

# Review Article: Arrowroot - Gluten-free, Multipurpose Crops

Shubhangi Kumari <sup>1</sup>, Dr. Avinash Singh <sup>2</sup>, Prachi Tamrakar <sup>3</sup>

<sup>2</sup> Associate Professor, <sup>3</sup> PhD Research Scholar

<sup>1</sup> Department of Food Technology, Warner College of Dairy Technology

<sup>2</sup> Department of Dairy Technology

<sup>3</sup> Department of Horticulture

## Abstract

Arrowroot is a starchy vegetable obtained from rhizomes of the tropical plant *Maranta arundinacea*. It contains several medicinal properties such as antioxidant properties, anti-anemic properties, anti-diabetic properties, anti-inflammatory properties, hepatoprotective properties, antimicrobial properties and chemoprotective properties. Arrowroot is in general employed to obtain starch and may yield near about 12-15% of the starch by dry weight. Arrowroot is said to be a tropical tuber native to Indonesia. It's usually processed into a powder, also called arrowroot flour that comes with a dense store of energy and used widely in both sweet and savoury dishes alike although it may have medicinal properties as well. The powder is extracted from the plant's rhizome, an underground stem with the multiple roots that store it's starch and energy. Arrowroot powder is fine, clear white, and odorless item like corn starch but ranks high on nutritional content found use as a thickening agent in the food industries. Some of the potent Ayurveda and medicinal properties of arrowroot includes alexeteric that thwarts toxin and infection, anti-dysenteric relieves and averts stomach as upset, aphrodisiac stimulates sexual drive, antipyretic subsides fever, depurative works as a purifying agent and hypocholesterolemic diminishes cholesterol levels of the blood. Aside from being high in protein and several nutrients, arrowroot is very easy to digest, making it ideal for children and older adults who may need gentler food. Its high starch content, arrowroot may be suitable for gluten-free diets, promote weight loss, help treat diarrhea, and strengthen your immune system.

**Keywords:** Arrowroot, Starch, Gluten-free Diet, Celiac Disease

## Introduction

Arrowroot powder is frequently used as a thickening agent in foods or a gluten-free replacement for the wheat flour. Though it's also added to homemade cosmetics, scientific research on these applications is lacking anyhow.

Arrowroot flour are used in the food and cosmetic products like gluten-free cookies, cake, biscuits, bread, muffins, and dry shampoo, talcum and baby powder substitute, deodorant ingredient, homemade makeup etc.

Arrowroot (*Maranta arundinacea* L.) plant is a tall herb with the short-leafy branched stem from Marantaceae family which yields some thick, fleshy, creeping, spindle-shaped, long (15 to 20 cm) and dull white to creamy colored rootstock rhizomes which contain fine easily digestible starch. It is indigenous to tropical America. It is an under-exploited tuber crop and rhizomes are valued as foodstuff and as a source of starch. It is tolerant to shade conditions and can be cultivated under coconut and areca nut plantations and can yield 20-30 tones fresh rhizomes per hectare. It can be economically important crop as it serves as a raw material for cottage industry by unemployed women and the rural youth. It is a nourishing food for children, chronically diseased and convalescents. Arrowroot starch has many medicinal uses as well. As it is said to be nutritive starch that can be easily digested, it is given to baby and people recovering from an illness or medical treatment. The starch possesses demulcent and anti-diarrhoeal properties and is to be used in the treatment of intestinal disorders which add medicinal value to the crop. It is widely distributed throughout the tropical countries like West Indies particularly St. Vincent, which produces about 95% of the world's commercial supply; India, Sri Lanka, Indonesia, Philippines and Australia. In India, arrowroot is mainly cultivated in Uttar Pradesh, Bihar, Orissa, West Bengal, Assam and Kerala. Its powder is one of the nature's finest carbohydrates [1].

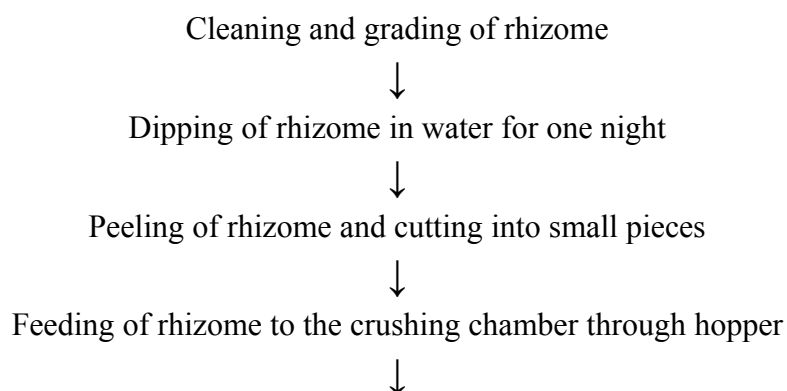
Arrowroot as a potential for producing gluten-free products, considering the nutritional and technological properties of plant. Arrowroot rhizome has high amounts of phosphorus, sodium, potassium, magnesium, iron, calcium, and zinc [2].

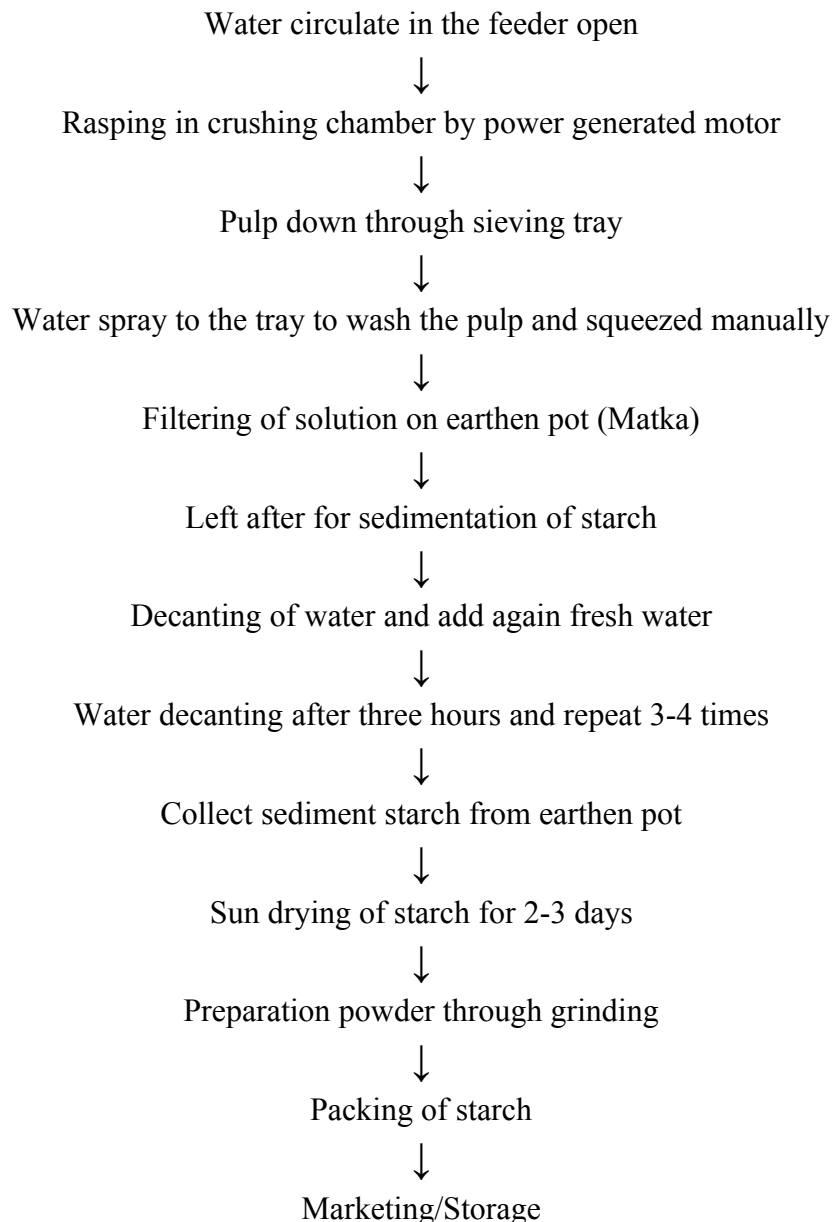
### Starch Extraction

The rhizomes are hereby washed thoroughly and then cleaned off the paper-like scale. The scales must be carefully removed before extracting starch because they impart a disagreeable flavor. After removing the scale, the roots are said to be washed again, drained and finally reduced to a pulp by beating them in mortars or subjecting them to the action of a wheel rasp. The milky liquid thus obtained is passed through a coarse cloth or hair sieve and the pure starch, which is insoluble, is allowed to settle at bottom.

It is a best source of easily absorbable starch. When taken daily it helps to lower the cholesterol. It works due to presence of bioactive compounds such as alkaloids, carbohydrate, cardiac glycosides, amino acids, phenolic compounds, terpenoids, saponins, flavones and gum. Arrowroot starch has extensive application in the medicinal, nutraceutical, industrial and bakery products [3].

### Flow Chart of Arrowroot Starch





### Starch and its Properties

The basic functional properties of starch (hardness/firmness, cohesiveness, adhesiveness, elasticity, and brittleness) are determined by a set of attributes; including the molecular composition of starch itself, the crystalline arrangement, the presence of residues from the extraction process, and any modifications to the structure [4].

In food preparation, flours and starches from tuberous sources can meet the industrial requirements of carbohydrate-based food products, since they slimy at relatively low temperatures with swift and uniform swelling of granules, and exhibit a profile of high viscosity when compared with the cereal starches [5].

Food prepared with arrowroot starch possesses high in vitro and in vivo digestibility (ranging from 30.07% to 95.7%). In general, it is said that high digestibility is associated with starch retrogradation in

the prepared food. This factor is also associated with a greater food attractiveness in the first phase of feeding (chewing and swallowing), providing the sensations of softness, stiffness, and crunchiness. The perception of these organoleptic characteristics is a dynamic process, which should involve the consumer, as well as the chemical and physical characterisation of the food, as determined by effective research methods. Retrogradation is an important research object, mainly due to its desirable or undesirable effect on final products, especially on texture and syneresis.

A key aspect is to determine if the arrowroot starch exhibits a physicochemical constitution that is similar to that for other native starches as well. However, properties of interest, including that of value, are associated with the characteristics of lightness and softness, and the functionality of gels and pastes that have a high applicability, clear paste, fluidity, and a good physical structure after cooling. The characteristics of clarity or transparency in the arrowroot starch gels are described as an advantage of the product.

One of the most widely employed for starch quality control in the food industry and in research studies. The viscosity curve is to be explained by Thomas and Atwell (1999). In the initial stage, the granules absorb water, swell, and, with temperature increase, a rupture occurs, leaching the amylose for suspension; concomitantly, bonding with amylopectin side chains occurs, increasing viscosity. After paste cooling, viscosity breakdown occurs, followed by retrogradation (molecular rearrangement), and then final viscosity. Arrowroot starch has a high content of carboxylic acid and that this factor is associated with starch quality. It is known that the presence of carboxylic acid in starch is associated with the contamination problems, resulting in its fermentation. Arrowroot starch is different in several characteristics, mainly because it is not colored and it's free of odors that would make its use unviable. The product has high water retention capacity, a high lipid absorption index, a moderate gelatinization temperature, and a moderate paste stability, thus having a high promise for use in the food industry.

The technical-functional properties of arrowroot starch have been investigated for potential applications. Verified that arrowroot starch is comparable to that in sodium carboxymethylcellulose, a polymer widely used in medicine preparation. They even concluded that the starch could be used as an excipient. The physicochemical and thermal properties of combined glycerol- and arrowroot starch-based biomembranes were investigated by the Gordillo et al. (2014), who showed that the blend presented a strong polymer matrix, suggesting that the starch has commercial potential for composites [6].

Properties of arrowroot starch indicate that this starch is of interest to the agroindustry sector, especially from perspective of current food market macro trends (healthiness, indulgence, and convenience). This interest is mainly because the chemical modifications are not required to reach properties of importance.

### **Chemical Composition and Utilization**

Arrowroot flour contain a remarkable amount of phosphorus (98 mg), sodium (26 mg), potassium (454 mg), magnesium (25 mg), iron (2.22 mg), calcium (6 mg) and zinc (0.63 mg). it is an excellent source of potassium (454 mg per 100 g or 10% of RDA) [7].

Potassium is an important component of cell and body fluids that help regulate heart rate and blood

pressure. Arrowroot contains healthy levels of the B-complex group of vitamins such as niacin, thiamin, pyridoxine, pantothenic acid and riboflavin. The percent nutrient composition of *Maranta arundinacea* contains 0.18% protein, 85.7% carbohydrate, 12.14% moisture, 0.05% fat. Arrowroot is very low in calories; 100 fresh roots carry just 65 calories; less than that of potato, yam, cassava, etc. Its chief polymeric carbohydrates are amylopectin (80%) and amylose (20%). Its powder is fine, odorless, granular starch. It has relatively more protein than that of other tropical food. It is a good source of folates. 100 g arrowroot provides 338 µg or 84% of daily required levels of folates. Folate, along with vitamin B-12, is said to be one of the essential components that take part in the DNA synthesis and cell division. It is a free form of gluten. Gluten-free starch is used in special food preparations for the celiac disease patients. According to US the National Library of Medicine National Institutes of Health, being a low-glycemic index foods, arrowroot consumption in fact helps in better regulation of blood glucose levels in diabetes patients [8].

### Gluten-free Diet

A gluten-free diet (GFD) is a nutritional plan that strictly excludes gluten, which is a mixture of proteins found in wheat (and all of its species and hybrids, such as spelt, kamut, and triticale), as well as barley, rye, and oats [9]. Gluten may cause both gastrointestinal and systemic symptoms for those with gluten-related disorders, including coeliac disease (CD), non-coeliac gluten sensitivity (NCGS), gluten ataxia, dermatitis herpetiformis (DH), and wheat allergy [9]. In these people, the gluten-free diet is demonstrated as an effective treatment, but several studies show that about 79% of the people with coeliac disease have an incomplete recovery of the small bowel, despite a strict gluten-free diet. Gluten proteins have low nutritional and biological value and the grains that contain gluten are not essential in the human diet. However, an unbalanced selection of food and an incorrect choice of gluten-free replacement products may lead to nutritional deficiencies. Replacing flour from wheat or other gluten-containing cereals with gluten-free flours in commercial products may lead to a lower intake of important nutrients, such as iron and B vitamins.

This is essentially a diet that removes all food containing or contaminated with gluten. However, since gluten-containing whole grains contains fiber and nutrients including B vitamins, magnesium, and iron, it's important to make up for these missing nutrients. Along with consuming naturally gluten-free foods in their whole form like fruits, vegetables, legumes, nuts, seeds, fish, eggs, and poultry, the following whole grains are also to be inherently gluten-free:

- Arrowroot Quinoa
- Brown, Black and Red Rice Buckwheat
- Amaranth Millet Corn Sorghum Teff
- Gluten-free Oats etc.

Arrowroot powder is a gluten-free starch that could potentially be used as starch substitute for people with the celiac disease. This research is in its early days though, and further tests will need to be done to confirm its effectiveness as a gluten-free starch substitute. Though research into the benefits of arrowroot is still in its early stages, there's evidence that this root is a healthy addition to the most diets.

A gluten-free diet is not new. It is a sole treatment for 1-2% of Americans who have celiac disease, a

serious condition where the body attacks a protein called gluten, naturally found in many whole grains, causing a spectrum of symptoms that might range from bloating to intestinal damage. Up to 6% of people have a related stomach-upsetting but less threatening condition called non-celiac gluten sensitivity.

The use of a gluten-free diet for weight loss, partly fueled by the celebrity endorsements and personal testimonies of not only pounds quickly shed, but increased energy, improved digestion, and even a clearer skin. Consumer surveys reveal that people perceive gluten-free products to be healthier than their gluten-containing counterparts.

As the clinical application and popularity of the gluten-free diet escalate, consumer demands righteously continue to influence food market and labeling standards of gluten-free products. 2013, the European Union Regulation 609/2013 set out rules on compositional and labeling requirements for the gluten-free products. These guidelines ensure that people who are intolerant to gluten are adequately informed of difference between foods that are naturally free of gluten and foods that are to be produced, prepared and/or processed in order to reduce their gluten content. This guideline helps gluten-wary customers to navigate the current market and protect themselves from consuming products that may exacerbate their symptoms and/or activate immune-mediated mucosal damage even in absence of symptoms. The gluten-free diet encompasses food groups that are naturally devoid of gluten, such as fresh fruit, vegetables, seafood, meat, poultry, legumes, nuts, and most dairy products [11]. However, some of these products may also contain “hidden” gluten. Hence, product labels and ingredient lists need to be carefully reviewed. For the traditional gluten-containing foods, such as bakery products, there is currently a wide variety of gluten-free options available that use gluten-free cereals and pseudo cereals, such as rice, corn, quinoa, millet, and amaranth as their base ingredients.

### **Celiac Disease**

Celiac disease defined an autoimmune disorder originating by an aberrant adaptive immune response against gluten-containing grains in permitting individuals. Gluten-sensitive enteropathy was first to be described in 1888 by Samuel Gee, but only in 1953 it became clear the importance of the gluten in the origin of this pathology [12]. In celiac subjects the partake of gluten leads to an enteropathy with an impairment of the mucosal surface and consequently, abnormal absorption of the nutrients [13]. Celiac disease might be considered a syndrome, because of the wide spectrum of clinical manifestations and involvement of various human systems. Celiac disease represents peculiar features in comparison to others autoimmune disorders, including the complete recovery of the mucosal damage as well as the reversibility of its progression and chronic dynamics, with a total avoidance of the gluten. Conversely, it is now ascertained that undiagnosed celiac sprue, might have severe various consequences in children as well as in adult subjects [14]. Besides celiac disease and wheat barley and rye allergy, a new entity has been included, apparently not driven by an immune response.

### **The Non-celiac Gluten Sensitivity (NCGS)**

The pathogenesis of NCGS remains largely unknown, although it is now determined that it includes a set of factors.



The celiac disease sometimes called “celiac sprue”, is an immune reaction to eating gluten and chronic inflammatory disorder of the small intestine, produced by the ingestion of dietary gluten products in susceptible people. It is a multifactorial disease, including genetic and environmental factors. Environmental trigger is represented by gluten while the genetic tendency has been identified in the major histocompatibility complex region. Celiac disease is not said to be a rare disorder like previously thought, with a global prevalence around 1%. The reason of its under-recognition is mainly referable to the fact that about half of its affected people do not have the classic gastrointestinal symptoms, but they present nonspecific manifestations of nutritional deficiency or have no symptoms at all. Here we review the most recent data concerning pathogenesis, epidemiology, clinical presentation, available diagnostic tests and therapeutic management of celiac disease [15].

## **Pharmacologic Activity of Arrowroot**

### **Antidiarrheal Activity**

In developing countries, among children of age under 5, one of the major reasons for mortality is diarrhea. Diarrhea causes the expulsions of watery fecal matter 3 or more times a day. This leads to increased secretion and reduced absorption of fluids and causes loss of water and electrolytes and this leads to pain in the abdomen [16]. This can be resolved by using plants with antidiarrheal properties. The antidiarrheal and cytotoxic effects of methanolic extract of *Maranta arundinacea* leaves are screened in rats and brine shrimp, respectively. Antidiarrheal effect of *M. arundinacea* was screened out using castor oil-induced diarrhea, enteropooling test, and gastrointestinal motility tests at 200 mg/kg and 400 mg/kg body weight in rats where the cytotoxic activity was carried out by using brine shrimp lethality bioassay at diverse concentrations of *M. arundinacea*. The extract showed an antidiarrheal effect by inhibiting diarrheal occurrence by 42.67% at the dose of 200 mg/kg and 57.75% 400 mg/kg. It made a significant reduction in the castor oil-induced intestinal volume ( $2.14 \pm 0.16$  to  $1.61 \pm 0.12$  ml) in the enteropooling test as well as intestinal transit (33.00 to 43.36%) in the GI motility test. These effects are compared with the standard drug loperamide (5 mg/kg). Brine shrimp lethality test was conducted and LD50 was calculated as 420 g/ml. Therefore, the non-toxic highest dose of *M. arundinacea* was 400 g/ml. This shows that methanolic extract of *Maranta arundinacea* leaves has antidiarrheal activity [17].

### **Antioxidant Activity**

Compounds that can inhibit reactive oxygen species or reactive nitrogen species and free radicals are called as antioxidants. They have the capability to prevent the oxidative damage of cells and diseases like cancer, cardiovascular disease, cataracts, atherosclerosis, diabetes, arthritis, immune deficiency diseases, and aging [18].

The antioxidant activity of *M. arundinacea* was found using the ethanolic extract of its rhizomes using 1,1-diphenyl-2-picryl hydroxyl (DPPH) quenching assay, 2,2'-azinobis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) cation decolorization test, Reducing power, scavenging capacity towards hydrogen peroxide ( $H_2O_2$ ) radical, nitric oxide (NO) radical inhibition activity with standard assay procedures and Ferric Reducing Antioxidant Power (FRAP) Assay [19]. Methanol extract of *Maranta arundinacea* rhizome showed antioxidant and free radical hunting activity through in vitro models such as DPPH, hydroxyl radical, superoxide radical, ABTS radical cation, and reducing power in a dose- dependent manner when compared to the standard antioxidant. These studies showed that

Maranta arundinacea rhizome can be used as a good natural antioxidant [20].

### **Immunostimulatory Effect**

By boosting our natural immune protection in our body, we can obtain a healthy body by reducing exposure to diseases. The arrowroot tuber extracts were evaluated in vitro by using animal cell culture techniques, and in vivo by using BALB/c mice for screening their immunostimulatory effect. It showed that the extract stimulated IgM production by HB4C5 cells and immunoglobulin (IgG, IgA and IgM) production by splenocytes in vitro also enhanced interferon production. In vivo study showed that the arrowroot extracts increased the serum immunoglobulins levels in mice [21].

### **Antimicrobial Activity**

Clinically, microbial infections are the most threatening ones. The discovery of new antibiotics is needed to overcome the microbial resistance towards antibiotics. Plants with flavonoids usually have antimicrobial effects. The antimicrobial effect of *M. arundinacea* is determined in vitro with its methanolic tuberous extract against gram-positive bacteria, *Staphylococcus aureus*. Minimum inhibitory concentration and Minimum bacterial concentration against Methicillin-Resistant *Staphylococcus aureus* (MRSA) which is a strain of *S. aureus* is 100%. The inhibitory zone diameter was found to be 100% with a mean inhibitory zone diameter of 15.5 mm [21, 22].

### **Vibriocidal Activity**

The vibriocidal activity of the different solvents (aqueous, methanolic, ethanolic, and hexane) extracts of leaf and rhizome of *Maranta arundinacea* was conducted in vitro. It found that both leaf and rhizome extract was effective against the strains of *Vibrio cholerae* using agar well diffusion and minimum inhibitory concentration method. The ethanolic extract showed maximum inhibitory effect with an inhibition zone of  $26.23 \pm 0.53$  mm (MIC of  $80.00 \pm 10.06$  µg/ ml) in rhizome and  $24.27 \pm 0.12$  mm (MIC of  $100.00 \pm 12.82$  µg/ ml) in and leaf [23].

### **Antiulcerogenic Activity**

The antiulcerogenic activity of starch from *Maranta arundinacea* was evaluated in comparison with *Curcuma angustifolia* in vivo by the pyloric ligation-induced gastric ulcer method in albino rats. *Maranta arundinacea* showed a statistically significant decrease in volume, increase in the pH, reduced the free acidity of gastric juice, and decreased peptic activity. So, they have an antiulcer effect [24].

### **Anti-inflammatory Activity**

Anti-inflammatory activity of arrowroot extract mediated with selenium nanoparticles was evaluated using albumin denaturation assay and cytotoxic analysis had carried out on brine shrimp nauplii. An increase was found in the anti-inflammatory property of arrowroot- mediated selenium nanoparticles with increasing concentration in comparison to the standard diclofenac. The cytotoxic activity of arrowroot mediated selenium nanoparticles showed decreased cytotoxic activity in lesser concentrations [25].

### **Medicinal Uses of Arrowroot (Maranta Arundinacea)**

Arrowroot has many medicinal uses as well. As it is said to be a nutritive starch that can be easily



digested, it is given to baby and people recovering from an illness or medical treatment. Due to the urinary antiseptic properties, arrowroot tea helps in the urinary problems. When taken daily it helps to lower the cholesterol.

Arrowroot has innumerable medicinal uses. It is safe and effective remedy with no side-effects. It works due to the presence of bio-active compounds such as alkaloids, carbohydrate, cardiac glycosides, amino acids, terpenoids, saponins, phenolic compounds, flavones and gum [26].

Below is listed few important therapeutic uses of this commonly used starch powder:

**Bruises, swellings and pus in swellings:** Arrowroot powder and turmeric powder are applied topically.

**Dysentery:** About 10 gm of the starch boiled with about 200 ml water and sweetened with sugar is given in dysentery.

**Food Poisons and Bites of Venomous Snakes:** The expressed juice of the rhizome is an antidote.

**Gastritis:** Rhizome powder is given.

**Gangrene, Wounds from Poisoned Arrows, Spider Bites:** Mashed rhizome is applied.

**Leucorrhoea, as a Diuretic, Dry Cough, Rheumatism:** Rhizome powder or decoction is helpful in leucorrhoea.

**Recurrent Digestive Order of Children:** Arrowroot powder boiled in the water is given as food by adding milk and sugar.

**Smallpox:** The poultice of arrowroot is applied.

**Urinary Problems, Typhoid Fever, Bladder Ulceration:** Arrow root powder has cooling, soothing and demulcent action and therefore it helps in the fever, ulcers, burning urination, extravagant heat in the body, etc. The powder is boiled in milk, sugar is added as per taste and eaten as a food.

**Urine Infection:** Juice extracted by smashing rhizome and root is taken by mixing with root extract of mango and banana tree.

**Vegetable Poison:** Juice/ powder is given internally as antidote [27].

## Application in Food Industry and Cosmetic Products

### Bakery and Confectionary Products

The arrowroot can be consumed in form of biscuits, pasta, bread, cakes, puddings, jellies and hot sauces. Arrowroot makes clear, shimmering fruit gels and prevents the ice crystals formation in homemade ice cream [28].

Arrowroot powder in many of the sweet baked treats blended with other flours, such as almond flour, coconut flour and tapioca flour. Awesome for bread and dessert-type recipes.

I reach for arrowroot whenever I would like to make things a little bit crispier or crunchier, which is why I like to add some to crumbles, crisps or crumble bars. You could coat sweet potato fries in a dusting of arrowroot powder just before baking to make them crisp up some more.

### Arrowroot as a Thickener

Arrowroot is a well-known thickening agent. It stands up to acidic mixtures such as Asian sweet and sour sauce. Using it for thickening fruit sauces like cranberry sauce or really any slightly acidic sauces

like sweet teriyaki sauce. And then there is the whole savory world of sauces, soups, and gravy. It will not make the sauce go cloudy, such as cornstarch, flour, or other starchy thickening agents would. It's commonly used as an alternative to corn starch which is usually more expensive. When using arrowroot powder as a thickener for sauces and gravy, there are a couple of things which has to be remembered.

Arrowroot powder is twice the thickening power of wheat flour and is gluten free. Unlike cornstarch, arrowroot powder creates a perfectly clear gel and does not break down when combined with the acidic ingredients like fruit juices. Arrowroot also stands up to freezing, whereas mixtures thickened with corn starch tend to break down after freezing and thawing. Arrowroot powder is great as a thickener for everything from gravy to puddings and soups. Naturally gluten-free, arrowroot starch is an excellent thickening agent in puddings, sauces and stews, and makes a great binder in meat loaf and veggie burger mixtures [29].

### Industrial and Cosmetic Products

Arrowroot is an extensively used in many cosmetic products. Applied in place of talcum powder or chemically laced moisturizing creams, arrowroot is recognized as a herbal treatment to make skin softer and smoother and also as an oil absorbent. Arrowroot is the perfect alternative for the baby powder. Not only does it have superior properties to talcum powder, but talcum powder- based makeup and skin care products often contain carcinogens. Due to its excellent thickening property, it is also used in hair dye. In Britain, Canada, Europe and the USA, it also has non- food uses such as in carbonless paper manufacturing for computers [30].

### Conclusion

Arrowroot abounds with an impressive profile of essential nutrients and bioactive compounds that are beneficial not only for growth and development but also bolsters immunity, promotes digestion and control diabetes. Being a gluten-free starch, arrowroot is a perfect cereal to combat celiac disease, gluten intolerance and enhances overall health. This humble tuber has been used since times immemorial for its magnitude of health benefits and natural healing properties. Add this healthy gluten-free starch to your regular meal plan to reap the wellness incentives and also add variety to your staple diet.

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