Sensory Evaluation of Cookies Made from Sago (*Metroxylon sagu*) and its Mixture with Taro (*Colocasia esculenta*) Starch

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Abstract: Sensorial properties of cookies made of sago (*Metroxylon sagu* Rottb.) and its mixture with taro (*Colocasia esculenta* L. Schott) starch were evaluated to develop new effective utilization of sago and taro starch, which obtained from the intercropping in Leyte, Philippines. Cookies were made from sago starch and taro starch with different composition: 0% (control), 5% and 10% of taro starch was used instead of sago starch, which were named cookie A, B, and C, respectively. Cookies of 100% sago starch with different diameters or thicknesses were prepared as D and E, respectively. Cookies characteristics were evaluated by appearance, sweetness, hardness, crispness, and comprehensive evaluation by the panelists recruited from the 10 university students of 20s. The score of appearance, sweetness, and comprehensive evaluation of cookie D was the highest, 7.4, 7.8, and 6.0, respectively. Although sugar content was same for all cookies, score of sweetness was different for each cookie and was the most effective for comprehensive evaluation of sensory evaluation. Since cookie D has a larger diameter, total amount of sugar became larger than other cookies. In addition, bearing resistance of cookie D was significantly lower than other cookies, so it was speculated that it was easy to crumble, spreads quickly in the mouth and was digested quickly. These were presumed to be the reason for the high sweetness score of cookie D. Our results suggested that intercropping of sago and taro is effective to produce taro starch, which will be potential materials to make several kinds of cookies.

Keywords: Cookie, Sago and taro starch, Sensory evaluation

Introduction

Sago palm (*Metroxylon sagu* Rottb.) with taro (*Colocasia esculenta* L. Schott) are familiar in tropical lowland of Southeast Asia. Sago palm is deduced to originate in the place of Maluku Islands to New Guinea (Ehara 2015). Sago starch consumption in the world lies between 200,000 to 300,000 tons per year and accounts for about 3% of the total world market which is dominated by corn, potato and tapioca starches (Bujang 2010, Acuña et al. 2013). Makinao-Santillan and Santillan (2017) evaluated the areas of confirmed sago palm stands (768.39 ha) in Visayas and Mindanao, Philippines. The amount of sago starch production in the Philippines is still unknown until now. Japan imports 20,000 tons per year of sago starch from Malaysia and Indonesia every year as dusting powder for noodles (Joetsu Starch Co., Ltd, 2012).

Taro (Colocasia species and their wild populations) led to initial suggestions that taro originated as a natural species in the region of northeast India to Southeast Asia and was domesticated there (Ahmed et al. 2020). Taro (cocoyam) production in the world was 10,541,914 tons per year in 2019 (FAOSTAT 2021). Nigeria, the top taro producing country, accounted for 32 % of the global taro supply. The Philippines produce 104,943 tons of taro per year in 2019. Kalamay gabi is a type of Filipino delicacy made of glutinous rice flour, taro and coconut milk. Taro starch granules were small with the mean diameter of about 2 μm (Imanaka, 2014) and their shapes were irregular diamond or uneven spherical surface (Shi et al. 2017). Furthermore, taro starch can be introduced in the pharmaceutical field because of the very small size of granules. We tried to do the intercropping of sago palm and taro in Pangasugan, Leyte, Philippines (Kimura et al. 2008) in order to get new delicacy using sago with taro starch. Alcantara et al. (2013) reported taro cookies and noodles using taro powder in order to provide the opportunities to promote and support the use of taro.

The objectives of this study were to make new cookies made from sago with taro starch, to propose the sensory evaluation of sago with taro starch cookies and to recommend the utilization of the intercropping products of sago palm and taro starch during the early stage of sago palm cultivation.

Materials and Methods

1. Sample collection and starch preparation

Sago trunks were collected from the sago and taro intercropping experimental field developed in 2005, Pangasugan, Baybay, Leyte, Philippines. Sago grated materials from the trunk pith was collected and squeezed by a netting cloth with tap water. Sago starch was air-dried after washing with tap water several times in Leyte and stored in a vinyl bag.

Meanwhile, taro cultivar (Iniito, Ito ini) (Pardales 1997, Onwueme 1999, Vasquez et al. 2020, Pasiona 2021) corms from the intercropping field in Pangasugan were washed to remove soil and hand-peeled and trimmed to remove the skin and defective parts. Taro slurry was treated by the wet cloth sieving after grazing by a grater and dispersed in 0.2 mol/L sodium chloride solution at the pH of 8.6 using sodium hydroxide solution. Finally, taro starch was collected from the middle portion of the suspension by centrifuge according to the method of Higashibara et al. (1975). The taro starch was steeped in 0.05 % sodium hydroxide for 2 hours and shaking for 2 minutes (Jane et al. 1992). Taro starch was separated from the residue. The shaking procedure was repeated three times. The crude starch was collected and centrifuged (800g, 30 minutes). Gummy materials on the top of the suspension solution were removed by gentle washing. The starch was re-suspended and centrifuged, and the impurity was removed from the top layer. The taro starch was air-dried and stored in a vinyl bag. All samples were sent to Japan to make cookies.

2. Granule morphology of sago and taro starch

Granule size, color and shape of starch granules were evaluated by a light-transmitting microscope (Meiji Techno MT5000). The size of starch granules was determined by measuring the diameters of 40 randomly selected granules from the micrographs. The color (hue, value and chroma) of the sago and taro starch cookies was determined by the color chart (Oyama and Takehara 2008) for randomly chosen triplicate batches.

3. X-ray diffraction

The X-ray diffraction pattern of sago and taro starches was obtained by an X-ray diffractometer (Rigaku Smart Lab). The starch samples were exposed to X-ray beam at 30 mA and 40 kV. Data were recorded over a diffraction angle (2θ) range of 5° to 40°, Cu Kα radiation, with step angle of 0.02°/ s.

4. Blending and production of cookies

Sago starch was substituted with different levels of taro starch: 0% (control), 5% and 10%. Five g of microwave-heated butter to 50g of sago and taro starch for the control cookie mixture was stirred in a blender for 1.5 min and added 10g of sugar. Mix manually them for 1.5 min. Then, added 1/3 of egg to the mixture A. The mixed powder of sago and taro starch passed through a sieve and the mixture powder (mixture B and C) were put to make dough. The dough samples were in vinyl bags and stretched to roll or flat and stock in a refrigerator for 60 min. Thereafter, drew it to cut with a knife to 12 mm in height and 25 mm in diameter or with a round molding cutter to 12 mm in height and 36 mm in diameter. The samples were baked in an electric toaster (Mitsubishi RG-GS1, Japan) at 180 ˚C for 17 min. The baked cookies were cooled down in the air and stocked in the desiccators to keep the moisture condition in vinyl bags for 2 days, named Cookie A to D. Cookie A to C, cutting with a knife, was 25 mm in diameter, and Cookie D, cutting out shape, was 36 mm in diameter.

5. Texture analysis of cookies

The diameter (long and short axis) and height in the center of cookies were measure by a caliper and the mean values of diameter and height from 20 specimens were obtained. Three replicates were used for moisture content determination of cookies by an oven drying desiccation at 105 °C for 24 hours. The texture analyzer (Push-Cone, DIK-5561, Daiki, Japan) was used to measure the maximum stress (bearing resistance) of cookies using the spring with 39.2 N / 40 mm (Fig. 1), although a hardening instrument by Romeo et al. (2010) was used to measure the distance and the mechanical force.

Cookies were laid in the palate container and the Push-Cone was pressed onto the samples with the slow measuring speed. Bearing resistance (BR: kPa) was calculated by the equation of

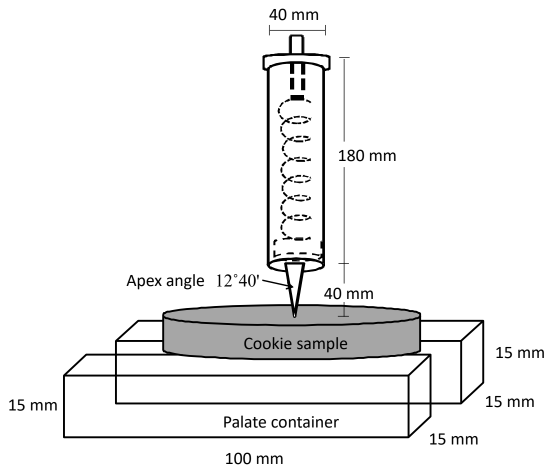

Fig 1. Bearing resistance measurement by a penetration resistance meter

$$r1 = 0.4 \times (40 - X) / 40 \quad (1)$$

where, r1: bottom radius at reading value of X mm

X: reading value (mm)

$$BR = ((T \times X) / 40) \times (1 / (\pi \times r1^2)) \times 10 \quad (2)$$

where, BR: bearing resistance (kPa)

T: strength of spring (N)

Finally from (1) and (2) equation to

$$BR = (2500 \times T \times X) / (\pi \times (40 - X)^2) \quad (3)$$

Crystalline components in cookie dough come to non-crystalline components, accompanied to hydration and swelling by heating. The non-crystalline components and melted sucrose provide crispy texture of cookies (Kawai 2016, 2017). The change in the bearing resistance of cookie depends on moisture content.

6. Sensory evaluation

Cookies characteristics were evaluated by appearance, sweetness, hardness, crispness and comprehensive evaluation by the panelists recruited from the 10 university students of 20s. The color of baked cookies is one of the important characteristics when the consumers picked up cookies. The appearance, sweetness, hardness and crispness were scored by the 10-point hedonic scale. Comprehensive evaluation was scored by the 9-point evaluation (“the most favorite”: 9 point; “always like eating”: 8 point; “eating when I get chance”: 7 point; “often eating because I like”: 6 point; “sometimes eating": 5 point; "eating when I can get": 4 point; "eating when I can not get anything": 3 point; "eating when I am forced"; 2 point; "not like eating", 1 point) (Kawasome et al. 1971). Next to Cookie D Cookie E was composed of 100% sago starch, which no monitor students knew.

The difference between cookies for each score was tested by Fisher's least significant difference method using Excel Statistics 2012 for Windows (SSRI Co., Ltd., Tokyo, Japan). The rank correlation was also examined for each evaluation item and bearing resistance. Factors affecting comprehensive evaluation were examined by stepwise multiple regression analysis using Excel Statistics 2012 for Windows. We chose appearance, sweetness, hardness, and crispness as explanatory variables. We used the forward selection method for variable selection and chose 2 as the threshold for the F-value.

Results

1. Properties of sago and taro starch

Sago starch indicated pale yellow (2.5Y 8/4) due to weak browning reaction based on the oxidation of phenol substances in the sago pith (Table 1). However, sago starch showed whitish color and its granules were round or oval shapes with diameter, ranging from 30 to 40 μm, which provided to the similar result of Nishiyama et al. (2016) that sago starch provided the mean value of 37.59 μm and the standard deviation of 11.0 μm (Fig. 2).

Taro starch granules were small, irregular and polygonal shapes (Shi et al. 2017, Setiarto et al. 2020). Particle size of taro starch granules varied from 1 to 3 μm under a light-transmitting microscope (Imanaka 2014). Taro starch granules had the irregular, polyhedral shape with a diameter of 1 to 3 μm (Fig. 3), which coincided with the results of the taro from Japan (Higashibara et al. 1975), India (Kani variety) (Sit et al. 2014a), Brazil (Andrade et al. 2017) and Turkey (Kahraman et al. 2020). However, it was smaller than those from Hawaii (Jane et al. 1992), India (Garu variety) (Sit et al. 2014a) and Sit et al. (2014b), and Indonesia (Wibisono et al. 2019, Setiarto et al. 2020). Taro starch showed light yellow orange (10YR8/3), which was in agreement with those reported by Sit et al. (2014a).

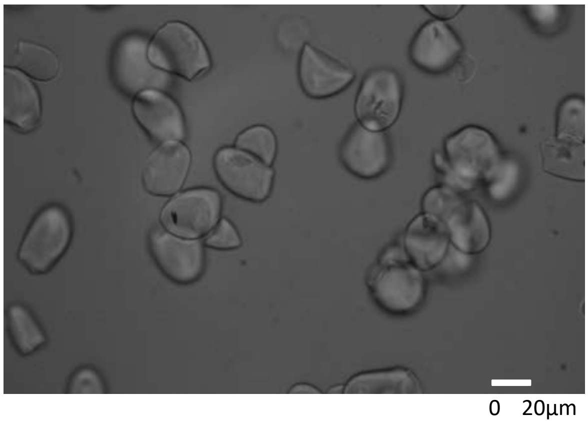

Fig 2. Sago starch grains under a light-transmitting microscope (x400)

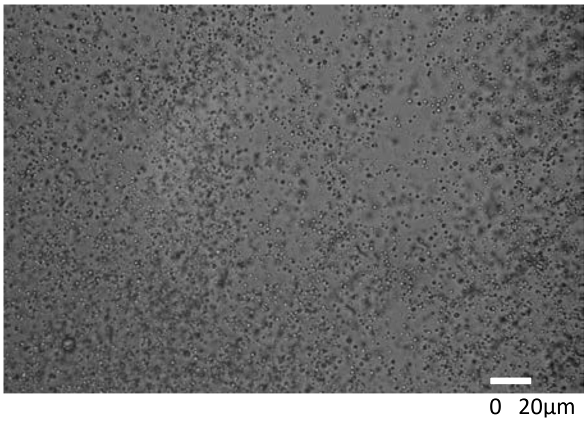

Fig 3. Taro starch grains under a light-transmitting microscope (x400)

Table 1. Morphology of sago and taro starch

	Color	Shape	Size*2
Sago starch	2.5Y8/4 Pale yellow	Temple bell	35-40
Taro starch	10YR8/3 Light yellow orange	Irregular spherical*1 Irregular diamond*1	1-2

*1: Shi et al. (2017), *2: µm.

2. X-ray diffraction analysis of sago and taro starch

The X-ray diffractograms of the sago and taro starch are shown in Fig. 4. The diffraction peaks at 2 θ

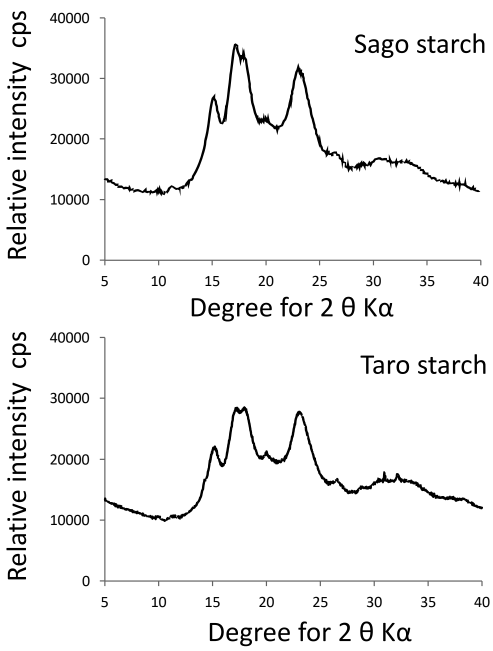

Fig 4. X-ray diffraction curves of sago and taro starch

Table 2. Characteristics of cookies

	A	B	C	D	E
Sago starch	100	95	90	100	100
Taro starch	0	5	10	0	0
Color	2.5Y5/3 -2.5Y4/3	5Y5/6 -7.5YR5/3	2.5Y7/3 -7.5YR5/4	2.5Y7/4 -10YR7/4	7.5YR6/1 -10YR7/4
Moisture*1	5.5	5.6	5.6	5.5	5.8
Diameter*2					
a	21.8 ± 2.8	24.4 ± 1.5	24.0 ± 1.6	37.3 ± 0.6	26.2 ± 1.2
b	17.2 ± 1.3	20.0 ± 0.9	22.8 ± 0.8	36.6 ± 0.7	20.6 ± 0.7
Height*2	11.5 ± 1.0	12.4 ± 1.6	10.8 ± 1.9	11.6 ± 0.4	13.6 ± 0.7
Bearing Resistance*3	24.8 ± 6.8	22.7 ± 3.4	26.7 ± 5.5	10.0 ± 2.2	25.3 ± 4.6

a: the longest diameter, b: the shortest diameter.
*1: %, *2: mm, *3: kPa.

are clearly exhibited at 5.6 (shoulder peak), 17, 18 and 23 degree for sago starch and 17, 18 and 23 degree for taro starch, respectively. The results of sago and taro starch exhibited a C type and A type X-ray diffraction pattern, which are comparable with the sago research of Nishiyama et al. (2016) and Okazaki (2018), and the taro research of Jane et al. (1992), Sit et al. (2014a, b), Andrade et al. (2017) and Kahraman et al. (2020).

3. Characteristics of cookies

The size of cookie ranged from 22 to 26 mm in diameter and from 11 to 15 mm in height for cutting roll with a knife and varied from 36 to 38 mm in diameter and 11 to 12 mm in height for cookie D and 20 to 28 mm in diameter and 12 to 14 mm in height for Cookie E (Table 2).

The color of the cookies evaluated (Table 2) was from yellowish brown (2.5Y5/3) to olive brown (2.5Y4/3), of which color development during baking was due to the chemical reaction between reducing sugars and amino acids in flours (Alflen et al., 2016). The consumers feel that the color of baked cookies is an important parameter for the initial acceptability. The cookies made from sago and taro starch provided light color (light yellow: 2.5Y7/3 to dull yellow: 7.5YR5/4) for the 100% sago starch cookie and dull brown (7.5YR5/3) to bright reddish (5YR5/6) for the 95 and 90% sago starch cookie. Moisture content of all cookie samples, related to the maximum strength (Wada and Higo, 2007), ranged from 5.5 to 5.8 % with the mean value of 5.6 % and the standard deviation of 0.1.

Bearing resistance values of cookies in Table 2 ranged from 10.0 to 26.7 kPa with large standard deviation, varying from 2.2 to 6.8 kPa. Bearing resistance of cookie D was significantly lower than other cookies (Fig. 5). These values of bearing resistance were remarkably lower than the breaking stress values (271 to 405 kPa) of cookies (Wada 1988) and the maximum hardening values (1120 to 1150 kPa) of cookies with low gelatinization characteristics reported by Wada and Higo (2007). The addition of different percentages of taro starch

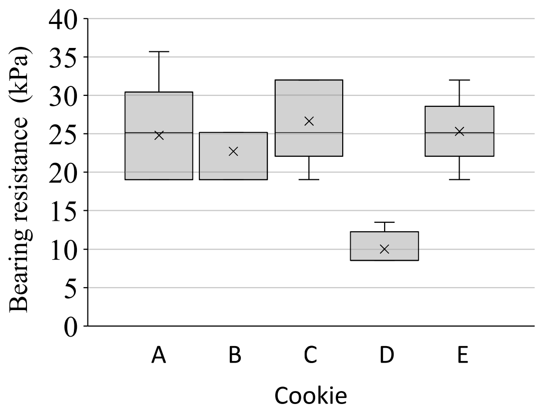

Fig 5. Box plot of bearing resistance

provided slightly different bearing resistance of cookies. Small amount (up to 10%) of taro starch brought the cracking in the center portion of cookie and low bearing resistance. However, there was not clear effect of taro starch addition to sago starch cookie dough on the bearing resistance of cookies.

4. Sensory evaluation

Sensory evaluation was carried out the cookies made of sago flour mixed with different levels of taro flour: 0% (Cookie A), 5% (Cookie B) and 10% (Cookie C). Cookies showed significant difference in hardness and crispness. Cookie C had a higher texture score than Cookie A and B.

The score ranged from 6.2 to 7.4 (mean: 6.6) for appearance, 4.3 to 7.8 (mean: 5.6) for sweetness, 4.6 to 6.6 (mean: 5.9) for hardness, 2.3 to 4.8 (mean: 4.1) for crispness and 4.2 to 6.0 (mean: 4.8) for comprehensive evaluation. The result of the comprehensive evaluation of baked cookies consequently presented better effect of taro starch mixing on sensory attributes. The score of appearance, sweetness, and comprehensive evaluation of cookie D was the highest, 7.4, 7.8, and 6.0, respectively (Fig. 6). Although no significant difference was found in appearance, sweetness and comprehensive evaluation of cookie D was significantly higher than other cookies. The score of hardness, crispness of cookie C was the highest, 6.6 and 4.8. Hardness and crispness of cookie D were significantly less than those of cookie C.

Table 3. Matrix of correlation coefficient between each score

	App	Swe	Har	Cri	Bea	Moi
Com	0.986**	0.976**	-0.931*	-0.850$^{\#}$	-0.937*	-0.178
App		0.996**	-0.908*	-0.825$^{\#}$	-0.899*	-0.102
Swe			-0.873$^{\#}$	-0.772	-0.861$^{\#}$	-0.0117
Har				0.974**	0.992**	0.424
Cri					0.973**	0.601
Bea						0.474

Com: Comprehensive, App: Appearance, Swe: Sweetness, Har: Hardness, Cri: Crispness, Bea: Bearing resistance, Moi: Moisture.
**: $p < 0.01$, *: $p < 0.05$, $^{\#}$: $p < 0.1$.

Table 4. Factors that influenced the comprehensive score of each cookie

	Standardized partial regression				Coefficient†
	App	Swe	Har	Cri	
Cookie A		0.798			0.59**
Cookie B		0.772		0.342	0.65*
Cookie C		0.619			0.31$^{\#}$
Cookie D				0.668	0.37*
Cookie E		0.916		0.431	0.74**

Com: Comprehensive, App: Appearance, Swe: Sweetness, Har: Hardness, Cri: Crispness.
†: Adjusted coefficient of determination.
**: $p < 0.01$, *: $p < 0.05$, $^{\#}$: $p < 0.1$.

Comprehensive evaluation showed a significant positive correlation with appearance and sweetness, and a significant negative correlation between crispness and bearing resistance. (Table 3). Standardized partial regression coefficient of sweetness was the highest except cookie D (Table 4), which score of sweetness varied from 7 to 10. Crispness was also chosen as a factor that influenced comprehensive evaluation including cookie D. Concerning cookie D, score of comprehensive evaluation was significantly correlated with score of crispness ($p < 0.05$). This crispness was significantly correlated with bearing resistance (Table 3).

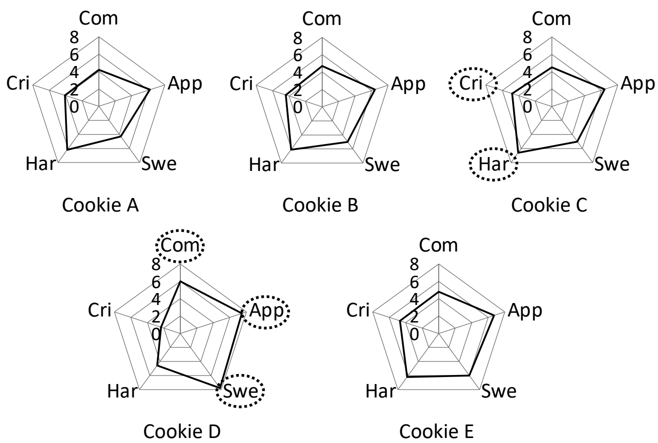

Fig 6. Sensory evaluation of cookies
Com: Comprehensive, App: Appearance, Swe: Sweetness,
Har: Hardness, Cri: Crispness.

Discussion

1. Biscuit, cookie and cracker of sago starch

The export of biscuits amounted to 881 ton and 1 billion yen and the import of biscuits were 27,828 ton and 11 billion yen in 2020 from the trade statistics of Japan (Ministry of Finance, Japan 2023).

The word "bis" of biscuit means "twice baked" from the Latin. In United Kingdom, Australia, Ireland and New Zealand biscuit means a small, flat, baked good which is either hard and crisp or else. However, biscuit in North America is a small, usually soft and flaky bread, generally made with baking soda, which is similar in texture to a scone, but which is usually not sweet.

Whereas cookie means a small, flat, baked good, which is either crisp or soft but firm in North America. In United Kingdom cookie is a sweet baked good which usually has chocolate chips, fruit, nuts etc, baked into it. Therefore, a cookie is often a little chunkier, softer and moisture than a biscuit. Cookies are great for incorporating whole and chopped or chopped ingredients like nuts, chocolate chips, sometimes, caramel chunks, and raisins. Federation of Fair Trade Conferences in Japan, established in 1984, defined a cookie as a good obtaining more than 40 % of the combined amount of sugars and edible fat (Fair Trade Commission 1971). National Biscuit Association in Japan decided to use the definition of cookie by Federation of Fair Conferences, Japan.

Sago cracker (Tebaloi) is famous and popular in Sarawak, Malaysia. Cracker is a dry, thin, crispy baked bread (usually salty or savoury, but sometimes sweet, as in the case of graham crackers and animal crackers) in UK, Australia, Ireland and New Zealand. However, in North America cracker is a short piece of twisted string tied to the end of a whip that creates the distinctive sound when the whip is thrown or cracked.

In this study sago and taro starch cookies were used for the evaluation even though they contained less than 40 % of sugars and fat which were under the definition limit of Federation of Fair Trade Conferences in Japan. It is thought that the intercropping increases sago palm and taro production and stabilizes the farmer's income in Leyte.

2. Sensory evaluation of sago and taro starch cookies

Sago and taro starch cookies were carried out by the sensory evaluation of 20s university students. The use of taro starch improves the crispness, and even with a thickness of 12 mm, it is rated higher than Cookie D, just like the 14 mm Cookie E (Table 2, Fig. 6). It was speculated that small size and irregular and polygonal shape (Fig. 3, Shi et al. 2017, Setiarto et al. 2020) of taro starch contributed to the improvement of crispness. However, Cookie C mixed with 10% was rated highest for hardness, but the comprehensive evaluation was the lowest. Since crispness is a factor that affects the comprehensive evaluation (Table 4), it was inferred that the use of taro starch might be appropriate at about 5%. Concerning this point, further evaluation is necessary, such as making cookies with a large diameter such as Cookie D, which rated highly.

Cookie D has a thickness of 12 mm and is the same as Cookies A to C, but it has a larger diameter (Table 2), so even if the sugar content was the same, total amount was larger. Concerning cookie D, score of comprehensive evaluation was significantly correlated with score of crispness ($p < 0.05$). This crispness was significantly correlated with bearing resistance (Table 3). This bearing resistance of Cookie D was significantly lower than other cookies (Table 2, Fig. 5), so it was speculated that it was easy to crumble, spreads quickly in the mouth and was digested quickly. These were presumed to be the reason for the high sweetness score of cookie D.

3. Recommendation of intercropping of sago palm and taro

Taro corm production followed by taro starch production in sago palm field at the early stage of sago palm is important in newly developing land. Both taro and sago palm require periodic wet condition. The good point of intercropping at the early stage assures that slow growth of sago palm can provide full sunshine to taro to bring satisfactory corm production.

Conclusions

Sago starch cookies containing up to 10% of taro starch were acceptable for younger generation from the result of sensory evaluation. Sago and taro starch cookies received a score of 6 as "I like them and eat them often" in comprehensive evaluation. Further improvement of cookie making of sago and taro starch in Leyte help the production of sago palm and taro. It is concluded that at the early growth stage of sago palm intercropping of sago and taro is effective to produce taro corm production and taro starch, which will be potential materials to make several kinds of cookies.

References

Acuña, T. R., S. B. Concepcion, A. J. A. Fedillaga, N. L. Laorden, and B. M. Ramoneda 2013 Issues and challenges in the establishment of sago plantation in the Philippines 2013 Biennial Convention, 1-6, Philippine Agricultural Economics & Development Association.

Ahmed, I., P. J. Lockhart, E. M. G. Agoo, K. W. Naing, D. V. Nguyen, D. K. Medhi and P. J. Matthews 2020 Evolutionary origins of taro (Colocasia esculenta) in Southeast Asia. Ecology and Evolution, 2020, 1-14.

Alcantara, R. M., W. A. Hurtada and E. I. Dizon 2013 The nutritional value and phytochemical components of taro [*Colocasia esculenta* (L.) Schott] powder and its selected processed foods. J. Nutr. Food Sci. 3: 207. doi:10.4172/2155-9600.1000207

Alflen, T. A., E. Quast, L. C. Bertan and E. M. Bainy 2016 Partial substitution of wheat flour with taro (Colocasia esculenta) flour on cookie quality. RECEN, 18: 202-212.

Andrade, L. A., N. A. Barbosa and J. Pereira 2017 Extraction and properties of starches from the non-traditional vegetables Yam and Taro. Polímeros 27: 151-157.

Bujang, K. 2010 Production and processing of sago: A food and fuel alternative. International Seminar on Sago & Spices for Food Security, Ambon, Indonesia, July 28-29, 2010, 1-6.

Ehara, H., 2015 Geographical origin, dispersal and distribution of the true sago palm. In: The Sago Palm: The Food and Environmental Challenges of the 21st Century (The Society of Sago Palm Studies ed.). Kyoto University Press (Kyoto) and Trans Pacific Press (Melbourne), 17-22.

Fair Trade Commission 1971 Fair competition rules of display of biscuits and its enforcement rules.

FAOSTAT 2021 Taro (cocoyam) in world + (Total), Average 1994-2019. http://www.fao.org/faostat/en/#data/QC/visualize (accessed on 1st Oct 2021)

Higashibara, M., K. Umeki and T. Yamamoto 1975 Isolation and some properties of taro root starch. Journal of Applied Glycoscience 22: 61-65 (in Japanese).

Imanaka, K. 2014 Morphological observation of starch particles in various foods and methodology of preparing samples for optical microscopes. Bulletin of Hiroshima Bunka Gaguken Two-Year College 47: 1-20 (in Japanese).

Jane, J., L. Shen, J., Chen, S. Lim, T. Kasemsuwan and W. K. Nip 1992 Physical and chemical studies of taro starches and flours. Cereal Chemistry 69: 528-535.

Joetsu Starch Co., Ltd 2012 Basic information of dusting powder, March 9, 2012, Agriculture and Livestock Industries Corporation (in Japanese) https://www.alic.go.jp/joho-d/joho08_000147.html (accessed on 1st Oct 2021)

Kahraman, B., M. Aricj and O. S. Toker 2020 Investigation of the properties of starch obtained from taro (Colocasia esculenta L. Schott) grown in Mersin, Turkey. Sigma J Eng Nat Sci 38: 875-887.

Kawai, K. 2016 Effect of moisture on changing in physical properties of food, Quality control of starchy foods. Kagaku to Seibutsu (Chemistry and Biology) 54: 540-542.

Kawai, K. 2017 thermal analysis for quality evaluation and control of food. The Japan Society of Calorimetry and Thermal Analysis 44: 146-149.

Kawasome, S., T. Ishima and S. Yoshikawa 1971 Effect of proportion of basic ingredients on the taste of cookies. Journal of Home Economics of Japan 22: 41-47 (in Japanese).

Kimura, S. D., S. Matsumura, S. B. Lina, M. Igura, M. Okazaki, M. A. Quevedo and A. B. Loreto 2008 Influence of slow-release fertilizers on sago palm growth in the early growth stage in a sago-taro Intercropping field. Sago Palm 16:1-9.

Makinao-Santillan, M. and J. R. Santillan 2017 Mapping suitable areas for mass propagation of sago palms in the Philippines. Mapping Sago 2017, University of the Philippines Mindanao, Davao Catholic Herald, 111-138.

Ministry of Finance, Japan 2023 https://www.biscuit.or.jp/summary/data/Import_Export_data.pdf (accessed on 3rd June 2023)

Nishiyama S., M. Okazaki, N. Katsumi, Y. Honda and M. Tsujimoto 2016 Surface charge on sago starch granules. Sago Palm 23: 77–83.

Okazaki, M. 2018 The structure and characteristics of sago starch. In: Sago Palm (Ehara. H., Y. Toyoda and D. V. Jonshon ed.). Springer, 247-259.

Onwueme, I. 1999 Taro cultivation in Asia and Pacific, RAP Publication, 1999/16, 1-50, FAO, Reginal Office for Asia and The Pacific, Bangkok, Thailand.

Oyama, M. and H. Takehara 2008 Revised Standard Soil Color Charts, Fujihira Kogyo Ltd.

Pardales, J. R. Jr. 1997 Ethnobotanical survey of edible aroids in the Philippines: II. Selection and conservation of and threats to genetic resources. Philipp J Crop Sci 22: 8-13.

Pasiona, L. C. 2021 Morphological characterization of taro (*Colocasia esculenta*) cultivars in the Bicol region, Philippines. Agrilkultara CRI Journal 1: 1-13 (ISSN: 2782-8816).

Romeo F.V., S. De Luca, A. Piscopo, V. Santisi and M. Poiana 2010 Shelf-life of Almond Pastry Cookies with Different Types of Packaging and Levels of Temperature. Food Sci Technol Int 16: 233-240.

Setiarto, R. H. B., H. D. Kusumaningrum, B. S. I. Jenie, T. Khusniati, N. Widhyastuti and I. Ramadhani, 2020 Microstructure and physicochemical characteristics of modified taro starch after annealing, autoclaving-cooling and heat moisture treatment. Food Res 4: 1226-1233.

Shi, A., G-X. Qu, H-X. Xu and Z-F. Li 2017 Study on physicochemical properties and microstructure of taro starch in Taizhou. Int J Environ Agric Res 3: 90-96.

Sit, N., S. Misra, D. Baruah, I. S. Badwaik, and S. C. Deka 2014a Physicochemical properties of taro and maize starch and their effect on texture, colour and sensory quality of tomato ketchup Starch/Stärke 66: 294-302.

Sit, N., S. Misra and S. C. Deka 2014b Characterization of physicochemical, functional, textural and color properties of starches from two different varieties of taro and their comparison to potato and rice starches. Food Sci Technol Res 20: 357-365.

Vasquez, E. A., P. D. Contero and D. O. Ferraren 2020 Free radical scavenging activity of taro (*Colocasia esculenta* (L.) Schott) varieties with varying flesh color. Ann Trop Res 42: 23-32.

Wada, Y. 1988 Cookies. Science of Cookery, 21 (4): 257-261 (in Japanese).

Wada, Y. and A. Higo 2007 Effect of moisture and temperature on the textural properties of commercial confectionery. Nippon Shokuhin Kagaku Kaishi 54: 253-260 (in Japanese).

Wibisono, Y., U. Ubaidillah and L. C. Hawa 2019 Microstructure changes of taro (Colocasia esculenta L. Schott) chips and grains during drying. IOP Conference Series: Earth and Environmental Science 230: 1-6.