I | H | A |
| J191 | B | J | I |
| J192 | C | K | J |
| J193 | L | D | K |
| J194 | L | E | M |
| J195 | A | F | M |
| J196 | F | A | E |
| J197 | F | B | G |
| J198 | C | G | H |
| J199 | H | D | I |
| J200 | E | I | J |
| J201 | F | K | J |
| J202 | K | G | L |
| J203 | M | H | L |
| J204 | A | I | M |
| J205 | A | J | B |
| J206 | C | K | B |
| J207 | D | C | L |
| J208 | M | E | D |
| J209 | F | A | D |
| J210 | E | G | B |
| J211 | C | H | F |
| J212 | I | D | G |
| J213 | H | J | E |
| J214 | I | F | K |
| J215 | G | L | J |
| J216 | H | M | K |
| J217 | A | L | I |
| J218 | B | J | M |
| J219 | A | C | K |
| J220 | L | D | B |
| J221 | C | M | E |
| J222 | F | C | A |
| J223 | B | G | D |
| J224 | E | C | H |
| J225 | I | F | D |
| J226 | E | J | G |
| J227 | H | K | F |
| J228 | I | G | L |
| J229 | M | J | H |
| J230 | K | I | A |
| J231 | J | B | L |
| J232 | M | C | K |
| J233 | A | D | L |
| J234 | M | B | E |
| J235 | B | F | A |
| J236 | G | B | C |
| J237 | H | C | D |
| J238 | E | I | D |
| J239 | J | E | F |
| J240 | K | G | F |
| J241 | L | G | H |
| J242 | M | I | H |
| J243 | A | I | J |
| J244 | K | B | J |
| J245 | K | L | C |
| J246 | D | L | M |
| J247 | E | M | A |
| J248 | E | A | D |
| J249 | B | E | F |
| J250 | C | F | G |
| J251 | H | D | G |
| J252 | H | I | E |
| J253 | J | F | I |
| J254 | J | G | K |
| J255 | L | H | K |
| J256 | M | I | L |
| J257 | J | M | A |
| J258 | A | B | K |
| J259 | C | L | B |
| J260 | D | M | C |
| J261 | C | A | E |
| J262 | D | F | B |
| J263 | G | C | E |
| J264 | F | D | H |
| J265 | I | E | G |
| J266 | H | F | J |
| J267 | K | G | I |
| J268 | H | L | J |
| J269 | I | K | M |
| J270 | A | J | L |
| J271 | K | M | B |
| J272 | C | L | A |
| J273 | M | D | B |
| J274 | A | E | B |
| J275 | B | F | C |
| J276 | D | C | G |
| J277 | E | H | D |
| J278 | E | I | F |
| J279 | F | G | J |
| J280 | K | H | G |
| J281 | I | L | H |
| J282 | I | M | J |
| J283 | J | K | A |
| J284 | B | K | L |
| J285 | C | L | M |
| J286 | D | M | A |
| J287 | D | A | C |
| J288 | E | D | B |
| J289 | E | C | F |
| J290 | G | D | F |
| J291 | H | G | E |
| J292 | I | H | F |
| J293 | I | G | J |
| J294 | J | H | K |
| J295 | L | K | I |
| J296 | J | L | M |
| J297 | M | K | A |
| J298 | L | B | A |
| J299 | C | B | M |
| J300 | B | D | A |
| J301 | B | C | E |
| J302 | F | D | C |
| J303 | G | D | E |
| J304 | F | E | H |
| J305 | F | I | G |
| J306 | J | G | H |
| J307 | I | K | H |
| J308 | L | J | I |
| J309 | M | K | J |
| J310 | K | A | L |
| J311 | L | B | M |
| J312 | M | A | C |
| J313 | B | C | A |
| J314 | D | C | B |
| J315 | D | E | C |
| J316 | E | D | F |
| J317 | G | E | F |
| J318 | G | F | H |
| J319 | G | H | I |
| J320 | I | J | H |
| J321 | J | I | K |
| J322 | L | K | J |
| J323 | M | L | K |
| J324 | L | A | M |
| J325 | B | A | M |
| J1 | L | A | J |
| J2 | K | M | B |
| J3 | C | A | L |
| J4 | B | D | M |
| J5 | E | A | C |
| J6 | D | F | B |
| J7 | G | C | E |
| J8 | D | H | F |
| J9 | E | I | G |
| J10 | H | F | J |
| J11 | G | K | I |
| J12 | J | H | L |
| J13 | K | I | M |
| J14 | L | E | A |
| J15 | F | M | B |
| J16 | A | G | C |
| J17 | H | B | D |
| J18 | E | I | C |
| J19 | F | D | J |
| J20 | K | E | G |
| J21 | F | L | H |
| J22 | M | G | I |
| J23 | H | A | J |
| J24 | B | I | K |
| J25 | C | J | L |
| J26 | D | M | K |
| J27 | H | J | A |
| J28 | B | I | K |
| J29 | C | J | L |
| J30 | M | K | D |
| J31 | A | L | E |
| J32 | F | M | B |
| J33 | C | G | A |
| J34 | D | B | H |
| J35 | E | C | I |
| J36 | D | J | F |
| J37 | G | E | K |
| J38 | F | L | H |
| J39 | I | M | G |
| J40 | J | G | A |
| J41 | B | H | K |
| J42 | I | C | L |
| J43 | D | J | M |
| J44 | E | K | A |
| J45 | F | B | L |
| J46 | G | M | C |
| J47 | D | A | H |
| J48 | E | I | B |
| J49 | J | C | F |
| J50 | D | K | G |
| J51 | L | H | E |
| J52 | M | F | I |
| J53 | A | I | E |
| J54 | B | F | J |
| J55 | K | C | G |
| J56 | H | D | L |
| J57 | I | E | M |
| J58 | J | A | F |
| J59 | K | B | G |
| J60 | H | C | L |
| J61 | M | I | D |
| J62 | A | E | J |
| J63 | B | K | F |
| J64 | G | L | C |
| J65 | M | D | H |
| J66 | I | A | C |
| J67 | B | J | D |
| J68 | C | K | E |
| J69 | L | D | F |
| J70 | G | E | M |
| J71 | A | F | H |
| J72 | I | G | B |
| J73 | C | H | J |
| J74 | I | D | K |
| J75 | J | E | L |
| J76 | M | F | K |
| J77 | A | G | L |
| J78 | M | H | B |
| J79 | A | H | E |
| J80 | I | B | F |
| J81 | G | J | C |
| J82 | H | K | D |
| J83 | E | L | I |
| J84 | J | M | F |
| J85 | G | K | A |
| J86 | H | L | B |
| J87 | M | C | I |
| J88 | J | A | D |
| J89 | E | B | K |
| J90 | L | F | C |
| J91 | D | G | M |
| J92 | D | F | A |
| J93 | E | B | G |
| J94 | F | C | H |
| J95 | G | D | I |
| J96 | J | E | H |
| J97 | I | F | K |
| J98 | L | G | J |
| J99 | K | H | M |
| J100 | I | L | A |
| J101 | J | B | M |
| J102 | A | K | C |
| J103 | B | L | D |
| J104 | C | M | E |
| J105 | C | A | E |
| J106 | F | D | B |
| J107 | C | E | G |
| J108 | F | H | D |
| J109 | G | I | E |
| J110 | H | J | F |
| J111 | K | G | I |
| J112 | L | J | H |
| J113 | K | M | I |
| J114 | A | L | J |
| J115 | K | B | M |
| J116 | L | C | A |
| J117 | M | D | B |
| J118 | A | D | C |
| J119 | B | E | D |
| J120 | C | F | E |
| J121 | F | G | D |
| J122 | E | H | G |
| J123 | H | I | F |
| J124 | I | J | G |
| J125 | J | K | H |
| J126 | K | L | I |
| J127 | L | M | J |
| J128 | M | A | K |
| J129 | L | B | A |
| J130 | B | C | M |

APPENDIX C. CONTINGENCY TABLES FOR TEXT ANALYSIS

Table 1. Contingency Table Showing Like and Dislike Attributes and Tastes of the different AT Genotypes with their Chi-square values

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Desired Attributes** | A | B | C | D | E | F | G | H | I | J | K | L | M | Total |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Appearance | 1 | 1 | 1 | 5 | 2 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 2 | 18 |
| Firmness | 1 | 4 | 3 | 2 | 1 | 3 | 0 | 2 | 0 | 2 | 1 | 1 | 1 | 21 |
| Familiarity | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Mealiness | 1 | 3 | 0 | 3 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 4 | 1 | 16 |
| Satisfying | 1 | 2 | 4 | 5 | 1 | 1 | 0 | 5 | 1 | 1 | 1 | 1 | 1 | 24 |
| Taste | 24 | 24 | 28 | 44 | 32 | 8 | 21 | 40 | 37 | 30 | 19 | 50 | 18 | 375 |
| Total Likes | 28 | 34 | 36 | 59 | 36 | 13 | 23 | 50 | 41 | 33 | 22 | 57 | 23 | 455 |
| Chi-square (X2) | 0.428 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Undesired Attributes** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Appearance | 11 | 1 | 3 | 3 | 7 | 7 | 1 | 1 | 2 | 5 | 7 | 1 | 3 | 52 |
| Aroma | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Firmness | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| Softness | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| Taste | 44 | 20 | 30 | 18 | 29 | 50 | 45 | 12 | 32 | 20 | 41 | 18 | 36 | 395 |
| Texture | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Total Dislike | 55 | 22 | 33 | 21 | 36 | 61 | 47 | 13 | 34 | 25 | 48 | 20 | 40 | 455 |
| Chi-square (X2) | 0.646 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Desired Taste** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Egg-like taste | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Highly sweet | 8 | 9 | 8 | 13 | 17 | 1 | 9 | 11 | 18 | 11 | 9 | 34 | 5 | 153 |
| Low sweet | 3 | 3 | 7 | 3 | 0 | 3 | 2 | 10 | 1 | 2 | 2 | 3 | 7 | 46 |
| Moderately sweet | 15 | 18 | 20 | 37 | 19 | 6 | 12 | 24 | 20 | 18 | 11 | 18 | 9 | 227 |
| Milky taste | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Non sweet | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 4 |
| Salty | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Yamlike | 2 | 4 | 1 | 5 | 0 | 2 | 0 | 4 | 0 | 2 | 0 | 0 | 2 | 22 |
| Total | 28 | 34 | 36 | 59 | 36 | 13 | 23 | 50 | 41 | 33 | 22 | 57 | 23 | 455 |
| Chi-square (X2) | <0.05 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Undesired Taste** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Bitter taste | 1 | 0 | 0 | 0 | 0 | 3 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 9 |
| Bitter aftertaste | 0 | 0 | 0 | 2 | 0 | 1 | 2 | 0 | 1 | 1 | 1 | 0 | 1 | 9 |
| Highly sweet | 10 | 4 | 5 | 2 | 15 | 5 | 20 | 2 | 16 | 12 | 23 | 13 | 4 | 131 |
| Low sweet | 21 | 6 | 9 | 2 | 7 | 32 | 11 | 4 | 6 | 6 | 14 | 2 | 11 | 131 |
| Moderately sweet | 6 | 2 | 0 | 1 | o | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 11 |
| No reason | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 6 |
| Nonsweet | 17 | 6 | 15 | 7 | 10 | 15 | 10 | 2 | 6 | 4 | 5 | 3 | 18 | 118 |
| Salty | 0 | 3 | 2 | 1 | 1 | 1 | 1 | 3 | 1 | 0 | 1 | 2 | 4 | 20 |
| Sour | 0 | 0 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 6 |
| Salty | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Yamlike taste | 0 | 1 | 0 | 4 | 1 | 1 | 0 | 0 | 0 | 2 | 2 | 0 | 2 | 13 |
| Total | 55 | 22 | 33 | 21 | 36 | 61 | 47 | 13 | 34 | 25 | 48 | 20 | 40 | 455 |
| Chi-square (X2) | <0.006 |  |  |  |  |  |  |  |  |  |  |  |  |  |

A=Purple, B= PG17305-N1, C=Ligri, D=Obare, E= PG17265-N1, F= PG17140-N2, G=Apomuden, H= PG173136-N1, I= PG17362-N1, J= CIP442162, K= PG17412-N2, L=Nan, M= PG17206-N5

Table 2. Contingency Table Showing Like and Dislike Attributes and Tastes of the different VT Genotypes with their Chi-square values

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Desired Attribute** | A | B | C | D | E | F | G | H | I | J | K | L | M | Total |
| Appearance | 0 | 3 | 0 | 1 | 1 | 2 | 0 | 2 | 1 | 0 | 2 | 1 | 3 | 16 |
| Firmness | 1 | 5 | 0 | 2 | 0 | 1 | 1 | 5 | 2 | 1 | 1 | 5 | 0 | 24 |
| Familiarity | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Mealiness | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 3 | 8 |
| Satisfying | 0 | 6 | 0 | 1 | 0 | 1 | 1 | 2 | 0 | 0 | 2 | 3 | 1 | 17 |
| Taste | 30 | 34 | 27 | 36 | 30 | 26 | 25 | 30 | 12 | 29 | 33 | 39 | 37 | 388 |
| Total | 31 | 48 | 29 | 40 | 33 | 30 | 27 | 39 | 17 | 30 | 38 | 48 | 44 | 454 |
| Chi-square (X2) | 0.017 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Undesired Attributes** | |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Appearance | 9 | 7 | 8 | 5 | 6 | 6 | 8 | 6 | 10 | 3 | 4 | 2 | 2 | 76 |
| Firmness | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 5 |
| Satisfying | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Taste | 22 | 29 | 13 | 30 | 33 | 27 | 44 | 32 | 18 | 32 | 31 | 26 | 20 | 357 |
| Texture | 2 | 2 | 3 | 0 | 0 | 0 | 3 | 1 | 0 | 2 | 1 | 0 | 1 | 15 |
| Total | 33 | 38 | 24 | 35 | 39 | 34 | 56 | 39 | 28 | 38 | 38 | 29 | 23 | 454 |
| Chi-square (X2) | 0.237 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Desired Taste** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Bitter aftertaste | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Highly sweet | 9 | 8 | 7 | 14 | 10 | 3 | 5 | 7 | 4 | 7 | 12 | 7 | 21 | 114 |
| Moderately sweet | 20 | 30 | 16 | 22 | 17 | 22 | 18 | 24 | 9 | 22 | 20 | 34 | 22 | 276 |
| Low sweet | 1 | 9 | 6 | 4 | 5 | 2 | 4 | 6 | 2 | 0 | 6 | 6 | 1 | 52 |
| Non sweet | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |
| Salty | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Sour | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Yamlike taste | 0 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 5 |
| Total | 31 | 48 | 29 | 40 | 33 | 30 | 27 | 39 | 17 | 30 | 38 | 48 | 44 | 454 |
| Chi-square | 0.489 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Undesired Taste** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Bitterness | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Bitter aftertaste | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 |
| Firmness | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Highly sweet | 6 | 2 | 6 | 10 | 12 | 12 | 15 | 12 | 10 | 18 | 13 | 9 | 10 | 135 |
| Low sweet | 10 | 15 | 8 | 5 | 10 | 9 | 15 | 9 | 6 | 6 | 10 | 7 | 5 | 115 |
| Mealiness | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 7 |
| Moderately sweet | 6 | 6 | 3 | 5 | 4 | 2 | 5 | 4 | 4 | 2 | 3 | 3 | 0 | 47 |
| Non sweet | 8 | 9 | 3 | 14 | 9 | 9 | 18 | 11 | 7 | 8 | 10 | 9 | 7 | 122 |
| Salty | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 4 |
| Sour | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Yamlike taste | 2 | 3 | 1 | 0 | 3 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 13 |
| Total | 33 | 38 | 24 | 35 | 39 | 34 | 56 | 39 | 28 | 38 | 38 | 29 | 23 | 454 |
| Chi square | 0.487 |  |  |  |  |  |  |  |  |  |  |  |  |  |

A-Apomuden, B-Ligri, C-Purple (Diedi), D-PGN16021-39, E-PGN16024-27, F-PGN16024-28, G-PGN16030, H-PGN16092-6, I-PGN1630-4, J-PGN16203-18, K-PGA14011-24, L-OBARE, M-NAN

Table 3. Contingency Table Showing Like and Dislike Attributes and Tastes of the different Southern AT Genotypes with their Chi-square values

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Desired Attributes** | **A** | **B** | **C** | **D** | **E** | **Total** |
| Appearance | 3 | 3 | 4 | 3 | 10 | 23 |
| Taste | 13 | 25 | 32 | 17 | 29 | 116 |
| Chi-square | 0.422 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| **Undesired Attributes** | |  |  |  |  |  |
| Appearance | 5 | 4 | 5 | 7 | 4 | 25 |
| Fibrousness | 0 | 0 | 0 | 1 | 0 | 1 |
| Taste | 21 | 24 | 16 | 31 | 18 | 110 |
| Texture | 1 | 0 | 0 | 1 | 1 | 3 |
| Total | 27 | 28 | 21 | 40 | 23 | 139 |
| Chi-square | 0.952 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| **Desirable Taste** | 0 | 0 | 1 | 1 | 0 | 2 |
| Appearance | 1 | 4 | 5 | 7 | 5 | 22 |
| Firmness | 14 | 22 | 24 | 12 | 31 | 103 |
| Sweet taste | 0 | 1 | 4 | 0 | 3 | 8 |
| Yamlike taste | 16 | 28 | 36 | 20 | 39 | 139 |
|  |  |  |  |  |  |  |
| **Undesired Taste** |  |  |  |  |  |  |
| Bitterness | 15 | 15 | 12 | 24 | 12 | 78 |
| Fibrousness | 2 | 1 | 0 | 1 | 0 | 4 |
| Low sweet | 0 | 2 | 0 | 2 | 2 | 6 |
| Watery taste | 8 | 8 | 8 | 11 | 7 | 42 |
| No Flavour | 0 | 1 | 0 | 0 | 2 | 3 |
| Sweet taste | 1 | 0 | 1 | 0 | 0 | 2 |
| Total | 27 | 28 | 21 | 40 | 23 | 139 |
| Chi-square | 0.681 |  |  |  |  |  |

A- PGA14229-2, B- PGA12151-73, C- PGA12010-15, D- PGA14011-13, E- PGA14008-15