Suitability of orange-fleshed sweet potato genotypes for ingredients of selected food products

J S Utomo and E Ginting
Indonesian Legumes and Tuber Crops Research Institute (ILETRI)
Jl. Raya Kendalpayak Km 8, Pakisaji, Malang, Indonesia
E-mail: jokosut@gmail.com

Abstract. Promotion of orange-fleshed sweet potato with high beta-carotene content would enhance the consumption of sweet potato as well as support the local-based food diversification. Deep-fried chips, jam, juice, and noodle are the products that commonly make from cereals and fruits other than tubers. Producing those products from sweet potato was aiming to study the suitability and acceptance concerning promoting their utilization and adoption once they are released as new varieties. Five orange-fleshed sweet potato genotypes, namely MSU 06071-82, MSU 06039-07, MSU 06042-18, MIS 0651-09, and Beta-2 were studied their suitability for making food products, such as deep-fried chips, jam, juice, and noodle-based on their physical, chemical and sensorial attributes. The results showed that MSU 06042-18 genotype with a relatively high beta-carotene content (5.425 μg/100 g wb) was suitable for the ingredient of deep-fried chips jam, juice, and noodle products, followed by MSU 05036-11 and Beta-2. In particular, MSU 06071-82 and MIS 0651-09 genotypes were suitable for juice ingredients based on the parameter evaluated. This information is essential in terms of enhancing the adoption of orange-fleshed sweet potato genotypes by farmers and their utilization by food processors.

1. Introduction
Most of the sweet potato production in Indonesia (89%) is used for foods with a consumption level of 3.15 kg/capita/year [1][2]. As an industrial raw material, sweet potato is mainly used for filler in tomato sauce. While for food products are yet limited to traditional foods, such as boiled, deep-fried, and mashed sweet potatoes, snacks, and deep-fried chips, which are usually assumed to be less attractive compared to those products derived from wheat flour, resulting in a slow growth rate of sweet potato consumption and subsequent production development, even tends to decrease for the harvested area [3].

Therefore, diversification of sweet potato utilization into a variety and attractive of processed products with relatively simple technology [4], is warranted to increase sweet potato consumption and give the added value to the products as well as enhances the development of sweet potato-based agroindustry. In addition to diversification, efforts to increase consumption of sweet potato can be encouraged through the promotion of sweet potato as a functional food along with the increase in public health awareness. The flesh colour of the sweet potatoes can be white, yellow, or orange, and their skin colour may either be white, yellow, orange, red, or purple. The orange colour is due to the presence of beta-carotene [5].
Beta-carotene is a major component of carotenoids (86-90%) in sweet potato, a pigment that is responsible for the yellow to the orange colour of the tuber flesh [6]. Beta-carotene was available in all types of sweet potato ranging from 91.95±2.05 μg/g DW in white sweet potato to 376.03±11.05 μg/g DW in orange sweet potato [7]. Deficiency of vitamin A may cause interferences in vision from the mild to severe one (blindness), immune system against infectious diseases, growth, and development, particularly for children [8] and also reducing the risk of developing certain types of cancers, as well as cardiovascular, eye, skin or bone diseases [9]. Therefore, consumption of beta-carotene-rich sweet potato is yet playing an important role in combating vitamin A deficiency in Sub-Saharan Africa [10].

Beta-carotene levels in sweet potato vary from 0 to more than 4,000 μg / 100 g and may reach up to 20,000 μg / 100 g [11]. The content of beta-carotene in sweet potato is positively correlated with the intensity of yellow/orange colours of the tubers [6] [12] [13]. Concerning beta-carotene, two orange-fleshed varieties, namely Beta 1 and Beta 2 have been released by The Indonesian Ministry of Agriculture in 2009 with considerably high beta-carotene content of 12,031 ug /100 g and 4,629 µg/100 g fwb, respectively [14].

The breeding of sweet potato varieties with high beta carotene content is facing a problem of high moisture content and low dry matter content (<30%) [15] as well as sweet and soft mouthfeels [6]. These characteristics are less preferred by breeders, sweet potato industries, and consumers. Beta-1 variety, which contains moisture up to 79% with only 21% of dry matter content [14], giving a quite low flour yield recovery (around 12.3%). Due to the soft/tender texture, the steamed, boiled, or deep-fried fresh tubers are also less desired. Therefore, breeding to improve these characteristics needs to be performed continuously.

In this study, the materials were selected from 11 promising clones that had been studied previously from their physical, chemical, and sensorial characteristics [16], particularly the beta-carotene and dry matter contents as well as the texture profiles after steaming [17].

| Clones           | Fiber (% dwb) | Starch (% dwb) | Amylose (% dwb) | Beta-carotene (μg/100 g) |
|------------------|---------------|----------------|-----------------|--------------------------|
| MSU 06039-21     | 3.93          | 50.62          | 23.56           | 1,706                    |
| MSU 06044-03     | 4.00          | 56.93          | 23.71           | 4,812                    |
| MSU 05036-11     | 3.89          | 51.51          | 25.47           | 4,003                    |
| MSU 05036-23     | 3.54          | 50.94          | 23.73           | 9,295                    |
| MSU 06039-07     | 3.74          | 55.07          | 21.36           | 996                      |
| MSU 06042-18     | 3.61          | 56.80          | 22.49           | 5,425                    |
| MSU 06043-42     | 3.71          | 51.55          | 21.90           | 3,936                    |
| MIS 0651-15      | 3.45          | 56.01          | 23.72           | 4,624                    |
| MIS 0651-09      | 3.53          | 60.32          | 24.89           | 5,574                    |
| MSU 06071-82     | 4.29          | 59.29          | 22.08           | 3,871                    |
| MSU 05036-17     | 3.43          | 62.03          | 23.31           | 7,412                    |
| Beta 2           | 3.73          | 52.74          | 23.92           | 1,422                    |

Source: Ginting et. al. [16]

2. Material and methods
The study was conducted at the Food Chemistry and Processing Laboratory, Indonesian Legume and Tuber Crops Research Institutes. These five promising sweet potato clones with high productivity (> 25 tons/ha) and contained beta carotene content around 5,000 μg / 100 g were processed into deep-fried chips, jam, juice, and noodle to identify the suitability and acceptance concerning promoting their utilization and adoption once they are released as new varieties. About four promising clones of orange-fleshed sweet potato were selected, namely MSU 06071-82, MSU 06039-07, MSU 06042-18, MIS 0651-09, and Beta 2 was used as a check.
**Sweet potato chips.** The tubers were sliced into 3 mm thick and weight for 1 kg, then processed into deep-fried chips using vacuum deep-frying at 140°C, 70-72 cmHg, for 10 minutes. The fried chips are then spun in order to reduce the amount of oil that sticks to the chips.

**Sweet potato jam.** Sweet potato tubers were steamed for 15 minutes and then pounded to form mashed sweet potato which was then followed by the addition of mango podang at a portion of 50% mashed sweet potato and 50% mango Podang variety. Sweetpotato jam is homogenized by mixing the mixture using a blender to form a homogeneous jam.

**Sweet potato juice.** Sweet potato juice was blended the mashed sweet potato with orange juice from Siam variety. Sweet potato juice is made based on patent no. IDP000054861 (2018). Sweet potato noodles. Noodles (using 40% of mashed sweet potato, 10% of tapioca and 50% of wheat flour) based on Patent no. IDP000043493 (2017).

Observations included the physical and chemical properties that determine the quality of the respective product. Hunter colour was measured using Color Reader CR-10 (Konica Minolta Sensing, Inc, Japan), absolute color system measurement L*, a* and b* [18], yield recovery (weight-based calculation), and hardness was determined using Texture Analyzer [19]. Viscosity was determined using Brookfield Visco analyzer [24]. moisture and ash contents using gravimetric method [25].

The study was designed using Complete Randomized Design (CRD) and research was repeated 3 times. The data obtained is calculated by analysis of variance and followed by an LSD test to see differences between treatments with 5% level of confidence. The sensorial attributes, such as colour, aroma, texture, and taste of products were also observed using Hedonic tests with 20 panelists and sensory test results are presented descriptively.

3. Result and discussion

3.1. Deep-fried sweet potato chips

The moisture content of raw material used were varied, MSU 05036-11 (77.13%), MSU06071-82 (73.21%), MSU 06042-18 (72.50%), MIS 0651-09 (70.22%) and Beta 2 (79.43%). The moisture content of sweet potato chips was significantly different among clones with the highest values at MSU 05036-11 and the lowest at MSU 06042-18 (Table 2). In addition to an initial moisture content of the fresh tubers [16], these differences may also due to differences in the speed of migration and evaporation of water from the tubers during frying which are associated with the physical and chemical properties of a particular clone. The water content of these chips has met the requirements of national standard quality, which is a maximum of 5% [22]. This suggests that the temperature of deep-frying at 140°C for 10 minutes using a vacuum fryer is suitable for orange-fleshed sweet potato for its moisture content.

| Clones         | Moisture (%)  | Ash (% dwb) | Fat (% dwb) | Yield recovery (%) | Hardness (Newton) | Hunter colour |
|----------------|---------------|-------------|-------------|--------------------|-------------------|---------------|
|                |               |             |             |                    |                   | L*            | a*            | b*            |
| MSU 05036-11   | 4.04 a        | 2.61 d      | 28.73 b     | 24.33 d            | 8.16 c            | 61.03 c       | 17.53 b       | 38.80 bc       |
| MSU 06071-82   | 2.70 c        | 3.25 b      | 24.63 d     | 30.97 b            | 11.28 ab          | 63.93 b       | 12.53 e       | 37.43 c        |
| MSU 06042-18   | 2.25 d        | 2.87 c      | 23.18 e     | 29.80 bc           | 7.59 c            | 64.40 b       | 17.20 c       | 43.30 a        |
| MIS 0651-09    | 3.68 b        | 2.41 e      | 27.63 c     | 36.17 a            | 12.30 a           | 61.07 c       | 19.60 a       | 39.20 b        |
| Beta 2         | 2.81 c        | 3.63 a      | 33.43 a     | 28.60 c            | 9.12 bc           | 65.80 a       | 13.43 d       | 35.27 d        |
| LSD 5%         | 0.21          | 1.31        | 0.92        | 1.45               | 2.38              | 1.29          | 0.29          | 1.65           |
| CV (%)         | 3.57          | 0.06        | 1.78        | 2.57               | 13.06             | 1.08          | 1.05          | 2.52           |

Numbers in the same column followed by the different letters are significantly different at 5% of the LSD test.

Note: L*: Lightness level from a dark range (0) to light (100)

a*: green (–100) to red (+100)

b*: blue (–100) to yellow (+100)
The ash contents of deep-fried chips were also significantly different among clones with the highest value seen at Beta 2 and the lowest in MSU 05036-11. The ash content of the chips exceeded the maximum limit (2%) required by national standard quality (DSN, 1996), which relates to the type of orange sweet potato used in this study whose fresh tuber ash content ranges from 3-4.5% dwb [16].

The difference of sweet potato clones was significantly affected the fat content of chips produced with the highest values obtained in Beta 2 and the lowest in MSU 06042-18. This can be affected when the initial moisture content of the tuber is the highest in Beta 2 (79.43%) [16], thus absorb more oil to replace the migrated water [23]. The fat content of orange sweet potato chips is relatively higher when compared to four purple sweet potato clones fried without vacuum at 145°C for 10 minutes which ranges from 19-32% fat [20].

The highest recovery of chips was obtained in MIS 0651-09 and the lowest was at MSU 05036-11 (Table 2). This difference is influenced by the initial and final moisture content. The hardness of chips varied among clones of sweet potato with the highest value (hard) obtained on the MIS 0651-09 and MSU 06071-82 clones, while the other three clones had the lowest value (crispy) (Table 3). This difference is not only due to differences in the initial moisture content of the tubers, but can also be related to the levels of amylose and amylopectin of each variety. The brightest chips were seen in Beta 2, while MSU 05036-11 and MIS 0651-09 showed the darkest chips (Table 3), considerably dictated by the initial orange colours of their fresh tubers.

**Table 3. Scores of sensorial properties of deep-fried chips prepared from five clones.**

| Clones       | Colour preferences | Aroma preferences | Texture preferences | Taste preferences | Texture |
|--------------|--------------------|-------------------|---------------------|-------------------|---------|
| MSU 05036-11 | 2.9                | 3.8               | 3.9                 | 3.8               | 3.9     |
| MSU 06071-82 | 3.4                | 4                 | 3.4                 | 3.4               | 3.2     |
| MSU 06042-18 | 3.8                | 3.6               | 3.4                 | 3.6               | 3.6     |
| MIS 0651-09  | 4                  | 3.6               | 3.1                 | 3.2               | 3.2     |
| Beta 2       | 3.7                | 3.6               | 4.3                 | 3.9               | 4.3     |

Scores of preferences for colour, taste and texture:
1. Strongly dislike
2. Moderately dislike
3. Slightly like
4. Moderately Like
5. Strongly like

Texture score: 1. Very hard; 2. Hard; 3. Slightly crispy; 4. Crispy; 5. Very crispy

The sensory test results showed that the colours of chips made from MSU 06042-18, MIS 0651-09, and Beta 2 were moderately liked by panelists (Table 3), while the rest two clones were less preferred. This shows that panelists tend to prefer bright colour chips compared to darker ones. For the aroma of chips, all chips were fairly liked by panelists. The texture of chips processed from MSU 05036-11 and Beta 2 was liked by panelists because they were more crispy, while the other three clones were slightly crispy (Table 3). Similarly, the taste of chips processed from MSU 05036-11, MSU 06042-18, and Beta 2 was also liked, while the other two were less preferred. Overall, the chips that were processed from Beta 2 gave the highest scores for colour, aroma, texture, and taste, followed by MSU 06042-18 and MSU 05036-11.

3.2. Sweet potato jam

The Physical and chemical properties of sweet potato jam made from a blend of 50% mashed sweet potato and 50% mango are present in Table 4. The moisture content of the jam differed among clones of sweet potato used, but the range is relatively narrow. This resulted in a similar yield recovery (final weight) of jam prepared from five clones/varieties with the range of 90.8-95.8%. The lowest value of lightness (L*) was showed in jam made from Beta 2 (dark/deep orange). The viscosity of the jam varied greatly with the highest value obtained in MSU 06042-18 and Beta 2, while the lowest value was exhibited in MSU 06071-82. These differences were more due to the differences in
amylose/amylopectin ratio as starch components which would dictate the gelatinization and retrogradation profiles of the gel after cooling down as the amounts of sugar added for all jams were the same. The jam produced from MSU 06071-82 was the least viscous compared to other jams, reflecting weak retrogradation of the gel. This kind of jam is usually not desired for smearing purposes on the bread. Nevertheless, the too viscous jam is also less liked as it is difficult to be spread. This latter type of jam is more suitable for cake or bread fillers. The slightly different values of total acid were might due to differences in water content because the amounts of citric acid added were the same.

Table 4. Physical and chemical properties of jam made from five clones of sweet potato.

| Clones       | Recovery (%) | Viscosity (cps) | Hunter Colour | Moisture (%) | Sugar (%) | Total acid (ml 0.01 N NaOH/g) |
|--------------|--------------|-----------------|---------------|--------------|-----------|-------------------------------|
| MSU 05036-11 | 95.82 a      | 355.00 b        | 38.40 ab      | 13.30 a      | 33.57 bc  | 4.932 a                      |
| MSU06071-82  | 95.38 a c    | 192.67 b        | 39.60 19.70 b | 32.97 c      | 47.10 c   | 32.88 a                      |
| MSU 06042-18 | 94.52 a      | 656.00 a        | 37.80 b       | 11.13 c      | 48.35 b   | 30.12 a                      |
| MIS 0651-09  | 94.68 a      | 311.67 b        | 39.40 a       | 12.20 b      | 46.82 c   | 33.22 a                      |
| Beta 2       | 91.03 a      | 594.00 a        | 35.67 c       | 6.67 d       | 49.32 a   | 32.56 a                      |
| LSD 5%       | ns           | 78.22           | 1.39          | 4.72         | 2.81      | 0.39 ns                       |
| CV (%)       | 2.78         | 9.85            | 1.93          | 0.98         | 1.77      | 0.43 ns                       |

Numbers in the same column followed by the different letters are significantly different at 5% of LSD test

Note: L *: Lightness level from a dark range (0) to light (100
a *: green (-100) to red (+100)
b *: blue (-100) to yellow (+100)
cps: centipoise, ns = non-significant

The colour of jam prepared from MSU 05036-11, MSU 06042-18, and Beta 2 was moderately liked, while MIS 0651-09 was slightly liked and MSU 06071-82 was disliked (Table 5). This shows that the jam with a darker colour (Table 4) is preferred by panelists. Besides the orange flesh colour, the colour of the jam is also influenced by the caramelization of sugar when heated. The viscosity of jam prepared from five clones was fairly liked, although they considerably varied when measured using a viscosity meter (Table 4). The aroma of all jams was also moderately liked by the panelists, except for the jam made from MSU 06071-82 which had a less liked aroma. The taste of jams made from Beta 2 and MSU 06071-82 was slightly liked, while jams from the other three clones were moderately liked. This shows that blended sweet potato mash with mango acceptable for an ingredient of jam. Overall, the most accepted aroma, viscosity, and taste jam were coming from MSU 06042-18, followed by MSU 05036-11, Beta 2, and MIS 0651-09.

Table 5. Scores of sensorial attributes of jam prepare from five sweet potato clones.

| Clones       | Colour | Viscosity | Aroma | Taste | Total score |
|--------------|--------|-----------|-------|-------|-------------|
| MSU 05036-11 | 4.1    | 3.7       | 3.7   | 3.9   | 15.4        |
| MSU 06071-82 | 2.4    | 3.7       | 3.2   | 3.4   | 12.7        |
| MSU 06042-18 | 4.1    | 4.0       | 3.7   | 3.8   | 15.6        |
| MIS 0651-09  | 2.9    | 4.0       | 3.5   | 4.1   | 14.5        |
| Beta 2       | 3.8    | 3.9       | 3.7   | 3.3   | 14.7        |

Scores of preferences for colour, viscosity, aroma, and taste:
1. Strongly dislike
2. Moderately dislike
3. Slightly like
4. Moderately Like
5. Strongly like

3.3. Sweet potato juice
Sweet potato juice was processed from a blend of mashed sweet potato and orange juice to get a similar colour of juice. The moisture contents of sweet potato juice significantly varied (Table 6), which were mainly due to the initial moisture content of fresh and steamed tubers. The reducing sugar
levels were also different with the highest values was found in MSU 06042-18 which had the highest reducing sugar content in the steamed tubers ca 24.29% fwb [17]. The highest TSS was found in juice prepared from MSU 06042-18 and MIS 0651-09 clones, while the lowest TSS was seen in Beta 2. The lowest value of viscosity was also obtained in Beta 2, but the highest value was obtained in MSU clones 06071-82, followed by MIS 0651-09. Meanwhile, the highest L* value occurred in MSU 05036-11, which also had the lowest L* value for its sweet potato mash ca 51.93 [17].

Table 6. Physical and chemical properties of juice made from five clones of sweet potato.

| Clones         | Moisture (%) | Reducing sugar (%) | TSS (brix) | Viscosity (cps) | L* | Hunter Colour |
|----------------|--------------|--------------------|------------|-----------------|----|---------------|
| MSU 05036-11   | 84.58 b      | 1.43 cd            | 14.80 c    | 108.33 d        | 49.43 a | 8.30 c | 38.83 a |
| MSU 06071-82   | 83.51 c      | 1.54 c             | 16.00 b    | 333.33 a        | 43.50 d | 10.93 b | 36.27 b |
| MSU 06042-18   | 82.31 d      | 2.56 a             | 17.00 a    | 141.67 c        | 44.43 c | 11.43 a | 35.67 bc |
| MIS 0651-09    | 82.33 d      | 2.21 b             | 17.00 a    | 179.17 b        | 45.70 b | 11.70 a | 38.00 a |
| Beta 2         | 85.12 a      | 1.28 d             | 13.97 d    | 120.83 d        | 44.83 c | 7.67 d  | 34.83 c |
| LSD 5%         | 0.08         | 0.25               | 0.29       | 17.52           | 0.68   | 0.46    | 0.95    |
| CV (%)         | 0.06         | 7.54               | 0.96       | 5.27            | 0.80   | 2.45    | 813     |

Numbers in the same column followed by the different letters are significantly different at 5% of LSD test

Note: L*: Lightness level from a dark range (0) to light (100)
  a*: green (–100) to red (+100)
  b*: blue (–100) to yellow (+100)
cps: centipoise
TSS: Total Soluble Solid

The colour of the juice is moderately liked, except for MSU 05036-11 which was slightly liked. MSU 05036-11 and Beta 2, which have lower viscosity juices (Table 6) were slightly like compared to the other three clones which were fairly liked. This was in agreement with the total soluble solids and viscosity values measured using the viscosity meter (Table 7).

Table 7. Scores of sensorial attributes of juices prepared from five sweet potato clones.

| Clones    | Colour | Viscosity | Aroma | Taste | Total score |
|-----------|--------|-----------|-------|-------|-------------|
| MSU 05036-11 | 3.1    | 3.4       | 3.4   | 3.6   | 13.5        |
| MSU 06071-82 | 4.3    | 3.8       | 4.1   | 4.0   | 16.2        |
| MSU 06042-18 | 4.2    | 3.9       | 4.1   | 3.9   | 16.1        |
| MIS 0651-09  | 4.1    | 3.8       | 3.9   | 3.6   | 15.4        |
| Beta 2      | 3.5    | 3.2       | 3.4   | 3.2   | 13.3        |

Scores of preferences for colour, viscosity, aroma, and taste:
1. Strongly dislike
2. Moderately dislike
3. Slightly like
4. Moderately Like
5. Strongly like

Also, the aroma of MSU 05036-11 and Beta 2 juices was slightly liked, while the other three clones were fairly liked. For taste criteria, only Beta 2 juice was slightly liked, while the other four clones were moderately liked. Based on total scores of colour, viscosity, aroma, and taste, the sweet potato juice prepared from MSU 06071-82 and MSU 06042-18 were the most liked by panelists, followed by MIS 0651-09.

3.4. Sweet potato noodle

The moisture contents of dry noodles were slightly different (Table 8) as the processing, particularly drying was mostly the same. Noodles made from Beta 2 had the highest ash content, followed by MSU 06071-82, merely due to differences in fresh tuber ash content [16]. The protein content of noodles was not significantly different among clones of sweet potatoes because the protein content was more influenced by the addition of egg liquid and wheat flour rather than the protein derived from the tuber which is generally quite low (<2%). All noodles produced have met the national standard.
quality requirements for dry noodles maximum moisture content (14.5% fwb) and minimum protein content of 4% for noodles not made from wheat flour) or at least 8% for noodles made from wheat flour (DSN, 2000). This shows that the use of 40% orange sweet potato paste or mash as a substitute for wheat flour for making dry noodles has met the national standard requirement.

Table 8. The chemical composition of dried noodles prepared from five clones of sweet potato.

| Clones     | Moisture (%) | Ash (% fwb) | Protein (% fwb) |
|------------|--------------|-------------|-----------------|
| MSU 05036-11 | 8.60 c       | 2.02 c      | 10.80 a         |
| MSU 06071-82 | 8.44 c       | 2.44 b      | 11.18 a         |
| MSU 06042-18 | 8.96 b       | 1.84 d      | 10.71 a         |
| MIS 0651-09  | 8.60 c       | 1.80 d      | 11.04 a         |
| Beta 2      | 9.97 a       | 2.58 a      | 11.10 a         |
| LSD 5%      | 0.27         | 0.06        | ns              |
| CV (%)      | 1.61         | 1.31        | 2.93            |

Numbers in the same column followed by the different letters are significantly different at 5% of LSD test.

The hardness levels of dried noodles were not significantly different among the sweet potato used because the moisture contents were almost the same (Table 9). Meanwhile, they were slightly different for wet noodles (dried noodles boiled for about 5 minutes) with the range values of 14.78-19.05 N. This can be related to differences in the consistency of the gel of each clone/variety, even though sweet potato gel is generally classified as soft gel [25]. In addition, the portion of 50% wheat flour 50% and 10% tapioca which was relatively larger than mashed sweet potato (40%) may also affect the levels of noodle hardness. This reflects that the differences due to the use of different sweet potato clones were relatively small. This is also in agreement with the fact that the dry noodle's abilities to absorb water during boiling were similar for all clones. The volume development of the noodles seemed to be in line with the levels of hardness (becoming soft), except for MSU 06042-18 which had the hardest noodles even though the volume development was the greatest. This may be attributed to the levels of noodle resilience against the given pressure which is associated with amylose/amylopectin contents. The colour of dried noodles was also relatively the same for five clones of sweet potato as both the colour of the mashed sweet potato and the colour of the wheat flour and tapioca used would dictate the final colour of the noodles.

Table 9. Physical properties of dried noodles and boiled noodles from five clones of sweet potato.

| Clones     | Hardness (dried noodles) (N) | Hardness (boiled noodles) (N) | Development of volume (%) | Water absorption (%) | Colour of dried noodles |
|------------|------------------------------|-------------------------------|---------------------------|---------------------|-------------------------|
| MSU 05036-11 | 1.82 a                       | 16.81 ab                      | 23.53 bc                  | 340.00 a            | 1.82 a 16.81 ab 23.53 a |
| MSU 06071-82 | 2.12 a                       | 19.05 a                       | 26.73 b                  | 389.00 a            | 2.12 a 19.05 a 25.07 a |
| MSU 06042-18 | 2.05 a                       | 14.78 b                      | 36.10 a                  | 348.00 a            | 2.05 a 14.78 b 36.10 a |
| MIS 0651-09  | 2.13 a                       | 18.04 ab                      | 25.17 bc                 | 345.67 a            | 2.13 a 18.04 ab 25.17 a |
| Beta 2      | 1.88 a                       | 17.89 ab                      | 23.23 c                  | 342.33 a            | 1.88 a 17.89 ab 23.23 a |
| LSD 5%      | ns                           | 3.42                           | 3.43                      | ns                  | ns 3.42 ns |
| CV (%)      | 12.21                       | 10.49                          | 6.76                      | 12.48 a            | 12.21 10.49 30.64 |

Numbers in the same column followed by the different letters are significantly different at 5% of LSD test.

Note: L*: Lightness level from a dark range (0) to light (100)
   a*: green (–100) to red (+100)
   b*: blue (–100) to yellow (+100)

The organoleptic test of sweet potato noodles was performed for both dried and boiled noodles. The colour of dried noodles from all sweet potato clones was slightly liked by panelists. For aroma, only dried noodles prepared from MSU 06042-18 clones were liked, while the other clones were slightly liked. This may be due to the presence of specific sweet potato aroma and liquid eggs as
supporting ingredients. Sweet potato noodles are usually marketed in the form of dried noodles, thus aroma is an important criterion for consumers in addition to colour and compactness of noodles. The highest score of colour acceptance for boiled noodles was exhibited by Beta 2 (moderately like), while MSU 06071-82 and MIS 0651-09 gave a lower score (Table 10). Panelists liked the aroma of boiled noodles made from MSU 05036-11, MSU 06042-18, and Beta 2, while MSU 06071-82 and MIS 0651-09 noodles were slightly liked. Beta 2’s noodle gave high scores for texture and taste, while MSU 06071-82 had low scores (slightly liked). The texture of MSU 05036-11, MSU 06071-82, and Beta 2 noodles were fairly chewy, similar to those of noodles sold in the market (usually made from 100% of wheat flour), however, noodles prepared from MSU 06042-18 and MIS 0651-09 were slightly chewy.

Table 10. Scores of sensorial attributes of boiled noodles prepared from five clones/varieties of sweet potato.

| Clones          | Colour (dried) | Aroma (dried) | Colour (boiled) | Aroma (boiled) | Texture preferences (boiled) | Taste preferences (boiled) | Texture (boiled) |
|-----------------|----------------|---------------|-----------------|----------------|-----------------------------|---------------------------|-----------------|
| MSU 05036-11    | 3.8            | 3.3           | 3.5             | 3.6            | 3.6                         | 3.6                       | 3.7             |
| MSU 06071-82    | 3.5            | 3.4           | 2.9             | 3.2            | 3.1                         | 2.8                       | 3.6             |
| MSU 06042-18    | 3.8            | 3.6           | 3.4             | 3.6            | 3.6                         | 3.6                       | 3.5             |
| MIS 0651-09     | 3.6            | 3.4           | 3.3             | 3.3            | 3.6                         | 3.4                       | 3.3             |
| Beta 2          | 3.6            | 3.3           | 3.9             | 3.6            | 3.9                         | 3.8                       | 3.7             |

Scores of preferences for colour, taste, and texture:
1. Strongly dislike
2. Moderately dislike
3. Slightly like
4. Moderately Like
5. Strongly like

Texture score: 1. Very firm; 2. Firm; 3. slightly chewy; 4. Chewy; 5. Very chewy

Based on the sensorial, physical, and chemical properties, the five clones of sweet potato had different suitability for making different types of food products. MSU 06042-18 was suitable for all products tested in this study, namely deep-fried chips, jam, juice and noodles. Therefore, it is promising to be released as food ingredients (Table 11). The beta-carotene content was also relatively high ca 5,425 µg / 100 g fwb [16].

Table 11. Suitability of the use of five sweet potato clones for food products based on the sensorial, chemical and physical properties of the products.

| Clones          | Suitable types of processed products                        |
|-----------------|------------------------------------------------------------|
| MSU 05036-11    | Deep-fried chips, Jam, Noodle                              |
| MSU 06071-82    | Juice                                                      |
| MSU 06042-18    | Deep-fried chips, Jam, Juice, Noodle                       |
| MIS 0651-09     | Jam, Juice                                                 |
| MSU 06039-07    | --                                                         |
| Beta 2          | Deep-fried chips, Jam, Noodle                              |

4. Conclusions

MSU 06042-18, an orange-flesh sweet potato promising clone was tailored for an ingredient of deep-fried chips, jam, juice, and noodles. MSU 06071-82 and MIS 0651-09 were especially suitable for juice, while MSU 05036-11 and Beta 2 were tailored for most of the food products, except for juice.

References
[1] FAOSTAT 2018 Statistical database of food balance sheet
[2] Suryani R 2018 Pusdatin Kementerian Pertanian Jakarta [In Indonesian]
[3] BPS 2020 Biro Pusat Statistik Indonesia Jakarta [In Indonesian]
[4] Ginting E, Yulifianti R and Jusuf M 2014 Pangan, 23(2) 194-206 [In Indonesian]
[5] Teow C C, Truong V D, McFeeters R F, Thompson R L, Pecota K V and Yencho GC 2007 *Food Chem.* **103** 829–838

[6] Woolfe J A 1992 *Sweet Potato Untapped Food Resource* (Cambridge: Cambridge University Press)

[7] Kammona S, Othman R, Jaswir I and Jamal P 2015 *Int. J. Pharmacy and Pharmaceutical Sciences* **7** (2) 347-351

[8] Laurie S M and van Heerden S M 2012 *African J. Food Sci.* **6(4)** 96-103

[9] Antonio J, Meléndez-Martínez, Mapelli-Brahm P, Hornero-Méndez D and Vicario I M 2019 *Carotenoid Esters in Foods: Physical Chemical and Biological Properties* ed. A Z Mercadante Chapter 1 p. 1-50

[10] Ofori G, Oduro I, Ellis W O and Dapaah K H 2009 *African J. of Food Sci.* **3(7)** 184-192

[11] Hongmin L, Xiaoding G and Daifu M 1996 Sweet potato ed. E T Rasco and V R Amante p.126-130

[12] Simonne A H, Kays S J, Koehler P E and Eitenmiller R R 1993 *J. Food Comp. Anal.* **6** 336-345

[13] Ginting E, Jusuf M and Rahayuningsih S A 2008 Crops: prospect of development of legumes and tuber-crops-based agroindustry ed. N Saleh, A A Rahmianna, Pardono, Samanhudi, C Anam and Yulianto *Proc. Nat. Sem. Devt. Leg. Tub.* p. 392-405

[14] Indonesian Legumes and Tuber Crops Research Institute (ILETRI) 2016 *Description of Legumes and Tuber Crops Improved Varieties* (Malang: Indonesian Legumesand Tuber Crops Research Institute) p. 213 [In Indonesian]

[15] Yamakawa O 1998 *Proc. Int. Workshop on Sweet Potato System toward the 21st Century* ed. D R LaBonte, M Yamashita and H Mochida (Japan) p. 1-8

[16] Ginting E, Utomo J S and Jusuf M 2012 *Proc. Nat. Seminar on The Results of Legumes and Tuber Crops Research* ed. A A Rahmianna, E Yusnawan, A Taufik, Sholihin, Suharsono, T Sundari and Hermanto (Malang) p. 603-614 [In Indonesian]

[17] Yulifianti R, Ginting E and Utomo J S 2016 *Proc. Int. Food Conf.* ed. I Epriliati, I Kusumawardani, A Ingani, Y Marsono, Sutriswati, E Otunola, P A Sopade, A Ristiarini and E Chuakeatirote (Surabaya) p. 269-275

[18] Soewarno T S 1990 *Fundamental of Food Quality Control and Standardization Food and Nutritional (Dasar-Dasar Pengawasan dan Standarisasi Mutu Pangan)* (Bogor: IPB Press) p 337 [In Indonesian]

[19] Walter W M Jr., Truong V D, Wiesenborn D P and Hamman D D 2000 *J. of Agriculture Food Chemistry* **48** 2937-2942

[20] Atkins P W 1994 *Physical Chemistry* 5th Edition (Oxford: Oxford University Press) p. 922-926

[21] AOAC 2005 *Official Methods of Analysis Association of Official Analytical Chemists* (Washington: Benjamin Franklin Station)

[22] National Standardization Agency 1996 Quality standard of sweetpotato chips SNI 01-4306-1996 (Jakarta: National Standardization Agency)

[23] Mirzaei HO, Karapanthios T, Garoumi H and Farhadpour F 2015 *MOJ Food process Technol* **1(1)** 17–19

[24] Ginting E, Rahayuningsih S A and Suprapto 2007 ILETRI Research Technical Report 2007 (No: K.5/ROPP/DIPA/2007) Malang 39 p [In Indonesian]

[25] Ginting E, Widodo Y, Rahayuningsih S A, and Jusuf M 2005 *Jurnal Penelitian Pertanian Tanaman Pangan* **24(1)** 9-18 [In Indonesian]