Tuber and Organoleptic Characteristics of Four Potato Varieties Grown Off-season in Sajang Village, Sembalun

I Nairfana¹, A Nikmatullah², M Sarjan³, Kisman²

¹Faculty of Agricultural Technology, Universitas Teknologi Sumbawa, Jalan Raya Olat Maras, Batu Alang, Sumbawa Indonesia
²Faculty of Agriculture, University of Mataram, Jalan Majapahit 62 Mataram, 83127, Indonesia
³Postgraduate Program, University of Mataram, Jalan Majapahit 62 Mataram, 83127, Indonesia

Email: ihlana.nairfana@uts.ac.id

Abstract: Quality of the tuber is an important factor determining utilization and economic values of the potato (Solanum tuberosum L.) plant. The acceptance of potato variety for industrial processing is determined by the dry matter, starch and reduced sugar contents as well as market acceptance of the products. These characteristics are influenced by the potato variety and cultivation season. This research aimed to evaluate the tuber and organoleptic properties of chips from four potato varieties grown during off-season, in Sajang Village of Sembalun District (at ca. 900 m above mean sea level). A plantation was undertaken at the end of rainy season in 2021, and comprised of four potato varieties, designated as McRusset, Ranger Russet, Chitra and Atlantic. After harvesting and stored at ambient temperature for 2 weeks, raw tubers were characterized for the dry matter, starch, and reduced sugar contents. The tubers were fried as french fries and chips, and sensory analysis were undertaken for likeliness in color, flavour, crispness and overall appearance. The different in properties of these four varieties and its industrial utilization is be presented and discussed in this paper.

1. Introduction

Potato (Solanum tuberosum L.) is an increasingly important commodity for Indonesia. Potato tuber contains carbohydrate and is rank as the fourth largest staple food after rice, wheat and barley. Potato tuber is also consumed as vegetable because of its nutritional content, especially vitamins and minerals. Every 100 g of potato tubers contains 77 kcal of energy, 19 g of carbohydrates, and 15 g of starch, 0.1 g of fat, 2 g of protein and 75 g of water [1].

Demand for potato commodities in Indonesia increased with rate of 13.95 percent per year from 2014 to 2018 [2]). The increase is due to many factors including an increase in population, a change in consumption pattern of the millenial and an increase utilization of potato for industry. On the other hand, the national potato production in the last 5 years has tended to remain constant, ranging from 1,200,000 - 1,300,000 tons in the 2015 - 2020 periods [2]. The production is dominated by potato variety suitable for cooked vegetables, and only limited farmers produced potato variety needed by industry (for chips, frenchfies and others). Therefore, to meet the demand, especially potato used for the industry (or called industrial potato), the Indonesian Governemnet allowed importation of 5,6 tonnes industrial potato, in form of processed potatoes, with value of US $ 20 billion [3].
Potato plants are generally cultivated at the end of the rainy season, because potato plant is sensitive to both excess and lack of water [4]. On the other hand, the industry needs continuous supply of the commodity, both in adequate quantity and quality. Therefore, it is necessary to develop cultivation of potato throughout the year, including during the rainy season. Season will affect both growth and quality of potato produced [5]. The response of potato plant to season and quality of tuber produced by the potato plants is influenced by the genetic character variety [5]. Currently, there are several varieties and clones of industrial potatoes such as the Atlantic variety, Chitra variety, Russet variety and Ranger Russet. Atlantic and Chitra potatoes are types of potatoes that have a white flesh color, often used as industrial processed ingredients. The Atlantic variety has a shelf life of about 100 days, comes from the United States and is high in starch and low in sugar. The Atlantic variety potato has long been cultivated in Sembalun but has not been cultivated in recent years due to difficulties in obtaining imported seeds from Australia, Canada or Scotland. Chitra potato variety comes from Australia, the flowering age starts from 40-45 days after planting and the harvest age is 100-110 days after planting and is suitable for planting in the dry season. In addition, there are several potential varieties of potato plants that can be planted in the rainy season such as the Mc Russet and Ranger Russet varieties [6]. To date, there is limited information available on the characteristics of industrial potato varieties produced in rainy season, and this research was undertaken to examine the characteristics of four potato tubers produced during off-season in Sembalun and evaluate the acceptance by consumers through sensory analysis.

2. Materials and method

2.1. Time, Place and Experimental Design

All four potato varieties were grown in Sajang Village, Sembalun, Lombok, West Nusa Tenggara from March-May 2021, that yielded 4 different varieties of industrial potatoes, namely Mc Russet, Ranger Russet, Chitra and Atlantic. The design used was Completely Randomized Blocks that was repeated 3 times. The chemical and organoleptic quality of four potato varieties was observed. Around 2.5-3 kg/potato variety is analysed for their chemical characteristics in The Analytical Laboratory, University of Mataram for wet to dry basis ratio (oven method), total solid content [7], specific gravity [7], starch content and sugar content by Luff Schoorl Method [8]. Wet and dry basis ratio, expressed as %, was determined by weighing the potato samples before and after drying in an oven. Specific gravity was measured by weighing clean tuber in both air and water by the method of [9]. Starch and sugar content were measured by adding Luff School Reactor.

To evaluate the different types of potato varieties to acceptability of potato french fries and chips to potential consumers, sensory analysis was performed by a panel of 40 members of semi-trained panellist. Each sample from different potato varieties was taken, washed, rinsed and cut into desired size (1.5 cm thick for french fries, and sliced 2-3 mm thickness for chips). The samples were then fried in cooking oil until for 3-4 minutes at 180°C [10]. Coded samples were presented to the panellists and scored for colour, flavour, crispness and overall acceptability on a 5-point Scoring scale. The panellist was then asked to describe each sample and choose which of the samples they prefer the most. This sensory evaluation was done in Food and Agroindustry Laboratory in Universitas Teknologi Sumbawa.

3. Results and discussion

3.1. Wet to Dry Basis Ratio

Figure 1 shows the wet and dry weight and Figure 2 shows the weight and dry basis ratio of four potato varieties used in this research. Different potato varieties gave non-significant differences in wet and dry basis ratio.
Total dry matter has the correlation to wet to dry basis ratio of the potatoes. The more dry weight of the potato means the more dry matter that the potato contains. The higher the dry matter, the better the results of the chips and also very efficient in the use of cooking oil. The yield of potato chips and french fries is directly related to the dry matter content of the raw materials used. Dry matter is related to specific gravity. From this research, Atlantic has the highest dry to wet basis (0.2396), this means it has more dry matter than other varieties. Even though Atlantic has the highest dry matter, the dry matter of other varieties is non-significantly different. In Indonesia, the Atlantic variety is in big demand by the business communities, especially for the snack of French fries and chips. According to the dry matter observed that are non-significantly different compared to Atlantic, these other varieties are potential for industrial used.

3.2. Solid Content and Specific Gravity
Potato tubers are consumed, cooked, or fried. Also, they are processed to produce chips, french fries, flakes, granules, and starch. The quality of potatoes in the entire production and supply chain is important, as it can affect the processing of the products. Solid content is an important parameter to establish quality for consumers and industrial use. Table 1 shows the solid content and specific gravity of four different potato varieties.

| Variety      | Solid Content (%) | Specific Gravity  |
|--------------|-------------------|-------------------|
| McRusset     | 21.4 +/- 7.15 b   | 1.083 +/- 0.02b   |
| Ranger Russet| 22.3 +/- 3.97 b   | 1.087 +/- 0.02b   |
| Chitra       | 23.9 +/- 3.16 ab  | 1.094 +/- 0.01a   |
| Atlantic     | 24.0 +/- 2.20 a   | 1.095 +/- 0.03a   |

Solid content affects the texture, yield, and fat content of the different processed products. Commercial industries prefer potatoes with higher solid content as it is significantly correlated
with specific gravity, and potatoes with higher specific gravity are suitable for baking, chipping, frying, and mashing. The amount of solid content can also influence the final color of chips, which has to be optimal for consumer satisfaction. The solid content result of four potato varieties were significant (P<0.05). The specific gravity of potatoes ranges from 1.083-1.095. The highest specific gravity value was Atlantic, followed by Chitra, Ranger Russet and Mc Russet. According to Indofood, the minimum specific gravity for industrial chips is 1.07. Therefore all the potato varieties observed meets the specific gravity criteria for potato industry quality.

The specific gravity of potato tubers is an important quality criterion for processing potatoes. It is used to estimate the solids or dry matter content of tubers, the higher the dry matter content the lower the water content and the higher the specific gravity. Specific gravity is the measure of choice for estimating dry matter and starch content and ultimately for determining the processing quality of potato varieties. The ideal french fries is light in colour, crisp on the outside, fluffy or mealy on the inside and has a minimum of oiliness. Similarly, the ideal potato crisp is light in colour and absorbs a minimum of oil during frying. High specific gravity potatoes are needed to produce such products. Lower specific gravity potatoes are more costly to process. More water must be fried out of lower specific gravity potatoes to meet minimum quality standards. More potatoes must be processed to produce the same volume of product and the longer fry time results in potatoes absorbing more fat.

According to [11] the specific gravity has a correlation with the solid material content, the higher the solid material content, the higher the specific gravity and the clone is good as raw material. The density of potato tubers can affect the oil content produced. The higher the specific gravity of potato tubers, the lower the oil content in the resulting chips [12] Thus, the density of potato tubers determines the quality of processing. The yield of potato chips and french fries is directly related to the dry matter content of the raw materials used. Dry matter is related to specific gravity. Specific gravity is also related to the texture of cooked tubers. Bulbs with low specific gravity (1.05) were associated with a soggy texture, while tubers with high specific gravity and high density (1.10) were associated with a starchy texture. So, the four potatoes tested had specific gravity in accordance with the minimum standards of the french fries and chips processing industry.

Starch and Sugar Content
Changes in the carbohydrate content and metabolism are primary influences affecting the final product quality of processed potatoes. The measurement of sucrose and reducing sugars will indicate the maturity, storability, and processability of the potatoes.

Table 2. Sucrose, Reducing Sugar and Starch Content of Four Potato Varieties

| Variety     | Sucrose (%) | Reducing Sugar (%) | Starch (%) |
|-------------|-------------|--------------------|------------|
| Mc Russet   | 0.27+ 0.009 c | 0.84+ 0.009 b      | 22.10+ 0.01b |
| Ranger Russet | 0.26+ 0.008 c | 1.28+ 0.008 a      | 28.87+ 0.02 a |
| Chitra      | 0.80+ 0.011 a | 0.40+ 0.011 c      | 29.83+ 0.03a |
| Atlantic    | 0.58+ 0.013 b | 1.04+ 0.013 a      | 22.91+ 0.01 b |

Upon harvest, the amount of sucrose should be low (less than 2.7 mg. of sucrose/g of tuber). Further, if the glucose is above 0.25 mg/g of tuber, the potato slices will fry too dark for acceptable quality. These products will become excessively dark if the reducing sugar content is
The sucrose, reducing sugar and starch content results of the ANOVA of four potato varieties were significant \( (P<0.05) \). The sucrose content of potatoes ranges from 0.26-0.80\%, reducing sugar ranges from 0.40-1.28\%, and the starch content ranges from 22.10-29.83\%. Asgar et al\[12\] stated that the amount of reducing sugars for potatoes that will be processed as french fries and chips should not exceed 1\%. Therefore, three of the four varieties grown in Sembalun during off-season observed in this study are suitable for french fries and chips industry. Sugar content that exceeds the specified limit causes caramelization of the fried products so that the resulting chips are brown. The occurrence of caramelization or brown color in potato chips is also influenced by environmental factors, at temperatures moist or irrigated soil produces better chips compared to land without irrigation \[13\].The criteria for processed potato as an industrial ingredient according to \[13\] must pay attention to several things such as the level of tuber damage, internal damage, glycoalkaloid content, nutritional value, enzymes that cause browning, and sugar content and dry weight. These characters are not only inherited genetically but also influenced by the growing environment and nutritional adequacy, especially calcium \[13\]. Meanwhile, for vegetable potatoes (table potatoes), what is important is the flavor character (aroma, taste, and texture).

### 3.3. Sensory Analysis

#### 3.3.1. Color

The average color value of potato chips ranges from 1.8-3.3, with a range of cream and yellow colors (as shown in Table 2). This is because the four types of potatoes are white tuber potatoes, so that when they are fried, they become French fries and the chips are creamish yellow and evenly distributed. Atlantic are more golden yellow in color than others and it is significantly different to other varieties. The color for these potato products correlates to the sugar content of the potatoes. Even though the level of sugar contributes to the color of potato products, but sugar content is not the only determining factor, because there are other variables that influence, namely technical culture, environment, and variety \[14\]. The color of potato fries and chips of a variety can also be influenced by location and season. The chemical composition of potato tubers is important in processing. When fried in oil, potato chips turn brown to a degree that corresponds to the sugar content. As a rule, potatoes containing more than 1\% reducing sugar by dry weight are considered unacceptable. To be suitable as a raw material with a low browning level, a common practice is to store the tubers for a certain period, so that the sugar content is low and the tubers do not sprout. Of the four potato varieties tested, all varieties were acceptable to the panelists in terms of color for both French fries and chips.

#### 3.3.2. Flavor

The average value of the taste scores ranged from 3.7 to 4.2, means the potato varieties had significant effect on the flavor of french fries and chips. panelist accept the flavor of all the potato varieties and described it as “good” and “very good”. The potatoes for this evaluation were served original without salt or another flavor enhancer. This score is highly subjective and appears to vary widely among panelists. The taste of potato chips is also affected by the variety. The special characteristics of potato tubers are due to their starch and sugar content. The higher sugar content in potato tubers causes a sweet taste. In the tubers there is also a high solanine content which causes a bad smell (bitter). According to Shelley (1985), flavor is produced from a combination of taste, aroma, and texture. Flavor precursors synthesized by plants are present in potato raw materials and contain mainly sugars, amino acids, RNA, and fats. During cooking, flavor precursors react to produce a Maillard reaction and sugar, fat, and RNA degradation products that contribute to flavor.
3.3.3. Crispness
The average crispness of french fries ranged from 3.5-3.8, while for chips ranges from 2.1-2.3. This means panelists accept the crispness of french fries, and described it as fairly soft and crunchy. But panelist gave a lower score for chips and described it as slightly soft and soggy. The characteristics of the french fries produced by this potato variety are soft textured inside and crispy outside, while the crispy texture of the chips will decrease when the chips become cold, this is probably due to less than optimal frying, lack of pre-treatment (soaking in various crunchy ingredients, non-uniform frying temperature and time, and lack of oil draining). It is recommended to fry the chips as an industrial raw material using a good fryer so that not too much oil is trapped in the chips and the crispness can be maintained longer. The crispness or texture of potato chips is influenced by the chemical composition of the tubers. Crispness was caused by differences in the content of starch and pectin, which affected the texture [15]. The size and amount of starch can also affect crispness [11]. Overall, the four varieties observed are suitable for industrial use.

| Variety       | Colored | Flavor | Crispness | Overall Appearance |
|---------------|---------|--------|-----------|-------------------|
| Mc Russet     | 1.8c    | 2.8c   | 3.5a      | 4.3a              |
| Ranger Russet | 2.5ab   | 3.4b   | 3.8a      | 4.2a              |
| Chitra        | 2.7b    | 4.1a   | 3.6a      | 3.9b              |
| Atlantic      | 3.3a    | 4.1a   | 3.6a      | 3.8b              |

Note: color: 1=cream, 2=creamish yellow, 3=yellow, 4=golden brown, 5=brown
flavor: 1=very poor, 2=poor, 3=fair, 4=good, 5=very good
crispness: 1=very soft and soggy, 2=slightly soft and soggy, 3=fairly soft and crunchy 4=crunchy, 5=very crunchy
overall appearance: 1=very poor, 2=poor, 3=fair, 4=good, 5=very good

| Variety       | Colored | Flavor | Crispness | Overall Appearance |
|---------------|---------|--------|-----------|-------------------|
| Mc Russet     | 2.2b    | 2.5c   | 2.1a      | 3.2b              |
| Ranger Russet | 2.3b    | 3.1b   | 2.2a      | 3.3b              |
| Chitra        | 2.2b    | 4.2a   | 2.1a      | 4.2a              |
| Atlantic      | 3.0a    | 4.0a   | 2.3a      | 4.4a              |

Note: color: 1=cream, 2=creamish yellow, 3=yellow, 4=golden brown, 5=brown
flavor: 1=very poor, 2=poor, 3=fair, 4=good, 5=very good
crispness: 1=very soft and soggy, 2=slightly soft and soggy, 3=fairly soft and crunchy 4=crunchy, 5=very crunchy
overall appearance: 1=very poor, 2=poor, 3=fair, 4=good, 5=very good

3.4. Overall Appearance
Raw potato tubers from all varieties were analyzed for their overall appearances that include size and shape. Size and shape are of particular importance in determining the suitability of a cultivar for potato processing. Large, round tubers are preferred for chips since their shape facilitates removal of the peel with minimal peel loss and the size provides chips which can be sized for the consumer. Chip industry may use medium to small potatoes for individual serving-size packages for control of product weights. French fry manufacturers prefer large potatoes but require that they be oblong to long in

| Variety       | Color | Flavor | Crispness | Overall Appearance |
|---------------|-------|--------|-----------|-------------------|
| Mc Russet     | 2.2b  | 2.5c   | 2.1a      | 3.2b              |
| Ranger Russet | 2.3b  | 3.1b   | 2.2a      | 3.3b              |
| Chitra        | 2.2b  | 4.2a   | 2.1a      | 4.2a              |
| Atlantic      | 3.0a  | 4.0a   | 2.3a      | 4.4a              |

Note: color: 1=cream, 2=creamish yellow, 3=yellow, 4=golden brown, 5=brown
flavor: 1=very poor, 2=poor, 3=fair, 4=good, 5=very good
crispness: 1=very soft and soggy, 2=slightly soft and soggy, 3=fairly soft and crunchy 4=crunchy, 5=very crunchy
overall appearance: 1=very poor, 2=poor, 3=fair, 4=good, 5=very good
shape to produce long fries with minimal losses. The average value of the appearance score of potato chips ranged from 3.2-44. According to panelists, Mc Russet and Ranger Russet are more suitable for french fries, while Chitra and Atlantic are more suitable for chips. Figure 5 shows the different size and shape of all potato varieties.

Figure 2. Overall Appearance of Potato

4. Conclusion
All four potato varieties tested is suitable as main ingredients for industrial scale potato products, such as french fries and chips. The higher the dry to wet ratio will yield on a higher solid content and specific gravity, which contributes to good chemical quality of the tubers. But those potatoes with highersolid content and specific gravity has higher sugar and starch content, that contributes to the color of the end products. The solid content, specific gravity, sugar dan starch content of all four potato varieties meets the minimal requirements for commercial industrial potato. The panelist acceptance for all the potato varieties ranges from creamish to golden yellow in color, slightly soft to crispy texture and good flavor. By analyzing its size and shape, Mc Russet and Ranger Russet are more suitable for french fries, while Chitra and Atlantic are more suitable for chips. The significant correlation among different quality attributes may be helpful in further research for economic significance of potato varieties.

5. Acknowledgement
The authors would like to express special thanks to PT. ClarexindoMakmur Sejahtera for funding this research, and also to research team and students from University of Mataram and UniversitasTeknologi Sumbawa for the great collaboration.
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