Sriwijaya Journal of Environment
Article
ojs.pps.unsri.ac.id

Physical Characteristics of Purple Sweet Potato-Modified Starch and Rice Flour Combination for Instant Weaning Food

Ira Gusti Riani*, Aldilla Sari Utami, Marta Tika Handayani, Eka Nurriza Khairunnisa

Food Technology, Politeknik Negeri Sriwijaya, Palembang, Indonesia
**Corresponding author: e-mail address: ira.gusti.riani@polsri.ac.id*

Received	Received in revised form	Accepted	Available online
03 May 2023	03 May 2024	06 May 2024	19 May 2024

Abstract: Purple sweet potato is a source of carbohydrates that can be used as a substitute for rice. Besides its sweet taste, it has a striking color that comes from anthocyanins. Purple sweet potato is a rich potential local food, it was cheaper. Purple sweet potato powder is a practice innovation. It was a semi-finished product that was instant and easy to use. One of its uses is for weaning food. It must be high nutrition, hygienic and safe. Physical modification is considered safer because it does not use chemicals and leaves no chemical residue. This research aimed to study the physical characteristics of a combination of purple sweet potato-modified starch and rice flour on the instant weaning food. This study used a Factorial Completely Randomized Design with 6 treatments (a combination of purple sweet potato starch and rice flour). The parameters observed were viscosity, bulk density, time rehydration, and water absorption. The best treatment was F5 (100% modified starch and 0% rice flour) with 0.50 g/mL bulk density, 135.40% water absorbtion, 136.67 dPas and 31.70 s rehydration time.
Keywords: purple sweet potatoes starch, modified, ultrasound, weaning food, rice flour

1. Introduction

Tubers are one of the preferred sources of carbohydrates as a substitute for rice. Not only consists of one type, but tubers also consist of several types. Generally, tubers have starch such as carbohydrates that can be substituted for rice. The availability of tubers is relatively large. It has a lower price and is easy to cultivate. Tuber's potential as a raw material for food diversification. Purple sweet potato is one of the local tubers from Indonesia. It has a sweet taste. It can save sugar up to 20% [1]. It caused purple sweet potatoes to have high carbohydrate content. Purple sweet potato starch has 38,98% of amylose. It is higher than cassava starch [2]. Purple sweet potato has striking colour because of anthocyanin. Anthocyanin content was 11,051 mg/100 g. Purple sweet potato has the highest anthocyanin of all types of tubers. The advantages of anthocyanin as an antioxidant [3].

Purple sweet potato can be used as a raw material for processed products and semi-finished products. Semi-finished product is considered more practical to be used in further processing such as flour or starch. Purple sweet potato flour can be used in making cakes, noodles, or bread. However, native starch often encounters processing problems because it has instability in high temperatures, needs a long time to process, is too sticky, and is not stabilized [4].

Weaning food is an instant food that not require a long process. Serving weaning food is simply, just brewed using warm water. Nowadays, purple sweet potato is a good raw material for weaning food because it is high in carbohydrates. Weaning food-based purple sweet potato can be modified to increase its specific properties. The advantage was shorter serving time even without using warm water. Weaning food must be high nutrition, easy to serve and digest, hygienic, and safe. Instant weaning food is expected to be able to supply baby nutrition without milk. Physical modification of starch is considered safer because it uses no chemical additives and leaves no residue. However, it is easier and safer. The purpose of a starch modification is to change the physicochemical properties of native starch by breaking the structure of the molecule and rearranging it for a better structure [5].

The Ultrasound method is one of the physically modified starchs that can be used. Ultrasonication causes the starch granule surface to become porous and change micropores starch [6]. Microporous make water penetrate easier so more suitable for instant food [7]. The microporous structure affects the solubility index and water absorption index of instant food. Sweet purple potato starch is one of the local potentials that can increase the value of tuber flour as a main ingredient or substitute for food products. Ultrasound method can be optional in terms of physical modification to improve native properties of starch so can be applied to instant weaning food. This research aimed to study the physical characteristics of a combination of purple sweet potato-modified starch and rice flour on the instant weaning food.

2. Material and Methods

2.1. Materials

The sample in this study was sweet potato purple (*Ipomoea batatas* L.) obtained from Palembang, South Sumatera.

2.2. Methods

2.2.1. Sample collection and preparation

The preparation based on research [8] steps of Purple sweet potato starch preparation are:

a. Fresh tubers were washed, peeled, and were cut into small pieces.
b. Then Fresh tubers dipped in water. It's containing 10% salt for 12 hours with 1:1 (w/v) of water.
c. The sample was then milled in a blender at high speeds containing 1:1 (w/v) of tap water for 2 minutes.
d. The sample was filtered through a gauze cloth and the suspension was kept overnight for the settling of starch.
e. The supernatant was decanted, and the settled residue was further purified with repeated suspension in tap water (1:4 v/v) for 12 hours.
f. The purified starch was dried at 50°C for 6 hours.
g. Starch sieved through 80 mesh and sealed with plastic packaging.

2.2.2. Ultrasound purple sweet potato starch preparation

The ultrasound treatment based on research [8] steps of ultrasound treatment are Ultrasound treatment using a bath ultrasonic (Elmasonic 60 H) at 37 kHz frequency.

a. The aqueous starch suspension was treated with ultrasound during different solid-liquid ratios (1:1), sonication time for 15 minutes and sonication temperature at 30° using a Beaker glass 250 mL.
b. The starch was dried at 50°C for 6 hours in the oven (moisture content of 9- 10%).
c. The starch was sieved through 80 mesh and then stored at 4°C.

2.3. Experimentals variable and analytical procedures

This research used a Non Factorial Completely Randomized Design with six treatments. All treatments were replicated three times. The factors were the formulation of ultrasound-modified starch and rice flour. The formulation were:

F0 = 0% ultrasound modified starch: 100% rice flour
F1 = 20% ultrasound modified starch: 80% rice flour
F2 = 40% ultrasound modified starch: 60% rice flour
F3 = 60% ultrasound modified starch: 40% rice flour
F4 = 80% ultrasound modified starch: 20% rice flour
F5 = 100% ultrasound modified starch: 0% rice flour

2.3.1. Bulk Density

Bulk density was determined using the method as follows [9]:

a. The sample was filled into a 250 mL
b. The sample was tapped several times gently
c. The sample was weighed and the results for bulk density were reported as g/mL.

2.3.2. Viscosity

Apparent Viscosity of flour dispersions was determined using VT-4 as follows [10]:

a. The sample suspension was weighed about 10% in a 250-mL Beaker glass.
b. Sample was measured using a spindle at a shear rate of 100 rpm at 23 ± 1ºC.
c. The readings were recorded after 30 seconds of shearing time and results are reported in dPas.

2.3.3. Water absorption index (WAI)

Water absorption index (WAI was determined method as followed [11]

a. The sample was determined by weighing 5 g into pre-weighed 50 mL centrifuge tubes and then distilled water (25 mL) was added to each tube.
b. The tubes were vigorously shaken for 5 seconds to suspend the flour.
c. The suspension was allowed to solvate and swell for 20 minutes.
d. The samples were centrifuged at 1000 rpm for 15 minutes after which the supernatant was decanted.
e. And pellet was drained by touching with an adsorbent paper towel.
f. The water absorption index was determined as the difference between the weight of the drained tube and the weight of the original empty tube/weight of the dry sample.

2.3.4. Redrations time

Rehydration time was determined method as follows [12]

1. The sample was weighed about 50 grams into 150 mL at 60ºC
2. The readings were recorded the time until weaning food was ready to be served when it had dissolved completely. The results are reported in the second.

2.4. Data Analysis

Analysis of variance (ANOVA) was performed to determine the significant effect of the independent variables on the response variables. The treatments and their interactions were compared at $p<0.05$ level using the level significant difference method.

3. Results and Discussion

3.1 Bulk Density

Bulk density determined particle space in a certain volume, higher bulk density indicated the product had more concise and easier packing. bulk density affected product has more compact (nonvoluminous) [13]. The interaction between the formulation of purple sweet potato starch and rice starch has a significant effect on bulk density. F0 formulation (0% ultrasound-modified starch: 100% rice flour) has a higher bulk density than other formulations.

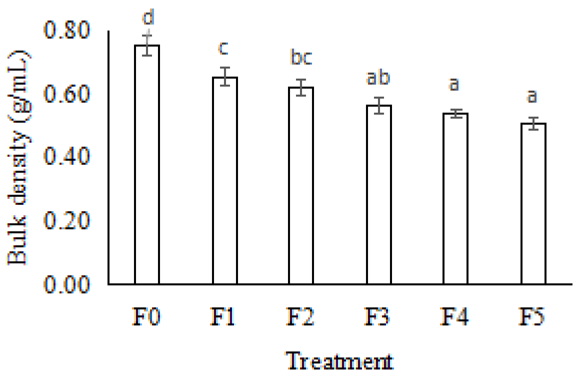

Figure 1. Bulk density graphic of formulation purple sweet potato starch and rice starch

The figure showed that the addition of rice flour concentration increased the bulk density of weaning food. Higher addition of ultrasound-modified starch will be reduced the bulk density of weaning food. Bulk density determines particle space in a certain volume. The ultrasound-modified starch granules are more porous and lighter. The ultrasound method caused the starch granules to become looser, forming cavities so the granules to become more porous. The power of the ultrasound method caused cavitation between starch polymers. The cavitation bubble diffused out of the liquid and reacted due to the polymer molecule.

So it disrupted the polymer chain and particle size became smaller [14]. Bulk density for instant food has generally between 0.3 to 0.8 g/mL, but bulk density for weaning food is 0.3 to 0.5 g/mL [15]. The higher bulk density caused a longer feeling of satiety for the baby however, it took a larger required pack [16]. This is not expected for babies because babies must be given food intake more often to fix their nutrition. Instant food that has a smaller bulk density will be lightweight and require a large space causes it is more porous. Smaller bulk density indicated the ability of food ingredients to absorb large amounts of water. The water absorption due to the pore structure present in the material so that the product became lighter. The pores created due to the ultrasonication treatment support faster water absorption so need to shorten the time for served during rehydration [17]. The pores formed allow the material to absorb water faster. Weaning food is expected to have good water absorption with a short rehydration time.

3.2. Viscosity

Viscosity indicated the friction of size in a fluid. The greater the viscosity of a food ingredient, it would be more difficult to flow [18]. The viscosity of the formulation of purple sweet potato starch and rice starch was 136.67 dPas to 231.67 dPas. Viscosity for formulation of sweet purple potato starch and rice flour starch can be seen in Figure 2.

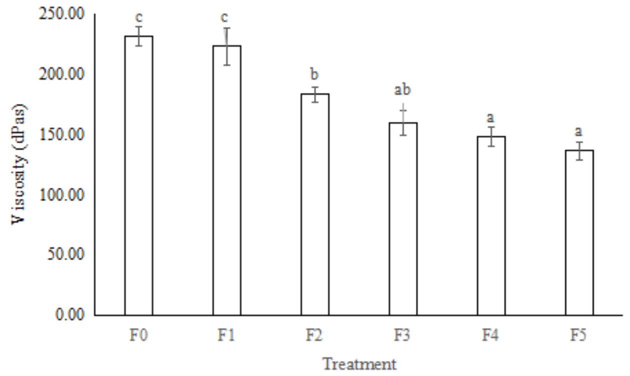

Figure 2. Viscosity graphic of formulation purple sweet potato starch and rice starch

The highest viscosity was found in F0 (0% ultrasound-modified starch : 100% rice flour). The interaction between the formulation of purple sweet potato starch and rice starch has a significant effect on viscosity. However, F4, dan F5 formulations did not show a significant effect. Ultrasound treatment results in more amylose being formed. F5 treatment (100% ultrasound-modified starch: 0% rice flour) had more amylose. Amylose content easily absorbs water, but easily also untied. This is because amylose has straight chains (1,4 glycosidic_). F0 treatment (0% ultrasound-modified starch: 100% rice flour) had more amylopectin, it come from rice flour. Amylopectin has branched chains (1,6 glycosidic) so it traps water more easily, makes the dough stickier, and causes high viscosity.

The result showed the addition of rice flour increases weaning food viscosity. Rice flour helps as a binder, and thickener and makes the dough more elastic and thicker [19]. Viscosity is influenced by the starch content and constituent materials. Starch suspension more when heated and gelatinization occurs. However, drying process repeatedly made a porous surface. Starch granules are heated at high temperatures so the affected suspension of starch granules is thicked, thus, the viscosity will be increased [20]. Moreover, protein content affected the solid suspension of weaning food too. Protein bond water more stably causes it has more amino acids compounds [21].

The best viscosity for weaning food was 100 to 300 dPa causes it is not too thick and considered with soup generally [22]. The research showed that all treatment was suitable for the viscosity of weaning food, there were 136.67 dPas to 231.67 dPas.

3.3. Water Absorbtion Index

The water absorption index was the ability to absorb water of material per gram. The greater water absorption index indicates substance soluble easily which makes it faster during the brewing process [23]. Figure 3 shows that the additional ultrasound-modified starch will be increase the absorption of weaning food.

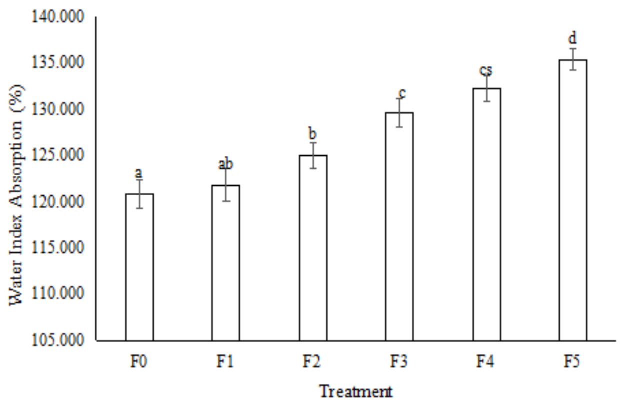

Figure 3. Water absorption index graphic of formulation purple sweet potato starch and rice starch

Amylose content determined the water absorption index. The higher the amylose content, the ability to absorb water greater. The amylose content for ultrasound-modified starch was higher than rice flour, it was 34.73%, while rice flour was 25.96%. F5 treatment (100% ultrasound-modified starch: 0% rice flour) has more carbohydrate than the other treatments (76.78%). F5 treatment has the highest water absorption index.

The cavitation condition caused the particlesto interact with each other molecule and affected cracks and damaged granules This condition caused the porous formation and absorbed water easily [24]. Ultrasonication disrupted the crystalline bonds of starch. The breakdown of the crystalline area then increased starch hydrolysis and hydrogen bond become weakened [25]. The break down of starch granules changed the crystalline structure to become an amorphous structure [26].

The high water content also affected the water absorption index. Starch has a high water content that can reduce the ability to absorb water [27]. High temperatures and long drying times increased the water absorption index of instant rice porridge [28]. Moreover, rice flour instant food has a faster rehydration time due to greater absorption. Drying rice flour instant has a porous surface that allowed it has rehydration process faster [39].

3.4. Rehydration Time

The desired rehydration for instant products was high in a short time [30]. Rehydration processing for weaning food uses warm water at a temperature of 60°C. Rehydration time was 41.933 seconds to 31.703 seconds. The rehydration time of the formulation purple sweet potato starch and rice flour starch can be seen in Figure 4. The interaction between formulations has a significant effect on the rehydration time of formulation purple sweet potato starch and rice flour starch. However, F4 and F5 treatments did not have a significant effect on rehydration time.

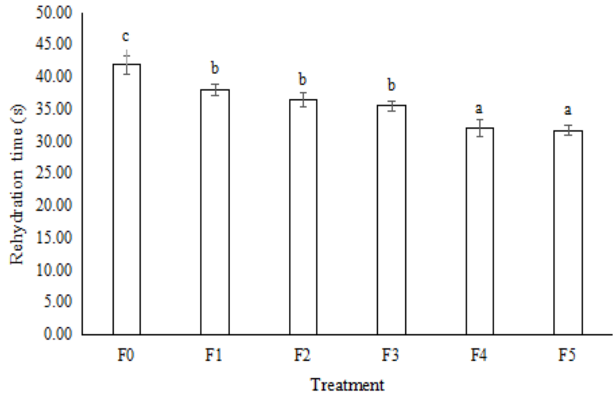

Figure 4. Rehydration time graphic of formulation purple sweet potato starch and rice starch

The figure showed that weaning food containing ultrasound-modified starch has a shorter rehydration time. It caused modified starch contain more amylose (34.73%.). Amylose content has a greater ability to absorb water. Weaning food brewed caused the hydrogen bonds between the amylose molecules to be released and then bond more water molecules. Native starch was 30.01%, while ultrasonically modified starch had 35.03% amylose [31]. Rehydration time is calculated by dissolving instant weaning food with warm water at a temperature of around 60 to 70°C, then calculating the time until ready to serve.

The indicator was weaning the food mixture as homogeneous. The rehydration time for commercial weaning food was 40.51 to 49.4 seconds [32]. The rehydration time of instant baby porridge in this research was 31.703 to 41.93 seconds. It showed the research has a shorter rehydration time than commercial weaning food. amorphous structure helps rehydrate fast. hydrogen bonds between the amylose molecules are released and bond more water molecules. The gelatinization process heat energy caused the starch hydrogen bonds to damage each other. This was able to integrate water diffused out to granules [33].

4. Conclusion

The result of this study indicated that the formulation of modified starch and rice flour has a significant effect on bulk density, water absorption, bulk density, and water absorption. The best treatment was F5 (100% modified starch and 0% rice flour) with 0.50 g/mL bulk density, 135.40% water absorption, 136.67 dPas, and 31.70 s rehydration time. The researcher recommended adding or substituting other raw materials for requirements of SNI-01-7111.1-2005 especially fat content for weaning food.

References

[1] S. Koswara. *Pengolahan Ubi Jalar*. Bogor:

Departemen Ilmu dan Teknologi Pangan Dan Seafast Center IPB, 2013.
[2] F. Polnaya., R, Breemer., G.H. Augustyn., H.C.D. Tuhumury, H.C.D. "Karakteristik Sifat-Sifat Fisiko-Kimia Pati Ubi Jalar, Ubi Kayu, Keladi dan Sagu". *Agrinimal*, vol.5, no.1, pp.37-42. 2015.
[3] S. Winarti. *Makanan Fungsional*. Yogyakarta: Graha Ilmu Cetakan Pertama. 2010.
[4] F. Kusnandar. *Teknologi Modifikasi Pati dan Aplikasinya Di Industri Pangan*. Bogor: Institut Pertanian Bogor. 2010.
[5] Br. Kaur., F. Ariffin., R. Bhat., A. Karim. "Progress in Starch Modification in The Last Decade". *Food Hydrocolloids*, vol. 26, pp. 398-404. 2012.
[6] J. Lee., T. Tuziuti, K. Yasui., S. Kentish., F. Grieser., M. Ashokkumar. Y. Iida. "Influence of Surface-Active Solutes on the Coalescence, Clustering, and Fragmentation of Acoustic Bubbles Confined in A Microspace". *Journal Physical Chemistry*, vol.11, no.51, pp.19015–19023. 2007
[7] Y. Wu., X. Du., H. Ge., Z. Lu. "Preparation Of Microporous Starch by Glucoamylase and Ultrasound". *Starch/Starke*, no.63, pp. 217-225. 2011.
[8] I.G. Riani., N. Malahayati., T.W. Widowati., M. Syafutri. "Physical Characteristic of Purple Sweet Potato (*Ipomoea batatas* L.) Modified Starch with Ultrasonication Method". *Sch J Eng Tech*, vol. 8, no., pp.59-65. 2020.
[9] T.R., Muchtadi., M. Sugiyono., Ayustaningwarno. *Ilmu Pangan*. Alfabeta. Bandung. 2010.
[10] W.L., McCabe., J.C. Smith., P. Harriot. *Chemistry Technic Operation Part Four Translate by Jasfi E*. Erlangga. Jakarta. 1987.
[11] C. Onyango., A. Mewa., Mutahi., A. Okoth. "Effect Of Heat Moisture Treated Cassava Starch and Amaranth Malt on The Quality Of Sorghum-Cassava-Amaranth Bread". *Journal Food Science.* Vol.7, no.5. pp.80-86. 2013.
[12] R. Tamrin., S. Pujilestari. "Karateristik Bubur Bayi Instan Berbahan Dasar Tepung Garut dan Tepung Kacang Merah". *Jurnal Konversi*, vol.5, no.2, pp.49-58. 2016.
[14] K. S. Suslick KS., Price GJ. "Applications Of Ultrasound to Materials Chemistry". *Annual Reviews Mater Science*, vol.29, pp.295–326. 1999.
[15] S. Rejeki., R. Libriani., F. Takzim. "Karakterisasi Fisik Bubur Bayi Instan Berbahan Dasar Tepung Beras Merah (*Oryza Nivara*) Dan Tepung Ikan Teri (*Stolephorus* sp.)" *Jurnal Sains dan Teknologi Pangan*, vol.3. no.5. pp:1674-1681. 2018
[16] F. S. Galung. "Karakterisasi dan Pengaruh Berbagai Perlakuan Terhadap Produksi Tepung Beras Merah (*Oryza Nivara*) Instan". *Jurnal Pertanian Berkelanjutan. Vol.*5, no.2. pp 1-6. 2017.
[17] R. Kumalasari., F. Setyoningrum., R. Ekafitri, R. "Karakteristik Fisik Dan Sifat Fungsional Beras Jagung Instan Akibat Penambahan Jenis Serat Dan Lama Pembekuan" *Jurnal pangan*, vol. 24, no.1. pp.37-48. 2015.
[18] D. Apriani., Gusnedi., Darvina. "Studi Tentang Nilai Viskositas Madu Hutan dari Beberapa Daerah di Sumater Barat untuk Mengetahui Kualitas Madu". *Pillar of Physics, vol.* 2. pp. 01-98. 2013.
[19] S. Koswara. *Teknologi Pengolahan Umbi-Umbian Bagian 4: Pengolahan Umbi Ganyong*. Bogor: Southeast Asian Food and Agricultural Science and Technology Center IPB. 2013.
[20] W.R. Asih., K.R. Kuswanto., Y.A. Widanti. "Penambahan Puree Daun Kelor (*Moringa Oleifera*) Dan Puree Pisang Ambon Untuk Formula Mpasi (Makanan Pendamping Asi)". *Jurnal Teknologi dan Industri Pangan*, vol.3. no.1. pp. 10-17. 2018.
[21] Winarno, F. G. *Kimia Pangan dan Gizi*. Gramedia Pustaka Utama, Jakarta. 1997.
[22] R. Tamrin., S. Pujilestari. "Karateristik Bubur Bayi Instan Berbahan Dasar Tepung Garut dan Tepung Kacang Merah". *Jurnal Konversi*, vol.5, no.2, pp.49-58. 2016.
[23] Yustiyani dan Setiawan. "Formulasi Bubur Instan Menggunakan Komposit Tepung Kacang Merah Dan Pati Ganyong Sebagai Makanan Sapihan". *Jurnal Gizi dan Pangan*, vol.8, no.2, pp.95-102. 2013
[24] S. D. Ardhiyanti., A.B. Ahza., D.N. Faridah., B. Kusbiantoro, B. "Karakteritik Tepung Beras Hasil Perlakuan Kombinasi Gelombang Mikro, Ultrasonikasi dan Pemanasan Lembab. Jurnal Teknologi dan Industri Pangan". vol.27, no.2, pp.175-184. 2016.
[25] A.R. Jambrak., Z. Herceg., D. Subaric., J. Babic., M. Brnc., B.I., Rimac., T. Bosiljkov., B. Tripalo., J. Gelo. "Ultrasound Effect on Physical Properties of Corn Starch". *Carb Pol*, vol. 79, pp. 91-100. 2010.
[26] N. Diniyah., A. Subagio., R.N.L. Sari., N. Yuwana. "Sifat Fisikokimia Dan Fungsional Pati Dari Mocaf Varietas Kaspro Dan Cimanggu". *Jurnal penelitian pascapanen pertanian, 15* (2):80-90. 2018.
[27] E. Ginting., Y. Widodo., S.A. Rahayuningsih., M. Jusuf. "Karakteristik Pati Beberapa Varietas Ubi Jalar". *Penelitian Pertanian Tanaman Pangan*. vol.28, no.1 pp.8-18. 2015.
[28] Y.H. Diza., T. Wahyuningsih, T., Silfia. "Penentuan Waktu Dan Suhu Pengeringan Optimal Terhadap Sifat Fisik Bahan Pengisi Bubur Kampiun Instan Menggunakan Pengering Vakum"**.** *Jurnal Litbang Industri*, vol.4, no.2, pp.105-114. 2014.

[29] F.S. Galung. "Karakterisasi Dan Pengaruh Berbagai Perlakuan Terhadap Produksi Tepung Beras Merah (*Oryza Nivara*) Instan". *Jurnal Pertanian Berkelanjutan. v*ol 5, no.2, pp.1-6. 2017.

[30] A. Slamet. "Fortifikasi tepung wortel dalam pembuatan bubur instan untuk peningkatan provitamin A". *Agrointek*, vol.5, no.1, pp.1-8. 2011.

[31] I. G. Riani., N. Malahayati., T.W. Widowati., M. Syafutri. "Physical Characteristic of Purple Sweet Potato (*Ipomoea batatas* L.) Modified Starch with Ultrasonication Method". *Sch J Eng Tech*, vol. 8, no., pp.59-65. 2020.

[32] H. Listiyoningrum dan Harijono. "Optimasi susu bubuk dalam makanan pedamping asi (MP-ASI)". *Jurnal Pangan dan Agroindustri*. Vol.3, no.4, pp.1302-1312. 2015.

[33] H. Palupi, A.A. Zainul., M. Nugroho "Pengaruh pre gelatinisasi terhadap karakteristik tepung singkong". *Jurnal Teknologi Pangan*. *Vol.*1, no.1, pp.1-15. 2017.