OPTIMIZATION OF TARO LEAVES FOR THE DEVELOPMENT OF VALUE ADDED FOOD PRODUCTS

Dissertation II Report

Submitted by:

Kritika Gupta

11718885

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School of Agriculture

Lovely Professional University, Phagwara

Under the guidance of

Dr. Ashwani Kumar

Assistant Professor

Department of Food Technology and Nutrition

School of Agriculture

Lovely Professional University, Phagwara

April 23, 2018

CERTIFICATE

This is to certify that **Kritika Gupta** (Registration No. 11718885) has personally completed M.Sc. Dissertation 1 entitled "*Optimization of taro leaves for the development of value added food products*" under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of dissertation has ever been submitted for any other purpose at any University.

The project report is appropriate for the submission and the partial fulfillment of the conditions for the evaluation leading to the award of Master of Nutrition and Dietetics.

Date: April 23, 2018

Signature of Supervisor

Dr. Ashwani Kumar
Assistant Professor
Department of Food Technology and Nutrition
School of Agriculture
Lovely Professional University
Phagwara, Punjab, India

DECLARATION

I hereby declare that the work presented in the pre-dissertation report entitled "OPTIMIZATION OF TARO LEAVES FOR THE DEVELOPMENT OF VALUE ADDED FOOD PRODUCTS" is my own and original. I have carried out the work at School of Agriculture, Lovely Professional University, Phagwara, Punjab, India under the guidance of **Dr. Ashwani Kumar,** Assistant Professor (Food Technology), School of Agriculture, Lovely Professional University, Phagwara, Punjab, India, for the award of the degree of Master of Science in Food Technology.

Date: April 23, 2018 **Kritika Gupta**

Place: Phagwara, Punjab (India) **Registration No. :** 11718885

I certified that the above statement made by the student is correct to the best of my knowledge and belief.

Place: Phagwara, Punjab (India) **Dr. Ashwani Kumar**

Date:

Assistant Professor
Dept. of Food Technology and Nutrition

School of Agriculture

Lovely Professional University
Phagwara, Punjab, India

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1. INTRODUCTION

Increasing vegetarianism and food security needs have increased plant based research. Numerous traditional evidences also demonstrate the immense potential of locally cultivated crops in medicine and food industry. In India, fresh-food preparations form an important component of the daily diet. Green leaves are well known for the nutritional and medicinal properties and the fact that they are cheaper, increases their consumption. *Colocasia* spp. is an ancient green leafy vegetable cultivated throughout the humid tropical regions (Onwueme, 1999). It is believed to be originated in South Central Asia, probably in India or the Malay Peninsula and spread to Burma and China in the East, and to Indonesia in the West; in historical times it spread to Egypt and the eastern Mediterranean, and then to Africa, the Guinea coast, and the Caribbean (Kay, 1987). Now, taro is pan-tropical in its distribution and cultivation. The highest percentage contribution of taro to the diet occurs in the Pacific Islands. West Africa has the largest area of cultivation and hence accounts for the greatest quantity of production.

Internationally it is also called edible yam, whereas in India it may be called by local names like Arbi, Chaembu, Shaeppamkizhangu or Ghuiyaa, depending on cultivation and consumption areas (Khare, 2007). Much of the literature describes the use of *Colocasia* stem as food. The use of leaves as food is limited to certain regions. The use of leaves for food purposes has not been recorded in the Eastern Mediterranean region (Matthews 2012). Extensive literature is available about its use as animal fodder. This paper is an attempt to revive the importance of *Colocasia* leaves and inculcate its traditionally known applications in food and therapy into modern day usage of food, nutrition and technology.

Colocasia leaves have important therapeutic and nutritional properties, which makes them worthy to be placed amongst other green leafy vegetables like spinach. The leaves are

exceptionally high in folate content, which can make them a preferred choice for pregnant and lactating women. Processing of leaves can reduce their anti-nutritional properties too. The iron and ascorbic acid composition of *Colocasia* leaves suggests them to be of high importance to girls and women in general and those patients suffering from deficiency of calcium, phosphorous or magnesium. The high potassium content can prove to be a good coagulant as well to prevent excessive bleeding or hemorrhages. Also the potassium - sodium ratio can make it a choice for patients suffering from blood pressure related problems. Presence of high amounts of carotenoids proposes them to be excellent antioxidants.

2. PROBLEM BACKGROUND

The consumption of taro leaves is confined to the rural areas and large part of the produce is wasted. Leaves have exceptionally good nutritive composition, especially folate, iron, carotenoids, calcium and other micronutrients. These micronutrients can help to combat deficiency diseases of folic acid and iron which are prevalent among Indian adolescents and pregnant women. In addition, iron and folic acid supplementation have been also found to be associated with decreased risk of preeclampsia and eclampsia among pregnant women, which accounts to nearly 25% cases of maternal mortality worldwide (Agrawal et al. 2015). The value added product made with the addition of taro leaf powder is expected to be high in iron, folic acid, zinc and potassium, which can help in control of hypertension, preeclampsia and eclampsia. Also, zinc is found to have antidiabetic properties, thus making the value added product suitable for diabetic patients.

3. REVIEW OF LITERATURE

3.1 Nutritional composition

Fresh *Colocasia* leaves have high moisture content of 82.15-90.6% (Ejoh et al., 1996; Oliveira & De Carvalho, 1975; Awasthi & Singh, 2000). The leaves have low protein content in the range of 18-30.7 mg $100g^{-1}$ (Gupta et al. 1989; Ejoh et al., 1996). The protein and dietary fibre content of *Colocasia* is more than other important green leaves, as it can be inferred from figure 1. The leaves have good amount of niacin, i.e. 7.12 mg per 100g dry matter (Oliveira & De Carvalho, 1975); which helps in regulation of metabolism. The amount of vitamin C (26.35 - 82.6mg $100g^{-1}$) and carotenoids (26.82mg $100g^{-1}$) present in leaves does not only contribute towards its antioxidant properties, but also the vitamin C can help in sufficient iron absorption. The amount of iron in *Colocasia* leaves (34.1-117mg kg^{-1}) is more than that present in mustard and spinach leaves (Figure 1). These nutrients signify its potential role in skin and blood health. No significant difference from other greens was found in the concentration of ascorbic acid, phylloquinones, calcium, sodium, phosphorous, magnesium and potassium. As per the data presented by Longvah et al. (2017) in Indian Food Composition Tables 2017, *Colocasia* leaves have low sodium-potassium (Na/K) ratio of 1:40, which makes it a friendly choice for the patients suffering from hypertension and stroke (Willey et al., 2017; Binia et al., 2015; Du et al., 2013). Zinc (8.2 - 42mg kg^{-1}) has a bioavailability of around 25.7% (Agte et al. 2000) and can help in boosting the immune system along with the other micronutrients. Good amount of zinc and copper makes it beneficial for the human immune system. The following infographic chart clearly shows that the Total Polyunsaturated Fatty Acids (TPUFA) content of *Colocasia* leaves is about 48-57% higher the other green leaves, providing evidence for it being a heart friendly food.

From Table 1, it can be also inferred that the composition of *Colocasia* leaves vary significantly for every single nutrient, which is possible due to different regions of testing samples.

Table 1. Nutritional Composition of *Colocasia* Leaves (Dry matter)

Nutrient	**Unit**	**Range**	**References**
Moisture (wet matter)	%	82.15 - 90.6	Ejoh et al., 1996; Oliveira & De Carvalho, 1975; Awasthi & Singh, 2000
Energy	kcal kg^{-1}	2810 - 3963	Ejoh et al., 1996; Oliveira & De Carvalho, 1975
Crude Protein	g kg^{-1}	180 - 307	Ejoh et al., 1996; Gupta et al., 1989
Ash	g kg^{-1}	98 - 154	Ejoh et al., 1996; Oliveira & De Carvalho, 1975; Gupta et al., 1989
Carbohydrates	g kg^{-1}	369 - 524	Ejoh et al., 1996; Longvah et al., 2017
Niacin	mg $100g^{-1}$	7.12	Oliveira & De Carvalho, 1975
Vitamin C	mg $100g^{-1}$	26.35-82.6	Awasthi & Singh, 2000; Mepba et al., 2007
Total carotenoids	mg $100g^{-1}$	1.2 - 26.82	Awasthi & Singh, 2000; Longvah et al.,2017
Calcium	g kg^{-1}	8.6-23.2	Ejoh et al., 1996; Oliveira & De Carvalho, 1975; Radek & Savage, 2008
Copper	mg kg^{-1}	2.9-12	Ejoh et al., 1996; Longvah et al., 2017
Iron	mg kg^{-1}	34.1-117	Ejoh et al., 1996; Longvah et al., 2017
Folic acid	µg $100g^{-1}$	5 (raw); 43 (cooked)	Devi et al. 2007; Agte et al. 2000
Magnesium	g kg^{-1}	1.7-7.52	Ejoh et al., 1996; Oliveira & De Carvalho, 1975

Phosphorous	g kg^{-1}	4.01-4.1	Ejoh et al., 1996; Oliveira & De Carvalho, 1975
Potassium	g kg^{-1}	2.13-18	Ejoh et al., 1996; Oliveira & De Carvalho, 1975
Sodium	mg kg^{-1}	10-70	Ejoh et al., 1996; Oliveira & De Carvalho, 1975
Manganese	mg kg^{-1}	259	Ejoh et al., 1996
Zinc	mg kg^{-1}	8.2-42	Ejoh et al., 1996; Longvah et al., 2017

3.2 Curative properties of Taro leaves

3.2.1 *Anti-cancerous*

A study conducted by Brown et al (2005) had suggested that *Colocasia* may have novel tumour specific anti-cancer activities as it is an accepted probiotic with chemo protective characteristics. Juice of leaves is used in the treatment of cancer of nose and warts (Masuma and Mahbubur 2017).

3.2.2 *Anti-compulsive activity*

In their study, Kalaria et al (2015) reported anti-compulsive activity demonstrated by hydroalcoholic extract of leaves of *Colocasia esculenta* (HECE). This study was carried on a group of adult male albino Swiss mice and their marble behaviour was studied. 20 marbles were arranged in four rows spaced evenly. Obsessive-compulsive behaviour was measured by considering the total number of marbles buried as an index. The results of HECE were compared with that of fluoxentine, a standard drug used to treat obsessive-compulsive behaviour. It was found that the HECE had double the effect of the standard drug.

3.2.3 *Anti-diabetic*

The tests conducted by Akter et al (2013) demonstrated the antihyperglycemic potential of methanolic extracts of C*olocasia esculenta* leaves which significantly reduced the blood sugar concentrations by 44.7 % in glucose-loaded Swiss albino mice. The leaves were sliced, air-dried and grounded into fine powder and 100 g of powder was extracted methanol (1:5, w/v). One of the groups received a standard drug *Gibenclamide*, whereas other groups received methanol extracts of *Colocasia* eaves at various doses. It was found that methanolic extracts had approximately 1.4 times higher effect that the reference drug.

3.2.4 *Anti-haemorrhagic*

The pressed juice obtained from the petiole of colocasia leaves is stypic or astringent and can arrest arterial haemorrhage (Khare 2007, Prajapati 2011).

3.2.5 *Anti-hepatotoxic*

The study conducted by Patil and Ageely concluded that the leaves of the *Colocasia esculenta* have antihepatotoxic efficacy, which may be attributed to the presence of anthocyanin or flavonoids (Patil and Ageely 2011).

3.2.6 *Anti-hypertensive*

Anti-hypertensive activity of the aqueous extract of *Colocasia esculenta* leaves were revealed in the study conducted by Vasant et al (2012), which was proposed to be due to the presence of flavonoids and/ or due to the inhibition of angiotensin converting enzyme (ACE), inhibition of phosphodiesterase or due to vasodilation resulted by the release of endothelium-dervied relaxing factor (EDRF).

3.2.7 *Laxative*

Dry vegetable preparation made from colocasia leaves can help in relieving constipation (Khare 2007; Manju et al., 2011).

3.2.8 To heal sting and bites

Leaf juice can be applied on scorpion sting or snakebite and is an important medicinal property (Devarkar et al. 2011).

3.2.9 Treatment of athlete's foot

Juice of the petioles is used in the treatment of athlete's foot, which refers to a fungal infection affecting the skin between toes (Masuma and Mahbubur 2016).

3.3 Traditional and modern Recipes Made out of *Colocasia* Leaves

3.3.1 *Patra*

Patra is a Gujarati dish made by rolling up the leaves one after another after getting smeared with besan paste. These are then cut into small pieces and steamed or deep fried as required.

3.3.2 *Turiya Patra*

Turiya Patra is an unusual but common combination of ridge gourd and patra. It is a Gujarati dish and often served during marriages.

3.3.3 *Lavingya Patra*

It is also a Guajarati dish and involves cooking thin layers of besan based paste rolled up in baby colocasia leaves. It is a good source of calcium.

3.3.4 *Alvati*

Alvati is a Konkani cuisine. It involves well cooking of colocasia leaves with coconut masala and star fruit, kack fruit seeds or bamboo shoots etc to break down oxalate crystal so as to avoid itchiness in mouth. It is very important to use only tender colocasia leaves only.

3.3.5 *Aluchi Bhaji*

Aluchi Bhaji is a Maharashtrian curry made using cokocasia leaves, peanuts and Bengal gram dal.

3.3.6 *Khatti bhujji (also called Garyali bhuji) and Patrodu*

These are the traditional recipes of Himachal Pradesh (Kapoor et al 2010). *Khatti bhujji* is prepared from whole plant of colocasia along with its leaves, stem and bulb. It is often consumed during *Diwali* festival. *Patrodu* is prepared from leaves of colocasia and can be shallow fried or deep-fried. It is usually made during rainy season.

3.3.7 *Anshi*

Anshi is another food made from edible colocasia leaves. It is a tribal food of Naga tribe and made by fermentation (Mao and Odyuo 2007).

3.4 Effect of processing on Taro

Various methods of processing like soaking and boiling have been found to reduce the oxalic content in the food, which is summarised as below. Baking the leaves will effectively increase the oxalate concentration of the baked dish (Savage et al 2009). Most pronounced effects (50% reduction) were produced by cooking and ensiling (Hang and Preston 2010).

3.4.1 *Effect of soaking on taro leaves*

Hang and co-workers found that soaking the leaves for up to 7-10 h in tap-water could reduce the soluble oxalate by 63.1 - 69.5% (Hang et al 2013).

3.4.2 *Effect of microwave boiling on taro*

Tannin content of *C. esculenta* was found to increase by 3.7% on microwave boiling with 5% NaCl salt which could be attributed to the effect of Na^+ and Cl^- that hinders the decomposition of hydrolysable tannins (Singh et al 2015). In the same experiment, flavonoid content was also increased by 34.3% which could be due to change in compound matrix or due to increased levels of free flavonols (Singh et al 2015; Azizah et al 2009); whereas the carotenoid content was increased by 142.9%.

3.4.3 *Effect of baking on taro leaves*

Taro leaves, grown in New Zealand, showed 49 % reduction in soluble oxalate content in young leaves and 73% reduction in that of mature leaves when baked with milk (Oscarsson and Savage 2007). Baking of any food leads to loss of water and thereby increasing the concentration of oxalate in food (Noonan and Savage 1999). Savage, Mårtensson and Sedcole (2008) found that addition of cow milk and coconut milk led to increase in calcium content and 43.2 % reduction oxalate content of the baked mixture.

3.4.4 *Effect of cooking on taro leaves*

In the study conducted by Hang and his co-workers, it was found that cooking the leaves for 10 minutes led to a mean 62.1 % reduction in soluble oxalate (Hang et al 2013).

3.4.5 *Effect of thermal processing on taro leaves*

Lectin and protease inhibitor effect can be reduced by processing with heat, thus increasing the eating and nutritional quality of leaves (Ravindarn *et al*., 2006 and Sumathi and Pattabiraman, 2007).

4. PROPOSED RESEARCH OBJECTIVES

The mandate of the present study is as under

a. Quality evaluation of taro leaves
b. To study the effect of various pretreatments on the nutritional and anti-nutritional factors of taro leaves
c. Development of value added food products and their quality evaluation
d. To study the shelf life of the developed products

5. PROPOSED RESEARCH METHODOLOGY

5.1 Experiment 1:

Quality evaluation of taro leaves

Proximate Nutrition Analysis

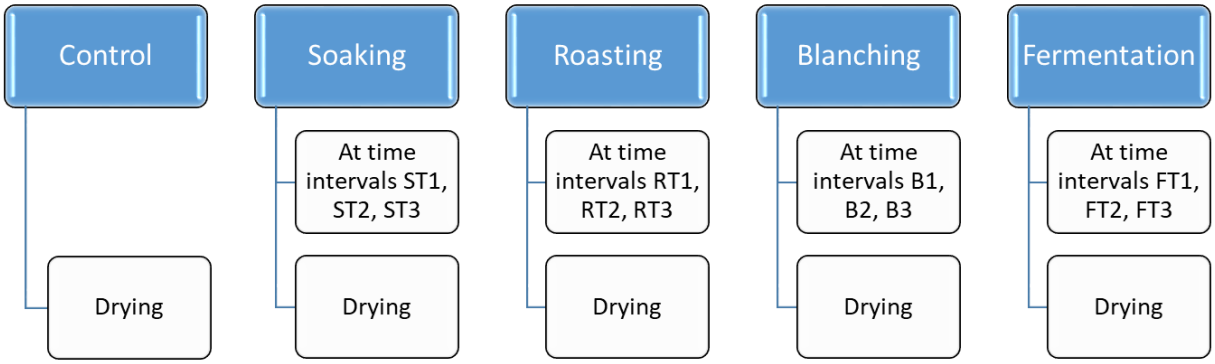
Moisture Content	AOAC 2000
Protein content	AOAC 2000
Fat content	Soxhlet extraction method
Crude fiber content	AOAC 2000
Ash content	AOAC 2000
Sugars	AOAC 2000
Dietary fiber content	Van Soest and Wine (1967), AOAC 991.43
Ascorbic Acid	AOAC 2004

Anti-Nutritional Factors

Oxalic Acid	Moureau and Savage 2009
Phytates	AOAC 986.11-1988
Tannins	Ricci et al. 2015
Phytic acid	Lewis et al. 2017
Saponins	Almutairi et al. 2014
Trypsin inhibitor	Zhang et al. 2008

5.2 Experiment 2:

To study the effect of various pretreatments on the nutritional and anti-nutritional value of taro leaves



5.3 Experiment 3:

Development of value added food products and their quality evaluation

Best of the above pretreatments will be selected for the pretreatment of the final product. The value added products to be analyzed will include chapatti, bread and extruded products like pasta. The obtained product will be analyzed for the following parameters.

i.	Moisture content	Olawuni et al. 2013
ii.	Free fatty acid content (FFA)	Balogun et al. 2012
iii.	Vitamin C content	Baba et al. 2016
iv.	Protein content	AOAC 2000
v.	Fat content	Soxhlet extraction method
vi.	Crude fiber content	AOAC 2000
vii.	Ash content	
viii.	Sugars	AOAC 2000
ix.	Dietary fiber content	Van Soest and Wine (1967), AOAC 991.43
x.	Ascorbic Acid	AOAC 2004
xi.	Oxalic Acid	Moureau and Savage 2009
xii.	Phytates	AOAC 986.11-1988
xiii.	Tannins	Ricci et al. 2015
xiv.	Phytic acid	Lewis et al. 2017
xv.	Saponins	Almutairi et al. 2014
xvi.	Trypsin inhibitor	Zhang et al. 2008

Organoleptic Evaluation

A **9-point hedonic scale** will be used to evaluate the experimental samples using 100 semi trained panelists. Healthy male and female of suitable age will be selected for the evaluation.

Expression	Points to be assigned
Liked extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6
Neither liked nor disliked	5

Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

Sample code	Color and appearance	Flavor and sweetness	Body and texture	Mouthfeel	Overall acceptability	Remarks (if any)

Mean sensory score on composite sensory scale for the developed product

Sensory attributes	**Possible score**	**Mean score ± SD**	**Number of judges**

5.4 Experiment 4:

To study the storage life of the developed products

The developed food products will be evaluated for its:

i. Effect of packaging material on the shelf life of the product
   Laminated Pouch
   High Density Poly Ethylene (HDPE)
   Aluminum Foil Pouches

ii. Test to be performed
   a. Moisture content (Olawuni et al. 2013)
   b. Free fatty acid content (FFA) (Balogun et al. 2012)
   c. Starch digestibility (Du et al. 2014)
   d. Protein digestibility (Mundi et al. 2012)
   e. Vitamin C content (Baba et al. 2016)
   f. Polyphenols (Sakakibara et al. 2003)
   g. Saponins (Dini et al. 2009)
   h. Phytates (AOAC 986.11-1988)
   i. Carotenoids (Delia and Mieko 2004)
   j. Change in water activity
   k. Microbiological analysis
      Yeast count
      Mold count
      Total Plate Count
   l. Organoleptic evaluation of the developed food product

6. EXPECTED RESEARCH OUTCOME

As a solution to the problem background, the dried taro leaf powder will have potential health benefiting properties like anti-hypertensive, anti-diabetic and anti-oxidant. The product enriched and developed with the help of the same will have the similar properties and advantages.

Apart from this, the product will be a low cost nutritional product thus suiting all the economic strata of the country. Since the underprivileged and the people belonging to low economic status usually suffer from the problems like iron deficiency anaemia, folic acid deficiency, preeclampsia and eclampsia, this product will find major place in therapeutic health sector.

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