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PHYSICOCHEMICAL, SENSORIAL AND FUNCTIONAL PROPERTIES OF ARROWROOT (*Maranta arundinacea*) FLOUR AS AFFECTED BY THE FLOUR EXTRACTION METHOD

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ABSTRACT

Arrowroot (*Maranta arundinacea*) could be used to substitute wheat flour in the food industry. The Wet extraction method, which extracts starch by crushing it with water, is the most prevalent method of extracting arrowroot flour. The purpose of this study was to compare the "wet method" and "dry method" of flour extraction in terms of the flour produced. Flour yield (%), sensory properties, proximate composition, and physicochemical and functional properties of the flour derived from the two methods were assessed using standard protocols. When compared to the wet method, the dry method yielded a higher flour yield. The flour from wet method resulted in better sensory properties (odour, appearance, flavour, texture, overall acceptability) than the flour from dry method. Proximate parameters, such as ash, crude fat, crude protein, and crude fiber contents of the flour from dry method were significantly ($P<0.05$) higher than those in the flour from wet method. The most prominent starch granule shapes were oval, spherical and irregular globular with no significant differences in the granule size between the two flour types. The flour densities revealed that arrowroot flours extracted using both procedures are suitable for use in the pharmaceutical industry. Viscosity, amylose content, and swelling power were significantly higher in the flour from the wet method indicating a better gel forming ability which is beneficial in food preparations. Wet extraction method was selected as the most suitable method for food preparations and for using arrowroot in the food industry.

1.Introduction

Plants are abundant in starch, which is a key source of energy. This carbohydrate can be utilized in the food industry as thickening agent, water retention agent, gelling agent, and colloidal stabilizers (Souza *et al*., 2019). Introduction of new starch sources with better functional characteristics has become a modern trend in the food industry, as it has the potential to influence the international markets. In recent years, starches from roots and tubers have received significant attention because of their prospective applications (Tetchi *et al*., 2007; Jyoti *et al*., 2011). Adding value to underutilized tuber crops and exploiting them for the food industry is a current trend.

Arrowroot (*Maranta arundinacea*, Family: Marantaceae) rhizome flour has a significant potential to replace wheat flour in food products as a gluten-free substitute. Colour of arrowroot flour is highly closer to white colour which will be an important fact when substituting wheat flour with arrowroot flour (Malki *et al*., 2022). Celiac disease and gluten intolerance can only be treated by the complete exclusion of gluten. Due to the lack of gluten-free alternatives, those replacement products can be relatively expensive. In this context, arrowroot rhizome flour has a high potential to succeed (Amante *et al.,* 2020).

Arrowroot is a perennial herbaceous tuber crop that originated in South and Central America but has since spread around the world, particularly in tropical regions (Deswina and Priadi, 2020). Arrowroot is known as "*Hulankeeriya*" or "*Aerukka*" in Sri Lanka. It has long been used in folk medicine as a medication. Arrowroot flour is used minimally in the local food industry due to lack of awareness and time-consuming starch extraction procedures, but rural communities consume porridges, curries, *roti* and similar products made of arrowroot flour.

Arrowroot rhizomes can result in 10 % - 20 % of starch yield from the manual wet extraction procedure. In many countries, the wet extraction method is the most popular flour extraction procedure for arrowroot, which involves extracting flour into water and allowing it to settle. The dried pellets are then crushed and sifted (Capina and Capina, 2017). Fresh arrowroot rhizome pieces are oven dried in the dry flour extraction process, and flour is prepared by grinding the dried pieces (Aprianita *et al*., 2014). The objective of this study was to determine the sensorial properties, proximate composition and physicochemical properties of arrowroot flour made by wet and dry extraction methods.

2. Materials and methods

2.1. Sample Collection

Arrowroot rhizomes at harvesting age were collected from Deraniyagala, Sabaragamuwa Province, Sri Lanka. Coconut milk powder, table salt, *Kithul* (*Caryota urens*) treacle, and commercial arrowroot powder (Brownson Pvt. Ltd., Sri Lanka) were purchased from the local market. All the chemicals used were of analytical reagent grade.

2.2. Wet Extraction Method of Arrowroot Flour

Arrowroot rhizomes were cleaned, scale leaves removed and rinsed under running tap water. Then, using a high-speed stainless steel blender (Preethi MG-172 E, Preethi Electrical Appliances, India), a 1:2 (w/w) ratio of arrowroot to water was crushed for 5 min, until a homogenous mass was obtained. The mixture was filtered using a double cotton cloth. For fiber separation, the mass washing operation with deionized water was done thrice. The water separation was carried out by manual flow after 12 h of flour sedimentation. The flour was then oven dried for 8 to 10 h at 60 °C with air circulation. Dried flour was ground to a fine powder using a grinder (Preethi MG-172 E). The flour was sifted through a 425 µm sieve and stored at -18 °C until further analyses. This method was developed by making slight modifications to Nogueira *et al*. (2018).

2.3. Dry Extraction Method of Arrowroot Flour

Arrowroot flour extraction by dry method was done as described by Aprianita *et al*. (2014) with slight modifications. Rhizomes were cleaned, scale leaves were removed, and cut into 1 cm size cubes. The pieces were oven dried at 65 °C for 24 h. The dried chips were ground to fine flour using a grinder (Preethi MG-172 E), sifted through a 425 µm sieve, and stored at -18 °C until further analyses.

2.4. Determination of Flour Yield

The flour yield was calculated using equation 1 (Souza *et al*., 2019).

Flour Yield (%) = [Weight of extracted flour / Weight of fresh rhizomes]*100----(1)

2.5. Preparation of Arrowroot Porridge and Sensory Evaluation

A porridge was prepared using arrowroot flour to determine the sensory properties of the flours resulted from the two extraction processes and compare those with a commercial arrowroot flour product available in the local market. Powdered coconut milk (65 g) was dissolved in water (1000 ml) and 200 g of arrowroot flour was added. The mixture was heated in a pan at medium heat. While stirring continuously, *Kithul* treacle (20 ml) and 1 g of table salt were added. The mixture was heated until boiling started. A trained panel of eight members carried out the sensory evaluation of arrowroot flour based porridge using a five-point hedonic scale (5 – Like very much through to 1 – Dislike very much) to rank the samples. The most consumer preferable flour type was determined and the relevant extraction method was selected for further analyses and product development.

2.6. Proximate Analysis

The two arrowroot flours resulting from the wet method and dry method were evaluated for their proximate compositions. Moisture content was measured by a moisture meter (Infrared Moisture Analyzer Kett FD-660, Kett, Japan). The total solid content was determined by oven drying at 105 °C for 3 h. Ash content was determined by the muffle incineration method at 540 °C, and crude protein was determined by the Kjeldahl distillation method. Crude fiber content and crude fat content were determined using a fiber analyzer (Fiber Extraction System F-6P, Spain) and the solvent extraction method (Fat Extraction System SX-6 MP, Spain), respectively according to the methods of Association of Official Analytical Chemists (2010). Total carbohydrate content and total gross energy were determined as described by Diddana *et al.* (2021).

2.7. Determination of Flour Colour and Starch Granular Morphology

The colour of arrowroot flour was assessed using the colourimeter (PCE-CSM 2, PCE Instruments, Unites States). The colourimeter was calibrated, and colour coordinates were recorded using the included calibration disc. The samples were placed in a watch glass and their surfaces flattened. Measurements were taken by setting the measurement head of the colourimeter on the prepared samples after covering them with a piece of clear polythene. The measurements were taken at three different locations on the samples. Colour characteristics were determined using the L* a* b* colour coordinates. a*(-a* for greenness and +a* for redness), L*(L* = 0 for black and L* = 100 for white), and b*(-b* for blueness and +b* for yellowness).

Starch granular morphology of flour samples was determined according to Wijesinghe (2015). A starch suspension was prepared to mix flour 1:1 (w/v) with a mixture of distilled water and glycerine (1:1 v/v). A thin smear was prepared on a glass slide with a coverslip after staining the starch solution with a 1.0 % iodine solution. Starch granules were observed under a light microscope (OPTICA Microscope B-290, Italy) at 40 x magnification and the images were captured with Optica Pro View digital camera software. The length, width, and shape of the starch granules were assessed. Dry arrowroot flour was applied as a thin layer on adhesive metallic support and then sputter-coated with gold to examine under a scanning electron microscope (SU 6600, HI-2108-003, Japan) operating at 5 kV (Horovitz *et al*., 2011).

2.8. Determination of Physicochemical Properties

2.8.1. Determination of Least Gelation Concentration (LGC)

Flour suspensions (2–10 % w/v) were made with distilled water (5 ml). The flour suspensions were mixed well for 5 min. After being heated for 30 min at 80 °C in a water bath, the test tubes underwent rapid cooling under flowing cold tap water for 2 h. When the sample from the inverted test tube did not drop, it was identified as the least gelation concentration for flours (Awokaya *et al.,* 2011).

2.8.2. Determination of Flour Density

Density tests were performed according to Musa *et al*. (2011).

Bulk Density – The occupied volume of a glass graduated cylinder with a 100 ml capacity was measured after 20 g of flour samples were weighed and poured into it.

Tapped Density – A graduated cylinder containing 20 g of flour was dropped 50 times from a height of 20 mm on a bench, and the volume of each drop was recorded.

Carr's Index – The ratio was calculated by dividing the difference between the tapped density and the bulk density by the tapped density and expressing it as a percentage.

Hausner Ratio – The Hausner ratio was obtained by dividing all of the samples' tapped density by their bulk density.

2.8.3. Determination of Flour Viscosity

The viscosity of arrowroot flour was measured using a digital viscometer (VISCOTM-6800, ATAGO, Japan). The flour was mixed with distilled water to create a starch suspension (10 %) and heated up to 78 °C. The viscosity (cP) of the flour solution was recorded at 3 minute intervals while rotating at 20 rpm (Sopade and Kassam, 1992).

2.8.4. Determination of Swelling Power and Solubility

With a few minor modifications, methods of Leach *et al*. (1959) were used to measure swelling power and solubility of arrowroot flour samples prepared using the wet method and the dry method. With constant stirring, 0.25 g of arrowroot flour was heated with 10 ml of distilled water at 78 °C for 30 min. The slurry was centrifuged for 15 min at 3000 rpm after being cooled to room temperature. Starch sediment was measured after the supernatant was properly removed. The supernatant was transferred to a pre-weighed petri dish, evaporated for 2 h at 130 °C, and then weighed. The amount of starch dissolved in water was represented by the residue left over after drying the supernatant. The outcome was given as equations (2) and (3);

Solubility (%) = [(Wss x 100) / Ws]------(2)

Swelling Power (g/g) = [(Wsp x 100)/(Ws x (100 – solubility %)]------(3)

Where; Wss – weight of the soluble starch, Ws – weight of the sample, Wsp – weight of the sediment paste

2.8.5. Determination of Moisture Sorption Capacity

Arrowroot flour (2 g) was spread evenly in a pre-weighed petri dish. The petri dish was put in a desiccator at room temperature with a relative humidity of 98 % until a constant weight was reached. The moisture sorption capacity was determined by calculating the percentage increase in weight (Shiihii *et al*., 2011).

2.8.6. Determination of Amylose Content

The amylose content of flour was determined according to Juliano (1971). Arrowroot flour (1 g) was mixed with 1 ml of 95 % (v/v) ethanol and 9 ml of 1 N NaOH. The mixture was heated for 10 min and volume up to 100 ml. From the sample suspension, 5 ml was mixed with 50 ml of distilled water, 1 ml of 1 N acetic acid, and 1.5 ml of iodine solution. The suspension was volume up to 100 ml and held for 20 min. The absorption at 620 nm was measured using a UV visible spectrophotometer (JENWAY 6305, Cole-Parmer Ltd, United Kingdom) and the standard curve was generated using pure potato amylose.

2.9. Experimental Design and Statistical Analysis

The experiments were arranged in a Completely Randomized Design (CRD). Measurements for physicochemical analyses were performed on triplicate samples. Results of the sensory evaluation (non-parametric data) were analyzed using the Kruskal Wallis test. Analysis of Variance (ANOVA) was used to analyze parametric data using MINITAB (version 19) statistical software.

3.Results and discussions

3.1.Effect of Extraction Method on Flour Yield

Arrowroot flour yields from two flour extraction methods are shown in Table 1. The dry method resulted a significantly higher (24.38 %) flour yield compared to the wet method (17.10 %) because the entire rhizome was used for flour production in the dry method. In addition, the wet method caused a greater removal of fibers from the rhizome. Consequently, a lower flour yield resulted in the wet extraction method. The current result of flour yield in the wet method complies with previous studies which suggest that the wet extraction process produces a flour yield of 10 – 20 % (Capina and Capina, 2017).

Table 1. Variation of arrowroot flour yield from dry method and wet method

Flour preparation method	Flour yield (%)
Dry method	24.38±2.36[a]
Wet method	17.10±2.32[b]

Mean±SD; n = 3

Between rows, mean values followed by different superscript letters are significantly different at p=0.05

3.2. Effect of Flour Extraction Method on Sensory Properties of Arrowroot Flour Based Porridge

Results of sensory evaluation revealed that the porridge made of arrowroot flour from the wet method (T1) gained the highest mean scores for the sensory attributes of odour (5.00), appearance (4.75), flavour (4.50), texture (4.00), and overall acceptability (5.00) (Figure 1). All sensory attributes differed significantly (P<0.05) among the three treatments. The porridge made of arrowroot flour from the dry method (T2) received lower mean scores for colour (2.00), appearance (3.50), flavour (2.50), texture (3.00), and overall acceptability (3.00). Inclusion of high fiber in the flour from the dry method has caused undesirable organoleptic properties of the product made using that flour. Therefore, the wet extraction method is more appropriate for arrowroot flour preparation and product development.

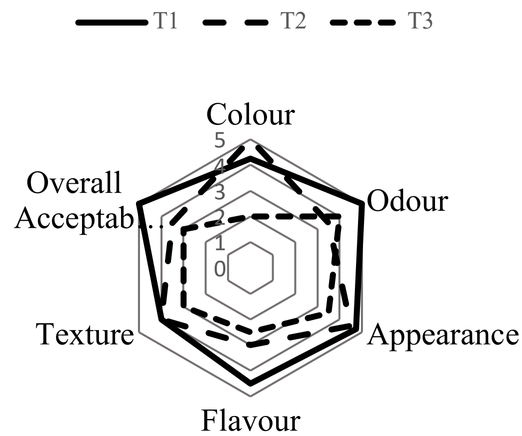

Figure 1. Mean scores obtained for the sensory attributes of arrowroot flour incorporated porridge
T1 –Flour from wet method, T2 – Flour from the market (commercial product), T3 – Flour from dry method

3.3. Effect of Flour Extraction Method on Proximate Composition of Flours

The moisture content of arrowroot flour from the dry method (12.27 %) was significantly higher than that of the flour from the wet method (10.60 %; Table 2). However, this difference could have been caused by the variation in preparation and drying procedures which were employed according to the extraction process. The total solid content was not significantly different between the two flour types. Dry method has resulted a higher ash content in the flour (2.32 %). However, the ash content in the flour from wet method in the current study (0.38 %) is higher compared to previous findings of ash level in arrowroot flour (wet method) from the Philippines (0.16 %; Capina and Capina, 2017). The crude fat content of flour from the dry method (0.71 %) was significantly higher than that of the wet method (0.43 %). The crude fat content of arrowroot flour from the wet extraction process was previously reported to be in the range of 0.25 % to 1.0 % (Erdman, 1986;

Madineni *et al*., 2012; Capina and Capina, 2017).

Table 2. Variation of proximate compositions of arrowroot flour extracted from dry method and wet method

Parameter	Flour from dry method	Flour from wet method
Moisture %	12.27±0.25[a]	10.60±0.52[b]
Total Solid %	91.68±1.54[a]	89.40±0.52[a]
Ash %	2.32±0.11[a]	0.38±0.03[b]
Crude Fat %	0.71±0.04[a]	0.43±0.06[b]
Crude protein %	5.50±0.35[a]	0.64±0.09[b]
Crude Fiber %	2.52±0.03[a]	1.02±0.40[b]
Carbohydrate%	87.20	87.95
Gross Energy (kcal/ 100 g)	377.19	358.23

Mean±SD; n = 3

Between columns, mean values followed by different superscript letters are significantly different at p = 0.05

Flour from the dry method reported a higher crude protein content (5.50 %) than the wet method (0.64 %). Aprianita *et al.* (2014) reported that arrowroot flour from the dry process had a protein content of 7.70 % wet method had a protein content of 0.60 %.

The reduced protein content of flour from the wet extraction process is due to the starch isolation process (Aprianita *et al*., 2014). The crude fiber content of flour from the dry method (2.52 %) was significantly higher than that of the wet method (1.02 %). This could be related to the removal of fiber during the wet extraction process. Previous studies have reported a soluble fiber level of 1.70 % in arrowroot flour from the wet method (Madineni *et al*., 2012).

With regard to the carbohydrate content of the flour, there was no difference between the two extraction processes. The flour from the dry method reported a higher gross energy content in comparison to the flour from the wet method (Table 2).

3.4. Starch Granular Morphology and Colour of Flour

Table 3. Variation in arrowroot starch granule shape, dimensions, and flour colour as resulted by wet method and dry method of flour extraction

Parameters	Dry method	Wet method
Granule shape and dimensions: Spherical shape	32.53±8.20[a]	30.50±8.43[a]
Oval shape	43.46±12.29[a]	50.28±10.63[a]
Irregular Globular shape	24.00±6.51[a]	19.20±2.74[a]
Length (µm)	44.99±2.44[a]	49.40±2.77[a]
Width (µm)	28.99±5.32[a]	30.31±0.93[a]
Flour colour: L*	82.46±1.19[b]	92.31±0.44[a]
a*	4.39±0.23[a]	1.36±0.06[b]
b*	16.28±0.23[a]	7.37±0.05[b]

Mean±SD; n = 3

Between columns, mean values followed by different superscript letters are significantly different at p = 0.05

(a) (b)

Figure 2. Arrowroot starch granule morphology under the (a) light microscope and (b) scanning electron microscope (A – Oval shape, B – Spherical shape, C – Irregular globular shape)

Oval, irregular globular, and spherical were the most commonly identified starch granule shapes. Ovoid and globular shapes were identified as the most prominent granule shapes for arrowroot by Perez *et al*. (1997). Cicular shaped or oval starch granules have been observed by Nougeira *et al*. (2018). However, the distribution of starch granule shapes (as percentages) was consistent between the two flour types. Fissures on the surfaces of granules were observed indicating the smoothness of arrowroot starch granules (Nougeira *et al*., 2018). The granule morphology under a light microscope and scanning electron microscope (SEM) are shown in Figure 2.

The length and width of the starch granules obtained by the two flour preparation methods did not differ significantly. The most prominent diameter of arrowroot starch granules, according to Souza *et al*., 2019, is between 20 and 35 µm. In the present study, the width of starch granules in both flour types ranged from 28.99 µm to 30.31 µm (Table 3).

The flour colour resulted from the two extraction methods was different in terms of lightness (L*), redness (a*), and yellowness (b*). While the flour from the dry method had much higher red and yellow colour tones, flour made using the wet method recorded significantly higher values for lightness. The dry method of making arrowroot flour results in a mixture of flour, fiber, and other residues, whereas the wet method involves washing the slurry to extract the flour which could have caused a higher lightness in it. The results indicated that arrowroot flour made using the wet method is relatively closer to white colour compared to the flour from the dry method, which is closer to reddish and brownish colour. It is indicated by higher a* and b* values of the flour from the dry method.

3.5. Results of Physicochemical Properties

3.5.1. Results of Least Gelation Concentration (LGC)

Gelation characteristics of the arrowroot flour are shown in Table 4. For the wet and dry extraction methods, the least gelation concentration (LGC) was 8 % and 10 %, respectively. This number is important for the determination of the ideal water to flour ratio for the desired texture in food processing operations based on flour. This is a significant consideration while preparing food because it is based on the structural components of flour, such as protein, carbohydrates, and lipids (Abbey and Ibeh, 1988). The length of the chain, the presence of phosphate ester in the remaining glucose, and the residual α-1, 6 linkages are among the factor that has the impact on the least gelation concentration, according to Klaochanpong *et al*. (2015). Arrowroot flour from the wet extraction method produces a more viscous gel from the least flour concentration that the dry method because flour from the dry method is containing more fiber content than the wet method flour.

Table 4. Gelation properties of arrowroot flour resulted from wet and dry methods

Concentration (%w/v)	Status of dry method	Status of wet method
2	Viscous liquid	Viscous liquid
4	Moderately soft gel	Soft gel
6	Soft gel	Soft gel + Firm gel
8	Soft gel + Firm gel	Firm gel
10	Firm gel	Very firm gel
Least gelation concentration (%w/v)	10	8

3.5.2. Results of Moisture Sorption Capacity

Results of moisture sorption capacity revealed that the flour produced by the dry method was more sensitive to atmospheric moisture when compared to the wet method (Table 5). When arrowroot flour from the dry method is exposed to the atmosphere it will absorb atmospheric moisture than flour from wet method and gain more moisture in it. This property determines the physical ability of starch when formulated into a tablet, which is especially important in the pharmaceutical industry (Musa *et al.*, 2011). Accordingly, arrowroot flour from the wet method has more potential to be used in the pharmaceutical industry. Moisture sorption capacity represents the amount of water absorbing molecules than starch. When the moisture sorption capacity is high starch polymer structure is looser in that starch while polymer while it is more compact for starches with low moisture sorption capacity. Moisture sorption capacity depends on the harvesting time, geographical location, or botanical source. Starches with high moisture sorption capacity easily get softened and are easy to digest but they tend to spoil faster (Aidoo *et al.*, 2022). Arrowroot flour from dry method had the highest moisture absorbance. Moisture absorbance increases with the presence of fiber (Azima *et al.*, 2020) and it has been proved by this study.

Table 5. Variation in moisture sorption capacity of arrowroot flour from dry method and wet method

	Moisture sorption capacity (%)						
	1 h	2 h	3 h	6 h	24 h	48 h	72 h
Wet method	4.65± 1.12^{a}	6.04± 1.51^{a}	7.00± 0.72^{a}	8.56± 134^{b}	15.89± 1.75^{b}	18.39± 1.08^{b}	21.19± 2.89^{b}
Dry method	7.23±1.47^{a}	7.39± 0.78^{a}	7.85± 1.54^{a}	14.47± 0.27^{a}	20.17± 0.64^{a}	33.76± 0.81^{a}	38.62± 1.50^{a}

Values are Mean ± SD;

The same superscript letter in each row represents values not significantly different from each other at p = 0.05

3.5.3. Results of Flour Densities, Amylose Content, Swelling Power and Solubility

The bulk density and tapped density of the two flour types were significantly different ($p<0.05$) but the Carrs index and Hausner ratio were not different (Table 6). When the Carrs index exceeds 23 % and the Hausner ratio exceeds 1.2, that flour does not have a good flow or compressibility (Muazu *et al*., 2011). Both flour types were in an acceptable range with improved compressibility when considering the Carrs index, which will be useful in the pharmaceutical industry. However, the Hausner ratio of the flours from the dry method and wet method were 1.26 and 1.29, respectively (Muazu *et al*., 2011).

The viscosity of arrowroot flour prepared by the wet method was higher than that prepared by the dry method. Less inclusion of fiber in the flour from the wet method has increased its purity and could have resulted in increased viscosity (Table 6). Arrowroot flour from wet method is having better gel forming ability than flour from dry method. The viscosity of the flours has a significant impact on their integrity and texture. Method of flour preparation and interactions between starch and hydrocolloids have an impact on viscosity. The stability of flours with higher viscosities is essential when they are used as thickeners or stabilizers. As a result, arrowroot flour from wet method produces more viscous gels, increasing its potential as an ingredient in foods (Aidoo *et al*., 2022).

The swelling power of the flour from the wet method (16.02 g/g) was significantly higher than that from the dry method (5.78 g/g; Table 6). Swelling power is positively correlated with viscosity (Singh *et al*., 2006) and it was evident in the present study. When the temperature increases, swelling of starch granules increases and it indicates the strength of internal forces of starch granules which maintains the granule structure (Hoover *et al*., 2010). When the temperature of water is continuously increased, it causes the molecules in starch granules to vibrate vigorously, breaking the intermolecular hydrogen bonds in amorphous regions. Due to swelling and partial solubilization of polymers, particularly amylose, water molecules connect to exposed hydroxyl groups of amylose and amylopectin by hydrogen bonding, increasing the granule size (Hoover, 2001). The Higher swelling power of the flour from wet method could be caused by the higher level of purity (low fiber) in that flour. Nogueira *et al*. (2018) reported the swelling power of arrowroot starch from wet extraction as 11.32 ± 0.53 g/g and it is in between the values obtained for two processing methods in the current study.

The solubility of arrowroot flour from the wet method flour was higher (10.67 ± 2.31 %) than that of from the dry method (6.13 ± 1.98 %) although the difference was not significant. According to previous studies, the solubility of arrowroot starch has been recorded as 17.22 % and 13.22% (Perez and Lares, 2005; Nogueira *et al*., 2018) and they are more compatible with the results obtained for flour from the wet method. The amylose content of the flour wet method was higher (28.47 %) than that from the dry method (16.20 %; Table 6). This difference could have been caused by the variation in flour composition under the two processing methods. Erdman (1986) recorded the amylose content in arrowroot as 19.9 % and which was lower than the result of the present study. Moorthy (2002) reported a range of 16 – 27% for the total amylose content of arrowroot starch. According to several studies (Tharanathan, 2003; Li *et al*., 2011; Fakhoury *et al*., 2012; Romero-Bastida *et al*., 2015), the high amylose content of arrowroot of starch would enable its use in the production of films with better technological properties, particularly when it comes to mechanical resistance and barrier properties. Thus, the arrowroot flour from the wet method will have a higher potential for film preparation.

Table 6. Variation in flour densities, viscosity, amylose content, swelling power and solubility for arrowroot flour from dry method and wet method

Parameter	Dry method	Wet method
Bulk Density (g/ml)	0.55±0.00[a]	0.39±0.00[b]
Tapped Density (g/ml)	0.70±0.01[a]	0.51±0.01[b]
Carrs Index (%)	20.74±1.28[a]	22.66±1.78[a]
Hausner ratio	1.26±0.01[a]	1.29±0.02[a]
Viscosity (cP)	6338±505[b]	7802±531[a]
Amylose content (%)	16.20±0.60[b]	28.47±0.34[a]
Swelling power (g/g)	5.78±0.28[b]	16.02±0.70[a]
Solubility (%)	6.13±1.98[a]	10.67±2.31[a]

db - Dry basis, Mean±SD; n = 3*

Between columns, mean values followed by different superscript letters are significantly different at p=0.05

4. Conclusions

The study assessed the properties of arrowroot flour produced by two distinct preparation procedures. In the wet extraction process, fiber removal is done to a significant extent. The dry extraction process resulted in a higher flour yield, but when sensory properties were considered, the wet method resulted the flour with preferred sensory attributes for the food industry. The dry method produced arrowroot flour with significantly higher ash, fat, protein, and fiber contents compared to the wet method. The least gelation concentration of the flour from the wet method was 8% indicating its better gel-forming ability. Both flour types are suitable for use in the pharmaceutical industry, according to the results of flour densities. The flour colour in wet method was closer to the white colour while the flour from dry method was slightly reddish in colour. Viscosity, amylose content, and swelling power were significantly higher in the wet method. The wet extraction method could be adopted as the most acceptable procedure for arrowroot flour production for the industry because of its potential to use as thickeners, stabilizers or food ingredient.

5.References

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