# Comparison of Guar and Xanthan Gums Added Gluten-free Muffins from Traditional Yam "Maha Angili Ala" (*Dioscorea alata*) Flour

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***Abstract*— Gluten-free foods are recommended in the world for Celiac disease. In the present study, gluten-free muffins were developed from "Maha angili ala" flour with either guar gum or xanthan gum as the stabilizer. Moreover, the physico-chemical properties of flour obtained from fully matured traditional yam "Maha angili ala" (*Dioscorea alata*) were investigated. Proximate analysis according to the standard AOAC procedures revealed that protein, ash, and fat contents of flour (moisture content, 5.25 ± 0.14%, dry basis) obtained from oven-dried and powdered "Maha angili ala" yams were; 6.99 ± 0.62%, 3.54 ± 0.16%, and 0.56 ± 0.08%, respectively. Colour analysis by a digital chromometer resulted $L^*$, $a^*$, $b^*$ values of flour were; 70.36 ± 0.80, 5.57 ± 1.64, and 16.63 ± 0.77, respectively. The water holding and oil holding capacities of the flour were; 1.58 ± 0.01 g of water/g of flour and 0.86 ± 0.03 g oil/g of flour, respectively. Three types of muffins such as control (no added gums), guar gum added, and xanthan gum added were developed. For the control analysis, wheat flour was used to develop control muffins. According to the muffin analysis, the guar gum added muffins were the most preferable with respect to sensory evaluation results. Collectively, this study suggested that "Maha angili ala" (*D. alata*) flour could be a potential source to develop gluten free muffins.**

***Keywords—bakery foods, Dioscorea spp., gluten-free, muffins, traditional yams***

## I. INTRODUCTION

Starchy tubers and root crops are essential energy sources of tropical and sub-tropical countries in the world. Tubers of *Dioscorea* spp. (Family: Dioscoraceae) are true yams and contribute 6% of the world root and tuber production [1]. It has been reported that nearly fourty *Dioscorea* spp. are grown in Sri Lanka [2]. Among them, *D. alata* and *D. esculenta* are the two most common cultivars of Sri Lanka. Moreover, edible tuberous roots, better known as yams or "*ala"* in Sinhalese, are a popular food source, particularly in rural areas, as they are packed with vital nutrients, with their high starch content making them a good substitute for cereals. Apart from the nutrition benefits, traditional yam cultivars belong to *D. alata* such as "Raja ala" and "Maha angili ala" are well recognized for their nutraceutical and health benefits including antioxidant, anticancer, anti-diabetic, immune stimulating, anti-hypertensive activities [3]. However, these valuable yams are currently underutilized in Sri Lanka and in this study an attempt was carried out to develop gluten-free muffins from "Maha angili ala" yam flour for commercialization.

During the past two decades, the demand for gluten-free foods has increased due to the growing number of consumers suffering of gluten intolerance disorder, known as coeliac disease, which is characterized by a permanent intolerance to the gliadin fraction of wheat, producing damages in the intestinal mucosa through inflammation of the micro-villi and thereby deteriorating the ability to absorb nutrients. To target the 0.5 – 1.0% of the world's population estimated to be affected by coeliac auto-immune disease, a number of food products that avoid the use of wheat (gliadin), barley (hordein) and rye (secalins) have been lately developed [4]. For example, muffins are widely consumed sweet, spongy breakfast or evening snack foods prepared traditionally from wheat flour, sugar, oil/fat, milk and eggs. However, wheat-free muffins are of interest in the present times not only for people who are gluten intolerant, but also for people interested in GF foods. Therefore, traditional yam "Maha angili ala" flour can be a possible substitute for wheat flour in preparation of gluten-free muffins.

## II. MATERIALS AND METHODS

### A. Yams and Flour Preparation

Traditional yam "Maha angili ala" (*D. alata*) was obtained from Agricultural Research Station, Department of Agriculture, Thelijjawila, Sri Lanka during April, 2018. Initially, yam tubers were cleaned thoroughly to remove dirty particles and weighted. Thereafter, the peel of the tubers were removed and washed again. Then, the tubers were cut into small slices which facilitate proper dehydration. Next, the slices were placed on a flat tray and kept in the dehydrator at 60℃ for 24 hours. The resulting slices were grinded until it becomes a fine powder. The flour obtained was sieved through the 250 micron sieve, sealed in polythene bags, and stored in the cold room.

### B. Proximate Analysis of Yam Flour

The moisture, crude protein, crude fat, and ash contents of flour were determined according to the standard AOAC official analytical methods. In addition, the total phenolic content was measured by Folin-Ciocalteu method and result was expressed mg gallic acid equivalent per 100 g of flour (mg GAE/100 g).

### C. Analysis of Physico-chemical Properties of Yam Flour

Color: The $L^*$, $a^*$, and $b^*$ colour values of flour and developed gluten-free muffins were determined by using a chromameter (Lovibond LC100, HunterLab, USA).

### D. Water Holding Capacity (WHC)

The WHC was measured by the modified centrifugation method published previously [5]. Briefly, the sample (3.0 g) was dispersed in 25 ml of distilled water and placed in pre weighted centrifuged tubes. Then the dispersions were stirred and were left at room temperature for 1 h, followed

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by centrifugation for 25 min at 3000 *g*. The supernatant was discarded and the moisture content of the sample was determined by dehydration in an oven for 1h at 37℃. The water absorption capacity was expressed as grams of water bound per gram of the sample on a dry basis.

### *E. Oil Holding Capacity (OHC)*

OHC of the flour sample was determined according to a previously published method [5] with slight modifications. Briefly, the sample (1.0 g) was mixed with 12 ml of coconut oil in pre-weighted centrifuge tubes. Then the dispersions were stirred and left at room temperature for 1 h followed by centrifugation for 25 min at 3000*g*. The oil supernatant was then removed and measured. The OHC of flour sample was expressed as the number of grams of oil hold by 1 g of sample (DW).

### *F. Preparation of Gluten-free Muffins*

In this study, two types of commercial food stabilizers (either guar gum or xanthan gum; the food grade from the commercial market) were used to develop gluten-free muffins from "Maha angili ala" flour (without wheat flour) and the control muffin samples were developed with wheat flour to compare physico-chemical characteristics (Table 1.).

First, sunflower oil and sugar were beaten for 10 min using a manual beater followed by the addition of egg and milk powder (dissolved in hot water) and the mixture was beaten for another 5 min.

TABLE 1. FORMULATION OF MUFFINS.

| **Ingredients** | **Control muffins (only wheat flour)** | **"Maha angili ala" flour with Guar gum** | **"Maha angili ala" flour with Xanthan gum** |
|---|---|---|---|
| Flour | 50 g | 49.85 g | 49.85 g |
| Sunflower oil | 20 g | 20 g | 20 g |
| Sugar | 30 g | 30 g | 30 g |
| Egg | 25 g | 25 g | 25 g |
| Milk powder | 14 g | 14 g | 14 g |
| Hot water | 70 ml | 70 ml | 70 ml |
| Baking powder | 2.5 g | 2.5 g | 2.5 g |
| Gum | 0 | 0.15 g | 0.15 g |

Then, flour (either "Maha angili ala" or wheat) baking powder, and gum were mixed well and added to the first oil, sugar, egg, and milk mixture. The combined mixtures were thoroughly mixed again for 10 min and poured in to the paper molds followed by baking in an oven at 180℃ for 30 min. The muffins were packed in poly packs and kept at 4℃ until further analysis.

### *G. Texture Profile Analysis of Muffins*

Approximately, 2.5 × 2.5 × 2.5 cm blocks of muffins were subjected to texture profile analysis using a texture analyzer (Texture Pro CT V1.8 Build 31) with a texture probe (TA11/1000, diameter 25 mm).

### *H. Sensory Evaluation of Muffins*

Randomly selected 30 semi-trained panelists were used to organoleptically assess the fresh muffin samples for appearance, colour, aroma, Texture (sponginess, softness), Taste, after taste, overall acceptability and rank. The sensory assessors scored their preference from 1 (Extremely dislike) to 5 (Extremely like) to inform their respective opinions on the test parameters. The assessors were further requested to comment freely on the muffin samples after their physical examinations of the samples and the Friedman non-parametric analysis was used to analyze data.

### *I. Statistical Analysis*

All analysis was carried out in triplicates and was reported as mean ± standard deviation. The collected data was finally analyzed by using, Minitab 17 package. For the parametric data analysis, One-way ANOVA was used at 95% confidence interval and for the pair wise comparison of the means Turkey's Analysis was used and MS Office Excel 2010 was used for the graphical representation of the data.

## III. RESULTS AND DISCUSSION

### *A. Proximate Analysis of "Maha angili ala" Yam Flour*

The proximate analysis results of yam flour are presented in Table 2. The all values are based on dry weight basis and the moisture content of flour was 5.25 ± 0.14%. Generally, this moisture content reduces the growth of molds and helps to store flour longer. Most of traditional yams of *Dioscorea* spp. are seasonal and for the commercialization of value-added food products from these flours the industry needs to store flour for the continuous production of muffins. Protein content in yams varies according to the species, environmental conditions and it also depends on the applied method of protein determination.

TABLE 2. PROXIMATE ANALYSIS OF "MAHA ANGILI ALA" YAM FLOUR.

| **Constituent** | **Composition (%, dry weight basis)** |
|---|---|
| Moisture | 5.25 ± 0.14 |
| Carbohydrates | 66.41 ± 2.83 |
| Protein | 6.99 ± 0.62 |
| Ash | 3.54 ± 0.16 |
| Fat | 0.56 ± 0.08 |

The protein value also differs according to the value of the nitrogen to protein conversion factor used. In general, protein content is calculated by multiplying nitrogen value, which is determined by the Kjeldahl method, by a nitrogen to protein conversion factor. In here not only protein nitrogen, but also non - protein nitrogen is determined by this method. The conventional value of the conversion factor is 6.25 for animal and some plant proteins and assumed that protein contain 16% of nitrogen. But the case is this requirement is not complete in some yams because of the presence of non – protein compound.

The Folin-Ciocalteu analysis resulted that the total phenol content of "Maha angili ala" yam flour was 106.59 ± 1.20 mg GAE/100 g. The phenols are responsible for the browning of foods and in this study no added food colours

because the yam flour itself converted to chocolate brown muffin after baking.

### B. Physico-chemical Properties of Yam Flour

The $L^*$, $a^*$, and $b^*$ chromameter values of the "Maha angili ala" flour were 70.36 ± 0.79, 5.57 ± 1.64, and 16.63 ± 0.77, respectively. Lightness of the flour is higher. In $a^*$ values, negative values indicate the closeness to green and positive values indicate the closeness to red colour. The flour sample is shown to be as close to redness. Negative $b^*$ values indicate closeness to blue color and positive values indicate closeness to yellowness. Colour of the flour sample is shown to be as close to yellow color. The WHC value of "Maha angili ala" yam flour is 1.58 g of water/g of flour and it represents the ability of a product to associate with water under conditions where water is limited [6]. The value of OHC is 0.86 g of oil/ g of flour. The water and oil holding capacity of food protein depend upon the intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrophobicity.

### C. Properties of Gluten-free Muffins

Two types of food gums (either guar gum or xanthan gum) were used to develop gluten-free muffins from "Maha angili ala" *D. alata* yam flour (Fig. 1) and they were compared with control muffins.

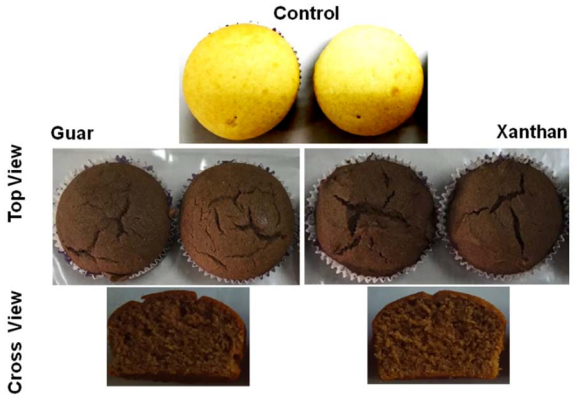


Fig. 1. Developed muffins from wheat flour (Control) and "Maha angili ala" flour (with either Guar or Xanthan gums).

The texture profile analysis of developed muffins has revealed that there is no significance difference of hardness, springiness, and chewiness in between Guar, Xanthan gums added muffins ("Maha angili ala" flour) and control muffins (wheat flour) (Table 3). The Chewiness is the energy needed to chew a solid food and disintegrate it for swallowing [7].

Moreover, when consider cohesiveness, there is no significant difference in Guar gum and Xanthan gum added muffins. However, these two types of developed gluten-free muffins from "Maha angili ala" are significantly different from control muffins in cohesiveness and gummines properties. The cohesiveness is a parameter related to the ability of the structural components of the crumb to remain assembled contributing to a lesser crumbling against the application of a force [8]. The control muffins developed from wheat flour have shown the highest gumminess. In another study, the gluten-free muffins developed jointly from rice and corn flour showed low chewiness at higher rate of American carob (*Prosopis alba*) flour [8].

TABLE 3. TEXTURE ANALYSIS RESULTS OF MUFFINS.

| Muffin | Hardness | Cohesiveness | Springiness | Gumminess | Chewiness |
|---|---|---|---|---|---|
| Control | 545.0 ± 164.5$^a$ | 0.63 ± 0.11$^a$ | 10.03 ± 1.63$^a$ | 341.1 ± 97.9$^a$ | 33.68 ± 12.41$^a$ |
| Guar | 425.0 ± 43.6$^a$ | 0.30 ± 0.04$^b$ | 14.79 ± 7.92$^a$ | 127.60 ± 14.0$^b$ | 19.16 ± 12.25$^a$ |
| Xantha n | 366.7 ± 82.5$^a$ | 0.35 ± 0.14$^b$ | 18.34 ± 13.77$^a$ | 135.1 ± 81.9$^b$ | 31.3 ± 38.70$^a$ |

Values for texture profile analysis are means ± SD; n=3, and means in the same column followed by different letters are significantly different ($p$<0.05).

Muffins usually present high volume with a porous structure that confers a spongy texture. One of the great challenges when developing gluten-free muffins is to find an ingredient to mimic gluten. Therefore, in this study two food gums such as guar and xanthan were used. The $L^*$, $a^*$, and $b^*$ colour values of the crust (top view) of guar gum added muffins were 31.87 ± 0.56, 13.54 ± 1.17, and 12.26 ± 1.84, respectively.

Meanwhile, the $L^*$, $a^*$, and $b^*$ colour values of the crust (top view) of xanthan gum added muffins were 31.93 ± 0.65, 12.23 ± 1.34, and 12.11 ± 1.16, respectively and showed no significant difference between two gums added muffins. The addition of non-cereal plant flours increases browning of muffins during the baking process. For example, gluten-free muffins developed from squash seed flour at 20% (w/w) has increased browning. The physic-chemical and textural analysis results revealed that though muffins are popular wheat flour-based baked food product that can be reformulated to be non-wheat and gluten-free with traditional yam "Maha angili ala" flour. This will be a potential economic crop to cultivate in farm scale and the flour can be introduced to the bakery industry.

### D. Sensory Evaluation of Muffins

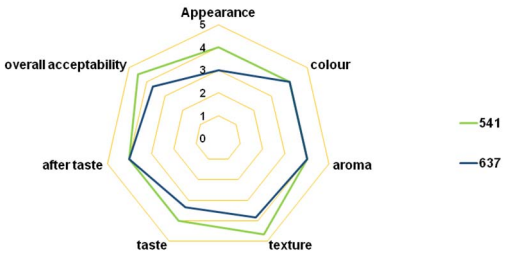


Fig. 2. Web diagram of the average rank of gluten-free muffins (541-Guar gum added and 637-Xanthan gum added) from "Maha angili ala" flour.

Developed gluten-free muffins were organoleptically assessed for appearance, colour, aroma, texture (sponginess and softness), taste, after taste, and overall acceptability. The web diagram of the average rank of the two types of muffins is presented in the Fig. 2.

According to the sensory analysis results, the quality attributes tested, such as appearance, taste, and texture of the Guar gum added muffins were the most acceptable by the panelists. Therefore, Guar gum can be recommended for use in the development of gluten-free muffins from *D. alata* flour with desirable sensory properties.

## IV. CONCLUSIONS

Comparing the texture profile of two types of gum added muffins with control wheat muffins, hardness, cohesiveness and gumminess were not significantly different in between three muffins. Moreover, the sensory evaluation of two types of gum added muffins, the guar gum added muffins had the acceptable level of sensory profile. Furthermore, the proximate analysis of "Maha angili ala" flour has concluded its available protein and minerals contents. Collectively, it can be concluded that "Maha angili ala" (*Dioscorea alata*) flour can be used as a substitute for wheat flour to develop nutritious gluten-free muffins for both healthy and people who are suffering with Celiac disorder.

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