Chemical Composition and Functional Properties of Egyptian Taro (*Colocasia esculenta*) Mucilage.

A. M. Basiony [1,*], M. B. Atta [2], E. I. Abd-Elazim [1], and A. S. Mohamed [1]

[1] *Food science and technology department, faculty of Agriculture, AL-Azhar University, Cairo, Egypt.*
[2] *Food science and technology department, Faculty of Agriculture, Tanta University, Egypt.*

* Corresponding author E-mail: Abdelltife.basiony@Azhar.edu.eg (A. Basiony)

ABSTRACT

The chemical composition and functional properties of mucilage extracted from Egyptian taro were studied. The mucilage's yield of Egyptian taro corms was 4.163%. The chemical compositions of the taro mucilage are 6.48, 6.78, 0.54, 6.01, 80.19 and 2.45 % for moisture, crude protein, ether extract, ash, total carbohydrates and crude fiber, respectively. The major amino acids are asparagine (14.9 gm/ 100 gm) glutamine (12.2 gm/ 100 gm), while cysteine (0.2gm/ 100 gm) was the minor amino acid. The major monosaccharides are glucose (22.51 µg/ gm) and fructose (20.11 µg/ gm), while the minor monosaccharide is arabinose (0.85 µg/ gm). The values of pH, solubility, swelling power, emulsion activity, emulsion stability, water absorption capacity and oil absorption capacity of taro mucilage are 6.06, 17.44%, 10.94%, 75.73 %, 93.90%, 4.5 ml/ mg and 1.50 ml/g, respectively. The high emulation activity and stability as well as water absorption capacity of the mucilage are desirable feature as safe emulsifier for natural food additives.

Keywords: Chemical composition, functional properties, taro mucilage, Amino acids, Monosaccharides

INTRODUCTION

Taro (*Colocasia esculenta*) is a tropical and subtropical plant belongs Araceae family (Murugesan et al. 2020). The world production of taro is estimated at 11.8 million tons (Nath et al. 2013). The greatest global production comes from developing countries especially West Africa region such as Nigeria, Cameroon, Ghana and Ivory Coast. Egypt ranks the 8th place (FAO, 2008) with 151.97 tons/ year (CAPMS, 2019). The taros corm contained a significant amount of mucilage ranging between 1.33 to 8.05 gm/ 100 gm depending on the extraction method (Andrade *et al.*, 2020). It is heterogeneous polysaccharide formed from different sugars (such as arabinose, galactose, glucose, mannose, xylose) and uronic acid units. It is slimy and has light color, where the carbohydrates are the main component represent 46 to 69 gm/ 100 gm of its mass following by protein representing 30 to 50 gm/ 100 gm (Njintang *et al.*, 2014). Beneficial for the texture, consequently and quality of the French-type bread (Bicalho *et al.*, 2019). Moreover, it may be used for acting as a binder, thickener, stabilizer, and emulsifier in the pharmaceutical, cosmetic, and food industries (Mijinyawa et al. 2018). Monoglycerides, propylene glycol monoesters, lactylate esters, acetylated monoglycerides and ethoxylated esters are synthetic commercial emulsifiers which are widely used in the food industries. However, natural emulsifiers such as lecithin and gum Arabic, guar, xanthan, locust bean and carrageenan gums are preferable ingredients by the consumers due to concerns of their health. Consequently, the target of modern researches is discovering and use of natural additives instead of the artificial ones. Moreover, extraction of mucilage from taro is easy, give a large yield and inexpensive compared to the price of synthetic ones (Andrade *et al.*, 2015).

This study was investigating the yield, chemical composition and functional properties of the mucilage extracted from taro.

MATERIALS AND METHODS

Materials

Taro corms

About 80 kg of taro (*Colocasia esculenta* L) corms were obtained from a private farm located at Kom Hamada, Al-Bihera Governorate, Egypt.

Chemicals

Sulfuric acid (98%) and hydrochloric acid (36%) were obtained from Bio Tech Company. Sodium hydroxide, boric acid, and petroleum ether (40- 60ºC) were obtained from Al-Gamhouria Trading Chemicals and Drugs Company, Cairo, Egypt. Acetonitrile (40%) and sodium phosphate were obtained from Sigma-Aldrich Co. USA.

Methods:

Preparation of taro mucilage

Fresh taro rhizomes (about 10 Kg) were washed in running water handily peeled by sharp knife and rewashed again. Three hundred grams of Rhizome were ground in blender (Kenwood, Type multione, China) for five minutes, and the mash was kept into refrigerator at 4ºC for 6.0 hr., then filtered through polyester textile (40×40 Cm) with porous 40 mesh according to Andrade *et al.* (2015).

Determination of some physical characteristics of prepared mucilage

Determination of pH, Solubility, swelling power and water absorption capacity

The pH of prepared taro mucilage was measured according to the method of Benesi (2005) using digital pH-meter (JENWAY model 3505, UK). The solubility and swelling strength were determined according to Sukhija *et al.* (2016) and calculated according to the following equations.

$$\text{Solubility } \mathbf{(S\%)} = \frac{\textbf{Weight of soluble sample}}{\textbf{Weight of sample}} \times 100$$

$$\text{Swelling power } \mathbf{(SP\%)} = \frac{\textbf{Weight of sediment paste}}{\textbf{Weight of sample} \times (\mathbf{100 - S\%})} \times 100$$

Determination of water absorption capacity and oil absorption capacity:

Water and oil absorption capacities of taro mucilage was determined according to the method of **Aremu *et al.* (2007)**.

Determination of emulsifying activity and its stability

Emulsifying activity and stability of taro mucilage was determined as described by Yamatsu *et al.* (1972).

Determination of chemical composition:

Moisture content (method no. 925.09), ether extract (method no. 925.38), crude protein using micro-kildahl (method no. 920.87) and ash content using muffle at 450-550℃ (method no. 923.03) of taro mucilage were determined as described in AOAC (2000), while total carbohydrates were calculated according to (Aurand 2013) in the following equation:

Total carbohydrate (%) = 100- (% protein+ % fat+ % ash+ % moisture). Also, monosaccharides of taro mucilage were estimated according to (Prates, 2002) using Agilent 1100 HPLC (Agilent Technologies, Wilmington, USA) equipped with four-unit pump (Agilent CA, USA), injector port (7125 CA, USA) and a G1314A UV detector. While total amino acids content was performed by amino acid analyzer (AAA) comparing the peak areas of the samples to a standard calibration curve as reported by (Andrade *et al.*, 2020).

Statistical analysis:

All determinations were performed in triplicates and the mean values were reported. The data obtained from the three replicates were analyzed by (ANOVA) using the **SPSS** Statistical Package Program (1998), and differences among the means were compared using the

Duncan's Multiple Range test. A significant level of 0.05 was chosen.

RESULTS AND DISCUSSION

The mucilage yield

The mucilage's yield of the Egyptian taro was 4.163 gm/ 100 gm corms. This result is in agreement with those reported by Manhivi *et al.* (2018) for both Amadumbe (*Colocasia esculenta*) and Cactus (*Opuntia spp.*) which was 4.44 gm/ 100 gm. On the other hand, it is higher than that (3.23 gm/ 100 gm) of the mucilage's yield from Taiwanese Yam and Taro (Huang *et al.*, 2010). These differences may be due to the type of plant, environmental conditions and agricultural treatments (Andrade *et al*, 2015).

Chemical composition of taro mucilage

Table (1) shows proximate composition of prepared taro mucilage is 6.48, 6.78, 0.54, 6.01, 80.19 and 2.45 % for moisture, crude protein, ether extract, ash, total carbohydrates and crude fiber, respectively. The protein content of Egyptian taro mucilage is 6.78 % which was comparable with (6.53 %) that reported by Huang *et al.* (2010). In contrast of moisture (6.48 %), ether extract (0.54 %), crude protein (6.78 %) and ash (6.01 %) were higher than those found by Manhivi *et al.* (2018). These variations could be explained by the maturation stage of the plant (Andrade *et al.*, 2015).

Amino acid composition of taro mucilage

Table (2) shows the essential and non-essential amino acids of taro mucilage. It is clear that the main amino acids are asparagine (14.9 gm/ 100 gm) and glutamine (12. 2 gm/ 100 gm) followed by alanine (7.4 gm/ 100 gm), valine (6.8 gm/ 100 gm), leucine (6.7 gm/ 100 gm) and glycine (6.1 gm/ 100 gm). On the other hand, cysteine (0.2 gm/ 100 gm), tyrosine (1.7 gm/ 100 gm) and threonine (2.7 gm/ 100 gm) are the minor amino acids. According to Njintang *et al.* (2014), the major amino acids present in the mucilage of six different varieties of taro were aspartic acid, asparagine, glutamine, glutamic acid, glycine, leucine and serine. Referring to the polarity of the amino acids, leucine, isoleucine, glycine, proline and methionine are nonpolar (hydrophobic) amino acids beside of some polar (hydrophilic) amino acids which could contribute to the emulsifying power of taro mucilage (Andrade *et al*., 2015). The emulsifiers are normally employed in backing products due where easy manipulation of the dough lead to increase in both the volume and shelf life of the final product (Kokelaar *et al*., 1996 and Ribotta *et al*. 2004).

Monosaccharides of taro mucilage

Monosaccharides of taro mucilage were fractionated by HPLC and the results were displayed in Table 3. The major monosaccharides in taro mucilage are glucose (22.51 μg/ gm) and fructose (20.11 μg/ gm) followed by mannose (13.87 μg/ gm) and rhamnose (9.61 μg/ gm) galactose (2.12 μg/ gm). The minor monosaccharide is arabinose (0.85 μg/ gm). These results are comparable with those reported by Njintang *et al*. (2014), who reported that the main monosaccharides present in the mucilage of six different types of taros are galactose, mannose and arabinose. According to Mollard and Joseleau (1994), the arabinogalactan protein of gum Arabic is responsible for its emulsifying power (Faucconier *et al*., 2000) and consists of the following major monosaccharides: arabinose, galactose, rhamnose, and glucose, refer to glucose that can be present in this chemical structure. According to Faccio *et al*. (2015), mucilage has a varied composition of monosaccharides depending on the method of extraction.

Functional properties of taro mucilage

Table (4) showed the pH and functional properties of taro mucilage. The pH value of taro mucilage is 6.06 which was comparable with those reported by Alalor et al. (2014). The solubility value is 7.44% of taro mucilage and agrees with the result of Njintang et al. (2014), who reported that the solubility of mucilage for three taro species were ranged from 15.8 to 18 %. Also, water absorption capacity and oil absorption capacity are 4.5 ml/ gm and 1.50 ml/ gm, which were in full agreement with the results of Gemede et al. (2018), who stated that water absorption capacity and oil absorption capacity of the pods of eight okra mucilage powder were ranged from 2.45 to 4.60 ml/ gm and from 0.02 to 3.64 ml/ gm, respectively. Swelling power of taro mucilage is 10.94%, which was lower than that (18%) as reported by Alalor et al. (2014). Emulation activity and emulation stability of taro mucilage are 75.73% and 93.90%, respectively. These values are higher than those found in eight types of okra mucilage, where the emulation activity and emulation stability were 42.22% and 74.45%, respectively as reported by Gemede et al. (2018). (Andrade et al., 2020) reported that the emulation activity and emulation stability of commercial gum Arabic are 68.24 and 68.00, respectively, which were lower than results of taro mucilage. These means that taro mucilage is better than that the commercial gum Arabic which is usually used as ideal hydrocolloidal agent for emulsifying. The superiority of both emulation activity and emulation stability of taro mucilages may be related to the protein content with the presence of weak-polar amino acids, such as leucine, isoleucine and tryptophan than those found in both okra mucilages and gum Arabic. Also, the presence of the methyl group, in the previous amino acids and low amounts of lipids may contribute to the emulsifying power by providing a hydrophobic moiety. The hydrophilic portion in this emulsifier mainly consists of hydroxyl-containing carbohydrates (Andrade et al., 2015).

CONCLUSIONS

Mucilage extracted from Egyptian taro is considered a natural emulsifier with high emulsifying power. This is due to the presence of weak polar amino acids, especially leucine and isoleucine, which can bind both fat and water. It also has a high ability to absorb water to form a gel. In addition, it can be used in the production of baked good as a substitute for fat to reduce calories and the negative effect of lipids. This makes taro's mucilage better than artificial emulsifiers that have disadvantages such as high price, toxicity and some side effects.

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Table 1: Chemical composition of taro mucilage

Components	Value (%)
Moisture	6.48±0.048
Crude protein	6.78±0.23
Ether extract	0.541±0.003
Ash content	6.01±0.09
Carbohydrate	80.18±0.16
Crude fiber	2.45±0.24

Values are the mean and standard deviations (M±SD) of three successful trails

Table 2: Amino acid composition of taro mucilage:

Amino acid composition	Value (g/ 100 gm)
Asparagine	14.9
Glutamine	12.2
Alanine	7.4
Glycine	6.1
Arginine	5.2
Histidine	3.5
Serine	3.4
Tyrosine	1.7
Cysteine	0.2
Total non-essential amino acids	54.6
Valine	6.8
Leucine	6.7
Methionine	5.2
Lysine	4.8
Phenylalanine	4.7
Isoleucine	4.5
Threonine	2.7
Total essential amino acids	35.4
Ammonia	10

Table 3: Monosaccharides of taro mucilage

Monosaccharides	Concentration (µg/ gm)
Glucose	22.51
Mannose	13.87
Galactose	2.12
Rhamnose	9.61
Fructose	20.11
Arabinose	0.85

Table 4: Functional properties of taro mucilage

Properties	Values
The pH value	6.06±0.13
Solubility %	17.44±0.16
Swelling power %	10.94±0.60
Water absorption capacity (ml/ gm)	4.50±.0593
Oil absorption capacity (ml/ gm)	1.50 ±0.06
Emulsion activity %	75.73±3. 37
Emulsion stability %	93.90±0.63

Values are the mean and standard deviations (M±SD) of three successful trails

التركيب الكيميائي والخواص الوظيفية للمادة المخاطية (ميوسيلاج) فى القلقاس المصرى

عبد اللطيف محمود بسيوني [1,*]، عصام اسماعيل عبد العظيم [1]، محمد بسيم عطا [2]، علاء الدين سلامة محمد [1]

[1]قسم علوم وتكنولوجيا الاغذية، كلية الزراعة، جامعة الأزهر، القاهرة، مصر.

[2]قسم علوم وتكنولوجيا الاغذية، كلية الزراعة، جامعة طنطا، مصر.

* البريد الإلكتروني للباحث الرئيسي:Abdelltife.basiony@Azhar.edu.eg

الملخص العربي

تهدف الدراسة الى دراسة التركيب الكيميائى والخواص الوظيفية للمادة المخاطية المستخلصة من القلقاس المصرى حيث كانت نسبة المادة المخاطية (ميوسيلاج) المستخلصة 4,361 جرام لكل 100 جرام كورمات قلقاس وكان التركيب الكيماوى لميوسيلاج القلقاس 6,48 – 6,78 – 0,54 – 6,01- 80,19 – 2,45 جرام / 100 القلقاس تقدير كل من الرطوبة والبروتين والدهن والرماد والكربوهيدرات والالياف على التوالى. الأحماض الأمينية ذات النسب الكبرى كانت كالاسباراجين 14,9(جرام /100 جرام) والجلوتامين (12,2 جرام /100 جرام) بينما السيستين (0,2 جرام /100 جرام) كان أقل الأحماض الأمينية. السكريات الأحادية الأعلى كانت الجلوكوز (22,51 ميكروجرام / جرام) والفركتوز (20,11 ميكروجرام /100جرام) بينما كان الأقل في النسبة الأرابينوز (0,85 ميكروجرام / جرام). قيمة رقم الحموضة والذوبانية وقوة الانتفاخ والنشاط الاستحلابى وثباتية المستحلب والقدرة على امتصاص الماء والقدرة على امتصاص الزيت لميوسيلاج القلقاس كانت 6,06 -17.44% -10,94%- 75,73 %- 93,9%- 4,5ملجرام / جرام – 1.5ملجرام /جرام على التوالى. النشاط الاستحلابى العالى وثباتية المستحلب وكذالك القدرة على ربط الماء للميوسيلاج مميزات مطلوبة من أجل عامل استحلاب آمن لإنتاج مواد مضافة طبيعية.

الكلمات الاسترشادية: التركيب الكيماوى، المادة المخاطية فى القلقاس، الخواص الوظيفية، الأحماض الأمينية، السكريات الأحادية