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COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

SCHOOL OF FOOD TECHNOLOGY, NUTRITION AND BIOENGINEERING

DEPARTMENT OF FOOD TECHNOLOGY AND NUTRITION

PRODUCTION OF INSTANT SOUP FLOUR FROM POTATO PEELS

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DECLARATION

I JOYCE MUDONDO hereby declare that all the information in this report is my original work and has never been presented or submitted to any university or institution for academic purposes leading to the award of the Bachelor's Degree of Science in Food Science and Technology.

Signature: ………………………… Date: 23/07/2019.

Mudondo Joyce

This research is submitted to the Department of Food Science and Technology for examination with the approval of my academic supervisor.

Signature: Date: 02/08/2019

Dr. Abel Atukwase

DEDICATION

I dedicate this report to my parents Mr. Isanga Fred and Mrs. Nakatudde Joyce, my Guardian, Mudondo Joyce Margaret and my entire family because they have been there for me whenever I needed them and I greatly thank them for their provision, help and advice. May the Almighty God bless them abundantly.

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ABBREVIATIONS

PPW	- Potato Peel Waste
WAC	- Water Absorption Capacity
OAC	-Oil Absorption Capacity
SP	- Swelling Power
WSI	-Water Solubility Index
WAI	- Water Absorption Index.
kg	- kilogram
ml	- millilitres
g	- grams
Rpm	- revolutions per minute
^{o}C	-degrees centigrade
xg	-number of times of gravitational force (g)
hr.	-hour
ha	-hectare
cp	-centipoise

ABSTRACT

Potato peels are considered waste products from the potato processing industry in Uganda. However, potato peels have a lot of benefits including being a good source of energy, minerals, vitamins, and fibre and can be used in the production of several value-added products. In Uganda, the potential of using potato peels in production of value added products has not yet been explored. This study therefore focused on using potato peels as a main ingredient in production of an instant flour for making soup. The potato peels were washed and subjected to two treatments namely heating at 61^{o}C for 10, 20 and 30 minutes and steaming for 5, 10 and 15 minutes. The heated peels were then oven dried at 100^{o}C for 7 hours, milled using a hammer mill and sieved using a 250-micron sieve. The functional and physicochemical properties of the potato peel flour were determined using standard methods. The potato peel flour with highest water absorption capacity among the heated and steamed potato peels was used in the formulation of instant soup; and after proximate composition and sensory evaluation was determined using standard methods. The oil absorption capacity (OAC) of potato-based soup flour from peels heated at 61^{o}C varied from 261.2 to 195.4%. The oil absorption capacity of the potato-based soup flour from peels steamed ranged from 258.3 to 205.4 The water absorption capacity of the potato-based soup flour from peels heated at 61^{o}C ranged from 365.3 to 287.0%. The water absorption capacity of the potato-based soup flour from peels steamed ranged from 296.5 to 280.1%. The swelling power of the potato-based soup flour from peels heated at 61^{o}C ranged from 2.1 to 2.2%. The swelling power of the potato-based soup flour from peels steamed ranged from 2.3 to 1.9%. The water absorption index of the potato-based soup flour from peels heated at 61^{o}C ranged from 5.2 to 5.5%. The water absorption index of the potato-based soup flour from peels steamed varied from 4.0 to 4.8%. The water solubility index of the potato-based soup flour from peels heated at 61^{o}C ranged from 7.4 to 10.7%. The water solubility index of the potato-based soup flour from peels steamed ranged from 9.3 to 15.1%. The pasting properties showed that the flours from the potato peels heated at 61^{o}C for 10 minutes showed the highest peak viscosity (457cp), trough (426cp), setback(411cp) and final(837cp) viscosity. The flours from the potato peels steamed for 5 minutes had the highest peak viscosity (641cp), trough(501cp), breakdown(140cp), setback(702cp) and final(1203cp) viscosity though the control: reference sample showed the highest pasting properties. The peak time ranged from 5.73 to 7.00 minutes with the reference sample having 5.73 minutes and the others having 7.00 minutes. The proximate composition of the formulated potato peel flour had a higher fibre content of 5.94%, ash content of 10.28%, fat content of 3.10%, protein content of 13.89% and carbohydrate content of 56.72%. The flour also had a 7.08% moisture content below the recommended flour moisture content of 8% as recommended by Jay (1978). The soup with formulation two (75% peel flour) from the potato peels steamed recorded the highest acceptability score for appearance, colour, thickness, mouthfeel and overall acceptability. The physicochemical and functional properties of the flours were influenced by the heat treatments and the steaming process with 75% peel flour (formulation two) gave the most acceptable flour. The study findings indicated that potato peels are suitable raw materials for production of instant flour that can be used in production of soup.

INTRODUCTION

1.1 Background

Potato (*Solanum tuberosum L.*) is the world's number one non-grain food commodity (Rykaczewska, 2013) and the third most important food crop globally in terms of consumption after rice and wheat (Birch *et al*., 2012; FAO 2013; Hancock *et al*., 2014). Over half of all production occurs in developing countries (Devaux *et al*., 2014). Nearly 400 million tons of potatoes are produced worldwide every year, leading to stability in food supply and socioeconomic impact (Halterman *et al*., 2016). Potatoes are therefore a critical crop in terms of ensuring food security worldwide (Birch *et al*., 2012). Potato is one of the most productive food crops in the world in terms of its yields of edible energy and good quality protein. Nutritionally, potatoes are considered a well-balanced major food plant with a good ratio of protein, calories and substantial amounts of vitamins especially vitamin C, major minerals and trace minerals (Emana and Nigussie, 2011).

In developing countries and under marginal growing conditions, potato is a cheap source of nutrients, thus playing an important role in guaranteeing food security, income generation, and employment opportunities (Lutaladio and Castaidi, 2009). Potato's short cropping cycle allows it to serve as a hunger-breaking crop, and makes it suitable for intercropping and double cropping, especially in cereal-based production systems in Africa and Asia (Cromme *et al*., 2010).

Around the world, consumer demand is shifting from fresh tubers to processed products and ever greater quantities of potatoes are being processed to meet the rising demand for convenience food and snacks (Walingo *et al*., 2004). The major drivers behind this trend include expanding urban populations, rising incomes, diversification of diets and lifestyles that leave less time for preparing the fresh product for consumption (FAO, 2009).

In Uganda, potato production is concentrated in Kigezi highlands of Kabale and Kisoro in the South West, Mountain Elgon districts of Mbale and Kapchorwa in Eastern Uganda with highlands between 1500 m and 3000m above sea level (Wang'ombe, 2008). The Kigezi highlands produce about 60 % of the total Ugandan potato output (FAO, 2008) and South Eastern Uganda contributes 10%. The remaining 30% comes from Mubende, Nebbi, Masaka, Mbarara and Rakai (Ferris *et al*., 2009: Okoboi, 2001).

The potato processing industry produces large volumes of waste in form of peels. In Uganda, most potato processors are not adding any value to the potato peel though these peels contain various nutrients and are increasingly being produced. In this study, the potato peels were processed into instant flour for production of soup.

1.2 Problem statement

The recent trend of consumers' preference for ready to eat food products due to their busy life-style led to the generation of food waste at large scale. Disposal of this waste imposes high costs on food processors and burdens the environment. Therefore, the industry is keen to utilize these wastes to mine high value ingredients that have potentials for pharmaceutical or nutraceutical product development (Mohammad *et al.*, 2015). Potato processing industries particularly potato-crisps manufacturing generates a huge volume of potato peel as a by-product. Industrial processing generates between 70 and 140 thousand tons of peels worldwide annually (Chang, 2011). Traditionally potato peel waste is used for producing low value animal feed or used as manure which causes waste of abundant nutritive materials having the properties of antioxidant, antibacterial, apoptotic, chemo preventive and anti-inflammatory. This massive amount of waste offers significant economic potential for creative uses other than animal feeds or fertilizers. The waste peels are a promising source of innovative products because of their valuable technological and/or nutritional properties. This research focused on utilization of the low value potato peels in the production of instant powder for making soup.

1.3 Objectives

1.3.1 General objective

To develop a commercially viable value-added product from potato peels.

1.3.2 Specific objectives

1. To determine the functional, physicochemical and nutritional properties of potato peel-based flour.
2. To evaluate the sensory acceptability of the potato peel-based soup.

1.4 Hypotheses

1. Potato peel-based flour does not have good functional, physicochemical and nutritional properties.
2. Soup from potato peel-based flour is not acceptable to consumers.

1.5 Significance of the study

The potato peel-based soup flour will be readily consumed by the general public because of its good nutritional composition. This will be providing the required nutrients like antioxidants and others as it will be eaten as a side dish besides other sauces hence complementing the meals. The utilization of the potato peels into soup flour will help to reduce the problem faced by the food industry of the poor waste disposal hence environmental conservation and enhance production of nutritive products. This will also increase the value of the inexpensive potato by-product hence increasing income sources for farmers and processors.

LITERATURE REVIEW

2.1 Geographic origin of potatoes

The cultivated potato originated about 8,000 years ago near Lake Titicaca, which sits at 3,800 m above sea level in the Andes mountain range of South America, on the border between Bolivia and Peru. To the Andeans and later to the Incas, it was known as papa. The centre of diversity for wild tuber-bearing potatoes (subsection *potatoe*) lies in Latin America, which is also considered the centre of origin. For the series *tuberosa* (to which *S. tuberosum* belongs) and most other series within the subsection *potatoe*, there are two centres of diversity (Patil, Sudaresha, Kuwar and Bhardwaj, 2016). One is a long-stretching Andean area in Venezuela, Colombia, Ecuador, Peru, Bolivia and Argentina. The other is in central Mexico. The distribution area of these wild potatoes is much larger: from the southwestern United States to southern Argentina and Chile (Child, 1990; Hawkes, 1990). By the 16th century potato was introduced into European countries by Spanish conquerors. The potato also received an unusually warm welcome in Ireland, where it proved suited to the cool air and moist soils. Irish immigrants took the tuber and the name, “Irish potato” to North America in the early 1700s. Generally, the cultivated *Solanum* species are also found within the centres of diversity for wild potatoes. The exception is the cultivated diploid form of *S. tuberosum* subsp. *tuberosum*, which is only found in a constricted area of southwestern Chile. The cultivated tetraploid *S. tuberosum* subsp. *tuberosum*, as known in Europe and most other parts of the world, is considered to be a selection from a small introduction of *S. tuberosum* subsp. *andigena* potatoes from Colombia and Peru, and as such has a very narrow genetic basis. The arguments for this thesis are that plants of the original introductions into Europe are known to have been late flowering and tuberising, and that the morphological description of these potatoes matches the *andigena* type (Howard, 1970). Through selection, this introduction was adapted to the longer day lengths and different environmental conditions of Europe. Simmonds (1966) has shown that such transition can take place in a fairly short period of approximately ten years of selection. From Europe, this new type of potato has spread all over the world as a cultivated crop. An alternative theory is that, after the potato blight epidemic in Europe, new germplasm of *S. tuberosum* subsp. *tuberosum* originating from Chile (Hawkes, 1990) was introduced into Europe. European colonizers took potato to all corners of the globe. Colonial governors, missionaries and settlers introduced potato growing to the flood plains of Bengal and Egypt’s Nile delta, the Atlas Mountains of Morocco, and the Jos plateau in Nigeria. Emigrant farmers took the potato to Australia and even to South America, establishing the potato in Argentina and Brazil. In the Asian heartland, the tuber moved along more ancient routes, finding its way from the Caucasus to Turkey’s Anatolian plateau, from Russia to western China, and from China to the

Korean Peninsula. In the mountain valleys of Tajikistan, some potato types have been grown long enough to be considered "old local varieties. The 20th century saw the potato finally emerge as a truly global food. The Soviet Union's annual potato harvest reached 100 million tonnes. In the years following the Second World War, huge areas of arable land in Germany and Britain were dedicated to potato, and countries like Belarus and Poland produced - and still do - more potatoes than cereals. From the 1960s, cultivation of potato began expanding in the developing world. In India and China alone, total production rose from 16 million tonnes in 1960 to almost 120 million in 2010. In Bangladesh, potato has become a valuable winter cash crop, while potato farmers in south East Asia have tapped into exploding demand from food industries. In sub-Saharan Africa, potato is a preferred food in many urban areas, and an important crop in the highlands of Cameroon, Kenya, Malawi and Rwanda (Patil, Sudaresha, Kuwar and Bhardwaj, 2016).

2.2 General description of potatoes

Potato (*Solanum tuberosum L.*) is the most important non-grain food crop in the world (FAOSTAT, 2013). It is grown in around 50 countries spread across both temperate and tropical regions and at elevations from sea level to 4000 m (Paul *et al*., 2012). More than half of the potato production takes place in developing countries including India and over one billion people have potato as their staple diet. It has steadily expanded globally with 35% increase in overall production since 1960.The increase in production is still higher in developing countries of Asia and Africa indicating its growing importance as a staple food source (Patil, Sudaresha, Kuwar and Bhardwaj, 2016).

The potato is an herbaceous plant and growth habit varies between and within species. The plant has a rosette or semi-rosette habit. The potato tuber is an enlarged portion of an underground stem or stolon. Tuber eyes are the buds from which next season's growth will emerge (Patil, Sudaresha, Kuwar and Bhardwaj, 2016). Eyes are concentrated near the apical end of the tuber, with fewer near the stolon or basal end. Eye number and distribution are characteristic of the variety (Patil, Sudaresha, Kuwar and Bhardwaj,2016).

Potato is an annual herbaceous plant, mainly reproduced vegetative by means of tubers and sometimes by botanical seeds, i.e., True Potato seeds. The tubers are underground stems and from that new shoots are produced. The stem is erect in the early stage but becomes spreading and prostrate later on. The leaves are compound and alternate, irregularly odd pinnate (Patil, Sudaresha, Kuwar and Bhardwaj, 2016).

Nutritionally, potatoes are second only to soybeans for amount of protein/ha, with the major storage protein being patatins, one of the most nutritionally balanced plant proteins known (Liedl et al.,1987). A single 150 g of potato tuber provides up to 45% of recommended daily allowance (RDA) for vitamin C,10% of vitamin B6, 8% niacin, 6% folate as well as significant amounts of other essential mineral requirements required. However, potato lacks many other essential nutrients like vitamin B12, Biotin, thiamin, riboflavin, alfa-carotene, lycopene, retinol and alfa-tocopherol and important minerals like copper, iodine and molybdenum required for human consumption (Meredith, 2012).

Table 1:Nutrient Composition of potatoes

Substance	Range (%)	Mean (%)
Dry matter	13.1-36.8	23.7
Starch	8.0-29.4	17.5
Reducing sugars	0.0-5.0	0.3
Total sugars	0.05-8.0	0.5
Crude fibre	0.17-3.48	0.71
Pectic substance	0.2-1.5	-
Total nitrogen	0.11-0.74	0.32
Crude protein	0.69-4.63	2.00
Lipids	0.02-0.2	0.12
Ash	0.44-1.87	1.1
Ascorbic acid	21.7-68.9*	-
Glycoalkaloids	0.2-41**	3-10
Phenolic compounds	5-30**	
	*mg/100g, **µg/100g	

Source: (Lister and Munro,2000)

2.3 Taxonomy of potatoes

Potato (*Solanum tuberosum L.*) belongs to the Solanaceae, a family of about 90 genera and 2800 species.*S. Tuberosum* is divided into two, only slightly different subspecies: *andigena*, a diploid which is adapted to short day conditions and is mainly grown in the Andes; and *tuberosum*, a tetraploid potato new cultivated around the world, is believed to be descended from a small introduction of *andigena* potatoes to Europe that later adopted to longer day length. The latest comprehensive taxonomic treatment of section Petota was published by Spooner *et al*., (2014). It recognizes eight cultivated species and 228 wild species, divided into 21 taxonomic series including 19 series for tuber bearing species and two series of non-tuberous species. Among these eight cultivated species of section Petota only *S. tuberosum* ssp. *tuberosum* is grown worldwide while others are restricted to the Andean countries where thousands of primitive cultivars are found.

Table 2:Scientific classification of potatoes

Scientific classification	
Kingdom	Plantae
Subkingdom	Viridaeplantae
Division	Tracheophyte
Subdivision	Spermatophytina
Class	Magnoliopsida
Order	Solanales
Family	Solanacceae
Genus	Solanum
Species	*Solanum tuberosum L.*

Source :(Spooner *et al*., 2014)

2.4 Uses of potatoes

Once harvested, potatoes can be used for a variety of purposes; as a fresh vegetable for cooking at home, as raw material for processing into food products, food ingredients, starch and alcohol, as food for animals and as seed tubers for growing the next season’s crop (FAO, 2009).

2.5 Potato peels

Potato peels are an agro industrial waste of one of the major crops worldwide (Franco *et al*., 2016). Potato peel waste is a zero value by product, which can occur in big amounts after industrial processing and can range from 15 to 40 % of the initial product mass, depending on the peeling method (Sepelev and Galoburda, 2015). As a consequence of growing production figures of processed potato products, considerable quantities of waste are generated. However, these waste peels are promising source of compounds which may be used because of their valuable technological or nutritional properties. On one side, the peels which are the major portion of processing waste, represent a severe disposal problem to the potato industry especially since the wet peels are prone to rapid microbial spoilage. On the other side, potato peels contain an array of nutritionally and pharmacologically interesting components such as phenolic compounds, glycoalkaloids and cell wall polysaccharides which may be used as natural antioxidants, precursors of steroid hormones and dietary fibre (Schieber and Saldaña, 2009).

2.6 Nutrients in the potato peels

According to Sepelev and Galoburda, 2015, raw potato peels have a high moisture and carbohydrate contents, but overall protein and lipid contents are generally low. In addition, potato peels contain a variety of valuable compounds, including phenols, dietary fibers, unsaturated fatty acids, amides among others (Schieber and Saldana, 2009; Wu *et al*., 2012). PPW is a good source of dietary fibre: primarily insoluble carbohydrates – cellulose, hemicellulose, lignin, pectin and gums (Al-Weshahy and Rao, 2012) with average content of 40 g 100 g^{-1} and it depends on the peeling method.

Table 3:Chemical composition of raw potato peel, g/100g

Compound	Average content
Water	84.2
Protein	1.8
Total lipids	0.3
Total carbohydrate	10.6
Starch	7.8
Total dietary fibre	2.5
Ash	1.3

Source: (Arapoglou *et al.,2009*)

2.7 Utilization of potato peels

2.7.1 Food processing

Potato peel waste is not suitable for non-ruminants without further treatment because it is too fibrous to be digested (Birch *et al*., 1981), but as an inexpensive by-product it contains a large quantity of starch, non-starch polysaccharides, lignin, polyphenols, protein and small amount of lipids. This makes it a cheap and valuable base material for extraction of valuable products (such as natural antioxidants, dietary fibre, biopolymers, etc.) and fermentation processes (Arapoglou *et al*., 2009;

Al-Weshahy and Rao, 2012; Wu *et al*., 2012). PPW features a high potential for ethanol production that has a large potential market (Arapoglou *et al*., 2010). PPW contains sufficient quantities of starch, cellulose, and hemicellulose. Among different compounds, lactic acid can be produced during hydrolysed PPW fermentation process using *rhizopus* fungus cultures (Zhang *et al*., 2007, 2008). PPW starch can be used for enzyme production such as thermostable α-amylase, a starch hydrolyzing enzyme that is widely used in different food industries. Positive results were achieved using *Bacillus subtilis* strains (Mahmood *et al*., 1998; Asgher *et al*., 2007) with maximum enzyme production after 48 h of cultivation at pH 7.0 and 50 °C. PPW can be used in healthy and functional food production as dietary fibre source. It can be used in bakery production and replace up to 10% of flour amount without changes in sensory quality (Sepelev and Galoburda, 2015).

2.7.2 Food preservation

Synthetic food preservatives could be used alone or in combination with natural preservatives both synthetic and natural antioxidants been used in food industry; however, application of synthetics preservatives has potential carcinogenic effects but use of natural preservatives alone has a better advantage for human health with low side effect. As a result, attention has been given to vegetable waste with rich source phenols (Sonia, Mini, and Geethalekshmi, 2016; Tiwari *et al*., 2009). Phenolic compound is found ubiquitously in plants and is of noticeable interest due to their antioxidant and antimicrobial properties (Pezeshk, Ojagh, and Alishahi, 2015). Food processing industries generate phenolic-rich vegetable by-products, and this has been an area of research investigations as a source of antioxidants and antimicrobial for food preservation (Pezeshk *et al.,* 2015). The entire tissue of fruits and vegetables is rich in bioactive compounds or phenols but the by-products have higher contents of antioxidant (Sonia *et al*., 2016). Due to the suspected long-term negative health effect, use of synthetic antioxidants and antibacterial on food has become a common concern of consumer safety. Therefore, the food industry has enforced to seek natural alternatives food preservative. Potato peel is one of the most important waste products with sufficient amount of phenolic compound so this could be used as a replacement for the current synthetic antioxidant and antimicrobial. Potato peel also has acquired attention as a natural antioxidant in food system due to its high content of polyphenols, which was reported to be 10 times higher than their levels in the flesh (Malmberg and Theander,1984) accounting for approximately 50 % of all polyphenols in potato tuber (Friedman,1997). Therefore, the effective utilization of potato peel as an antioxidant in food has been investigated extensively. Phenols extracted from PPW show potential in food industry as a natural antioxidant to prevent lipid oxidation (Singh and Rajini, 2004; Mohdaly *et al*., 2010). It is reported, that PPW extract is able to protect against oxidation of soybean oil (Onyeneho and Hettiarachchy, 1993; Zia-ur-Rehman *et al*., 2004; Amado *et al*., 2014) and fish-rapeseed oil mixture (Koduvayur Habeebullah *et al*., 2010).

2.7.3 Antioxidant Ingredient

Antioxidants inhibit oxidation of lipids in foods and consumption of high concentration synthetic antioxidant has carcinogenic effect unlike the natural antioxidants (Thorat *et al*., 2013). The antioxidant activity of potato peel extracts has strong radical scavenging ability and prevents oxidation reaction in oily foods (Koduvayur Habeebullah, Nielsen and Jacobsen, 2010). The dominant phenolic compounds of potato peel extracts are chlorogenic and gallic acids. These are potent sources of natural antioxidants that prevent oxidation of vegetable oil, and this could stabilize soybean oil oxidation reaction through minimizing peroxide, totox, and p-anisidine indices (Amado, Franco, Sánchez, Zapata and Vázquez, 2014; Mohdaly, Sarhan, Mahmoud, Ramadan, and Smetanska, 2010). The ability on minimizing oxidation on vegetable oil, potato peel extracts has equal performance with synthetic antioxidants such as butylhydroxyanisole (BHA) and butylhydroxytoluene (BHT). In comparison with mature potato, young potato peel has excellent source of bioactive phytochemicals nature with antioxidant potential (Arun *et al*., 2015). However, as compared to the application of synthetic antioxidants, potato peel extracts need to apply in higher amount but still looking the advantage of natural antioxidants than the synthetic, it is a promising source of natural antioxidant that could be used as ecofriendly product on food industries.

2.7.4 Antimicrobial Ingredient

More than three-quarter of the world's population has used medicinal plants for treatment of different disease. Herbal plants are important on prevention against highly pathogenic micro-organisms, and they are safer means of food preservation (Fatoki and Onifade, 2013; Kadhim Hindi and Ghani Chabuck, 2013). Potato peel extracts have antimicrobial compounds against bacterial and fungal organisms. The antimicrobial nature could be due to the presence of flavonoids and terpenes organic compounds (Nostro *et al*., 2000). Potato peel has bacteriostatic nature with nonmutagenic behavior and safe to use in food processing industries (Amanpour, 2015; Sotillo, Hadley, and Wolf-Hall, 1998). Therefore, potato peel extract is the future and natural against foodborne pathogenic microbial and the broad-spectrum nature of the plant help to discover new chemical classes of antibiotic substances that could serve as food preservative in food processing industries.

2.7.5 Pharmaceutical Ingredient

Pharmaceutical ingredient is a substance used in a finished pharmaceutical product, intended to give pharmacological activity to cure, mitigation, treatment, or prevention of disease (WHO, 2011). Peels of various fruits and vegetables are generally considered as waste product and are normally thrown away. But they have important elements, which could be used for pharmaceutical purpose (Parashar, Sharma, and Garg, 2014). Potato peel has a number of pharmacological interest compounds like glycoalkaloid which could be used as precursory for steroid hormone (Schieber and Aranda, 2009). When we look, the highest amounts of glycoalkaloids are found in potato peel than the flesh part of potato (Chem, 2009). In addition to this, potato powder has a potential of wound healing activity as antiulcerogenic agent (Dudek *et al.*, 2013). Therefore, use of potato peel as pharmaceutical ingredient is natural, nontoxic, and environmentally friendly. So, this could be one of the solutions on prevention of the current threat of drug resistance, emerging disease effective treatment and lower the health damaging side effect of synthetic drugs.

2.7.6 Wound management

Wound is a result of disruption of normal structure of skin. To ensure proper healing process, wound tissue need free of revitalized tissue, clear of infection, and moist. Wound dressings should cut dead tissue, exudate, prevent bacterial overgrowth. Various natural topical agents are available which help wound healing process (Keast, Forest-, and Forest-lalande, 2004). Potato peel is one of the natural wound healer herbal plants that has ability to produce high tensile strength of wounded skin (Panda, Sonkamble, and Patil, 2011). About 2.5% in ointment form of potato could trigger cutaneous wound healing through improve cells migration and gastric ulceration through protecting gastric mucosa wrinkles (Dudek *et al.*, 2013). Sterile potato peel dressings are better than gauze alone dressing particularly during the healing phase so potato peel dressings could be an alternative for wound dressing in developing countries (Van de Velde, De Buck, Dieltjens, and Aertgeerts, 2011). To use potato peel for wound dressing is readily available, cheap, easy to apply, less painful, and stored easily. Therefore, potato peel can fulfill the ideal dressing painless, non-adherent, non-allergic, non-antigenic, and antiseptic role.

2.7.7 Glycoalkaloids

Glycoalkaloids are naturally found in vegetable crops. Potato glycoalkaloids are known for their toxic nature but the glycoalkaloids found in potato leaves offer natural protection to the plant against pests (Ginzberg, Tokuhisa, and Veilleux, 2009; McCue, 2009). Potato peel has 43% of phenolic acids and 10% of the glycoalkaloids. The highest amounts of glycoalkaloids found in potato peel unlike of the potato flesh (Chem, 2009). Separation of toxic glycoalkaloids from potato peel prior applying in food processing is important to use for further pharmaceutics products. This can be performed using food grade water/ethanol solvents extraction method (Snchez Maldonado, 2014). The upper limit of glycoalkaloid content on food processing should not be exceeded 20 mg per 100g, and the concentrations found in the peel are 3 to 10 times than the flesh (Handling, Issue, and Cantwell, 1996). As a general trend, there is reduction in alkaloids due to its volatile nature. For instance, during potato processing, partial degradation of caffeic acid and glycoalkaloids occurred. However, the dried potato samples have higher steroidal alkaloids such as α-solanine and α-chaconine than fresh samples. The air-drying techniques had the highest steroidal alkaloid contents than freeze and vacuüm oven-drying (Handling *et al*., 1996; Snchez Maldonado, 2014). Therefore, potato peel extracts are not only used for food preservation but also could be used as pharmaceutical ingredient through separating glycoalkaloid from potato peel phenolic.

2.7.8 Source of Renewable Energy

Fossil fuel demand is increasing globally. This creates rapid depletion of the fossils fuel and influence fuel price. As all knows now the main source of environmental degradation is use of fossil fuel which is a global issue. Due to this reason, interest toward use of renewable energy is increasing from time to time (Singh, 2014). A biological procedure for potential retrieval of organic wastes is an anaerobic digestion that used for biogas production (Krus and Lucas, 2014). To cut environmental pollution and economic benefit, food processing industries are focusing on waste reuse. Potato peel as one of the food wastes which has a remarkable potential on production of renewable energy like biogas (Adeyosoye, Adesokan, Afolabi and Ekeocha, 2010). Therefore, potato peel wastes could give a lot for the worldwide green economy development of recent agenda.

2.7.9 Biogas Production

Food wastes for biogas production have high potential. Fruit and vegetable such as potato peel wastes took 55 days for complete digestion to produce biogas in anaerobic condition (Deressa, Libsu, Chavan, Manaye and Dabassa, 2015; Sedláček, Kubaská, Lehotská and Bodík, 2010). Biogas plants also give bio-manure also of energy production and help to solve problems about waste management and providing clean environment (Singh, 2014). Potato peel waste of an industrial is a mesophilic reactor of biogas production. When chemical pretreatments applied on potato peel, the biogas and

CH_4 yield improved (Krus and Lucas, 2014). Therefore, to decrease natural disasters such as environmental pollution, deforestation, and desertification, use of food waste as biogas for electric generating is prompt and essential.

2.7.10 Animal feed

The cost of livestock feed is increasing due to rising fertilizer costs and extreme weather. So, food wastes are an alternative source of feed ingredients. This can cut feed cost and disposal cost and reduce environment pollution (Rivin, Miller and Matel, 2012). Food wastes have a high nutritional value for livestock feed (Myer and Johnson, 2010). In developing countries, the demand for livestock products is increasing. But feed deficits are the main problem, so unconventional feed resources play an important role. Fruit and vegetable processing industries generate a huge amount of wastes. Such unconventional resources are an excellent source of nutrients for livestock (Wadhwa, Bakshi and Makkar, 2013). Potato peel is one of the prominent food wastes that could be used as alternative animal feed due to natural sources of energy and fiber with low levels of protein (Chimonyo, 2017). Therefore, food waste materials as residual wastes used as animal feed ingredients and feed additive is essential. For a long period, potato peel wastes have also been fed to swine traditionally without processing.

2.7.11 Pig feed

Feeding food waste and garbage to swine is a common practice. Food waste has most often been used as a source of feed for swine unlike other livestock's. Waste matter provision to swine as feed is encourage due to its high disposal costs and feed conversion efficiency of the animal (Westendorf and Myer, 2015). Potato peel is one of the food wastes produced in bulky with high levels of moisture that led to putrefaction in a short period. This will promote their usage as dietary energy and fiber source for pigs (Chimonyo, 2017). Food waste must be heat-treated before providing to swine cut the risk of animal diseases and cut harmful pathogens to safeguard pig meat consumers (Westendorf and Myer, 2015). Potato waste feeding has antimicrobial activity by reducing coliform bacteria and improved performance of weanling pigs (Jin *et al.*, 2014). Therefore, considering the dual advantage of potato peel used as feed and antimicrobial for pig is important both environmental and financial sustainability of potato processing factories.

2.8 Challenges associated with potato peels

Due to increasing urban populations and rising incomes of people living in developing country, the demand for processed food is dramatically increased(Maria and Freire,2010).Potato chips are the most common food processed potato product which produce a large amount of potato peel as by product(Stearns *et al*.,1994).Potato industries generate two types of waste: peels and effluents from peeling and cooking stage respectively(Alsayed *et al*.,2018).The quantum of wastes generated from potato processing industry constitutes about 12-20% of raw material processed (NDDB,2014).In food processing industries ,the most common cause of environmental pollution is associated with organic waste decomposition. The decomposition occurs when bacterial and other biological forms use the compounds as a source of food (Palthorp, Filbert and Richtor, 1987). The wastes generated from the potato processing industry are mostly in the form of unutilisable organic materials which when disposed on land create environmental pollution being prone to easy microbial attack. Open dumping is objectionable because of the odour, fly menace and unsightliness. When dumped in public sanitary landfills, high moisture content of the wastes results in leaching problems (Jacob, Chintagunta and Banerjee, 2016).

2.9 Functional and Physicochemical properties of flours and their Relevance to the soup quality

Functional properties are the fundamental physicochemical properties that reflect the complex interaction between the composition, structure, molecular conformation and physico-chemical properties of food components, together with the nature of environment in which these are associated and measured (Kaur and Singh, 2006; Siddiq *et al*., 2009). The functional properties of a food material affect how it interacts with other food components and it determines its application and end use. Therefore, food items with good functional properties can be easily incorporated into other foods and will yield good quality and acceptable end products (Ocheme *et al*., 2018). Processes such as drying and heating could change the structure and physical properties of the food matrices and as a consequence influence their hydration properties. The functional properties i.e. bulk density, water absorption capacity, oil absorption capacity are the intrinsic physicochemical characteristics of the flour which may affect the behavior of food systems during storage (Shobha *et al*., 2014).

Water absorption capacity of the flour is an important functional characteristic in the development of ready to eat food from cereal grains and high-water absorption capacity may assure product cohesiveness (Shobha *et al*., 2007). Water absorption capacity is important for certain product characteristics, such as the moistness of the product, starch retrogradation, and the subsequent product staling (Siddiq *et al*., 2009). Oil absorption capacity is the ability of flour protein to physically bind fat by capillary attraction and it is of great importance, since fats are flavour retainer and also increases the mouth feel of the foods. The oil absorption capacity of the flour is a critical assessment of flavor retention and increases the palatability of foods (Shobha *et al*., 2007). Oil absorption index is important since oil acts as flavor retainer and increase the mouth feel of foods, improvement of palatability and extension of shelf life particularly in bakery or meat products where fat absorptions are desired (Aremu *et al*.,2007). The oil absorption capacity of flours is important for the development of new food products as well as their storage stability (particularly for flavor binding and in the development of oxidative rancidity) (Siddiq *et al*., 2009).

Water solubility index determines the number of polysaccharides or polysaccharide release from the granule on the addition of excess of water. The water absorption index measures the volume occupied by the granule or starch polymer after swelling in excess of water (Nargis *et al*., 2017). The pasting properties of a food refer to the changes that occur in the food as a result of application of heat in the presence of water. These changes affect texture, digestibility, and end use of the food product (Ocheme *et al*., 2018). The pasting characteristics play an important role in the selection of a variety for use in the industry as thickener, binder or for any other use. The viscosity of the gel formed during heating and after heating is an important factor in the selection process. Pasting properties are dependent on the rigidity of starch granules which in turn affect the granule swelling potential and the amount of amylose leaching out in the solution (Kaushal, Kumar and Sharma, 2012).

3.0 Soup

Instant food is very popular in modern society. Soup is one of the top instant foods which people like so much with other fast food item. It is actually a part of modern daily life. Soup is very much convenient to eat. It is now fulfilling the consumer's social requirements (Sarker,2016). Soup is the one of the traditional foods which can be classified as an appetizer, warm food during cold and sick. In the modern world, commercially prepared instant soup such as canned, dehydrated, and frozen soups have replaced homemade soup as preparing a soup is a time-consuming process. Instant soup can become an alternative food for breakfast because it could fulfill the adequacy of energy and nutrient required by the body, very practical in preparation and taking only short time to serve (Sunyoto, Futiawati and Rahimah, 2012).

The preparation and consumption of soup as human food accompaniment must have begun around the time cooking of foods was invented (Rahman, Saifullah and Islam, 2012). A soup is typically prepared as a concoction of ingredients including pepper, tomatoes, onions, meat/fish, seasonings, spices and vegetables combined with other liquids or slurries; cooked together until an acceptable consistency, blend and desired taste are achieved. Sometimes, grain cereal or oilseed flours, potatoes and other additives are added as thickeners to improve the soup body; depending on the desired end product. Although, soup is a choice delicacy virtually everywhere; the recipe varies from place to place; depending on regional/traditional food habits, taste and local availability of specific ingredients (Dalby, 2003). Generally, the process of preparing a delicious soup is time consuming, laborious and painstaking; hence, semi-processed soup mix/powders have gained worldwide recognition in fast cookery. Being a liquid-food (usually served warm), a good soup powder should be re-hydratable and cook able within minimum time, retaining nutrients and palatability almost similar to the freshly cooked product (Abeysinghe and IIIeperuma, 2006).

Traditionally soups are classified into broad groups: Clear soups and Thick soups. Thick soups are further classified into purees which are vegetable soups thickened with starch, bisques made from pureed shellfish thickened with cream, cream soups in which béchamel sauce is used as a thickening agent and veloutes which are thickened with eggs, butter and cream (Rupesh *et al*.,2015). Dry soup mixes are often accepted by the consumers as they can be stored for a long duration even at room temperature and also requires a less storage space. Dry soup mixes are prepared either by blending dried ingredients along with thickening agents or by spray drying the formulated slurry of soup (Singh *et al*., 2003). Rice bran, rice and corn flours have been reported to act as thickening agent in manufacturing of soup (Jayadeep *et al*., 2008; Sabanis and Tzia, 2008).

New trends in food science now makes soup available in pre-processed form; as canned or dehydrated products permitting the inclusion of medicinal herbs, spices and adjustment of nutrients to meet specific dietary needs (Dalby,2003). The development of soup as convenience food product originated in France where the evening meal consisted entirely of soup. Soup was prepared from local ingredients which was readily and cheaply available, this basic concept has been developed to produce soup in its many forms and flavours as consumers convenience products (Abdel-Haleem and Omran,2014).Soup mixes have been developed for a number of food products including: dika kernels; fish, moringa leaves; vegetables and mushroom (Singh, 2011; Ogunsina and Radha,2010, Abeysinghe and IIIeperuma, 2006, Bamidele *et al*., 2015, Wartha *et al*.,2013, Chandramouli *et al*.,2012, Abdel-Haleem and Omran,2014).

In recent years, consumers have become more interested in foods with both health value. In general, ingredients origin, product formulation and process method used could affect consumer food choice (Bukya *et al, 2018*). The old aged people are increasing day by day. Instant soup mixes maybe better nutritional supplement for them for meeting their dietary requirements. Satusap *et al*. (2014) mentioned that instant soup which made from dried vegetables were good for older people. The food product which is available in the market may not be suitable for older people in terms of cost, low nutrition and physical characteristics (Sarker,2016). So, instant soup is best for them. Formulation of the food products are increasing day by day to meet the requirements of the consumers (Prodhan, 2017). The formulation on value added products are now the main target of the consumers. Because it can supply the nutritional value as well as delicious test to consumers.

METHODOLOGY

3.1 Research design

The quantitative experimental research design was used because it allowed strict control and manipulation of all factors that affected the results of the experiment. The potato peels were subjected to two treatments namely; heating at 61^{o}C for 10, 20 and 30 minutes and steaming for 5, 10 and 15 minutes. The heat-treated samples were dried in the oven at 100^{o}C for 7 hours. A sample that was not given any heat treatment was used as a reference.

3.2 Source of raw materials

The potato peels were obtained from Wandegeya Market, Kawempe Division, Kampala Capital City. The other materials namely; corn starch, salt, full cream milk powder, flavourant and onion powder were bought from Capital Shoppers, Nakasero, Central Division, Kampala Capital City.

3.3 Processing of the potato peels

The potato peels (200 kg) were sorted and washed thoroughly with portable water to make sure they are clean. The clean peels were then divided into two portions each of 90 kg and each portion subjected to one of the processing methods: steaming and heating at different time intervals. The other 20 kg were oven dried and used as a reference sample.

3.3.1 Heating of the peels

The first portion of potato peels (30 kg) was placed in the open jacketed kettle with 20 liters of clean water and heated at 61^{o}C for 10, 20 and 30 minutes. The water was drained out and the peels placed onto disinfected trays and taken for drying in the hot air drier at 100^{o}C for 7 hours.

3.3.2 Steaming of the peels

The second portion of the potato peels was placed on a netted tray and covered with a stainless-steel plate. The potato peels were placed over the open jacketed kettle with boiling water for 5, 10 and 15 minutes. The peels were placed onto disinfected trays and taken for drying in the hot air drier at 100^{o}C for 7 hours.

3.3.3 Preparation of the reference sample

The remaining 20 kg of the potato peels were placed on disinfected trays and dried in the oven for 7 hours at 100^{o}C.

3.3.4 Processing of the soup flour

After 7 hours in the oven at 100°C, the dried peels were milled separately using a hammer mill to obtain the powder which was passed through a 250-micron sieve to remove any large particles. The powders were then packaged in a polyethene bag and stored under room temperature.

3.4 Functional properties of the potato peel flour

3.4.1 Determination of swelling power

Swelling power was determined by the Method described by Takashi and Sieb (1988). One (1) g of flour sample was put into 5 ml centrifuge tube; 10 ml of distilled water was added and mixed gently. The slurry was heated in a water bath at a temperature of 100°C for 15 minutes. During heating, the slurry was stirred gently to prevent clumping of the flour. After 15 minutes, the test tube containing the paste was centrifuged at 3000 rpm for 10 minutes. The supernatant was decanted immediately after centrifuging. The weight of the sediment was then taken and recorded. The moisture content of the sediment gel was used to determine the dry matter content of the gel.

$$\text{Swelling power} = \frac{\text{weight of wet mass sediment}}{\text{weight of dry matter in gel}}$$

3.4.2 Determination of oil absorption capacity (OAC)

The method of Onwuka (2005) was used to determine the oil absorption capacity. One (1) gram of the flour was mixed with 10 ml refined corn oil in a centrifuge tube and allowed to stand at room temperature (25 ± 2°C) for 1 hr. The contents of test tube were centrifuged at 1600 x g for 20 minutes. The volume of free oil was recorded and decanted. Oil absorption capacity was expressed as ml of oil bound by 100 g dried flour**.**

$$\text{OAC \%} = \frac{\text{Amount of oil added} - \text{free oil}}{\text{weight of sample}} \times \text{density of corn oil} \times 100$$

3.4.3 Determination of water absorption capacity

Water absorption capacity was determined according to the Method described by Onwuka (2005). About 1 g of the flour sample was weighed into a 15 ml centrifuge tube and suspended in 10 ml of water. It was shaken on a platform tube rocker for 1 minute at room temperature. The sample was allowed to stand for 30 minutes and centrifuged at 1200 x g for 30 minutes. The volume of the free water was read directly from the centrifuge tube.

$$\text{WAC (\%)} = \frac{\text{amount of water added} - \text{free water}}{\text{weight of the sample}} \times \text{density of water} \times 100$$

3.5 Physicochemical properties of the potato peel flour

3.5.1 Determination of pasting properties of the flour

The pasting properties of potato peel flour were determined using the Rapid Visco Analyzer (RVA TECMASTER, Perten Instrument) as described by Newport Scientific (1998). The sample was turned into slurry by mixing 3.5 g of the flour with 25 ml of water inside the RVA can. The can was inserted into the tower, which was then lowered into the system. The slurry was heated from 50°C to 95°C and cooled back to 50°C within 14 minutes. Parameters estimated were peak, trough, final, breakdown and setback viscosities, pasting temperature, and time to reach peak viscosity.

3.5.2 Determination of water absorption index and water solubility index

Water absorption and water solubility index was determined using a Method described by Solsulsiki (1962). The crucibles and centrifuge tubes were dried in the oven at 105℃ for 20 minutes and allowed to cool in a desiccator, after cooling, the crucible and the centrifuge tubes were weighed. About 1g of the sample was weighed into the tube and 10 ml of distilled water added and stirred gently with a stirring rod for 30 minutes. The tube containing the paste was centrifuged at 4000 rpm for 15 minutes after which the supernatant was decanted into crucibles and dried in the oven at 105°C until the supernatant dried off. The residue remaining in the tubes was weighed and the crucible with the supernatant after drying.

Water absorption index was calculated as;

$$= \frac{(\text{weight of tube} + \text{residue after centrifuge}) - \text{weight of empty tube}}{\text{weight of sample}}$$

Water solubility index was calculated as;

$$= \frac{\text{weight of crucible after drying} - \text{weight of empty crucible}}{\text{weight of sample}} \times 100$$

3.6. Product formulation

The flours with the highest water absorption capacity among the flours from the heated and steamed potato peels was selected and used for product formulation. Only one flour sample was chosen from each treatment and subjected to two formulations each. The product was formulated based on the different proportions of the main ingredient (potato peel flour). The formulation was done at room temperature to ensure stability of the ingredients used.

Table 4: Formulations for the potato peel-based soup flour.

Ingredients	Formulation 1(g/100g)	Formulation 2 (g/100g)
Potato peel flour	80	75
Corn starch	4	4
Salt	0.5	0.5
Onions	4.5	3.5
Full cream milk	8	13
Flavorant	3	4

3.7 Proximate analysis of the potato soup flour

3.7.1 Determination of the moisture content

The moisture content of the flour was determined using the air oven method AOAC (1999). About 2 g of each sample (W1) was weighed using a digital weighing scale and put into a pre-weighed empty crucible (W2). The crucibles were put in an oven at 100^{o}C overnight and after which they were put into a desiccator to cool and weighed (W3), the moisture content was then calculated as follows:

$$\%\ \text{Moisture content} = \frac{\text{W3} - \text{W1}}{\text{W1}} \times 100$$

Where W1 = weight of the air-dried sample, W2 =weight of the empty crucible, W3=weight of the crucible + oven dried sample

3.7.2 Determination of protein content

The crude protein was determined using the Kjeldahl method as described by Kirk and sawyer (1991) who assumed that all the protein in the sample contained 16% Nitrogen. About 0.2 g of each flour sample was weighed and transferred into well labelled digesting test tubes. An aliquot of 10 ml of concentrated sulphuric acid and a little Kjeldahl catalyst was added to each test tube, they were digested at 420^{o}C on a digesting block to convert the nitrogen in the protein to ammonium ions. The end of digestion was indicated by the solution becoming clear, the samples were heated for another 20 minutes and then cooled. Exactly 90 ml of the distilled water was added to each test tube and then loaded onto the distillation unit of the Kjeltec auto analyzer. A blank containing no sample was also run at this time. Approximately 50 ml of 40% sodium hydroxide solution was added into each test tube and the liberated ammonia distilled in excess boric acid solution. The distillate was titrated against 0.005M hydrochloric acid to determine the ammonia absorbed by boric acid.

Protein content was then calculated as follows:

$$\%\ \text{Crude protein} = \frac{(\text{V2} - \text{V1})\text{MHCL}}{\text{W}} \times 14 \times 6.25 \times 100$$

Where V2 =volume (ml) of the hydrochloric acid solution required for the sample, V1=volume of the hydrochloric acid required for the blank test, M HCl= molarity of the hydrochloric acid, 6.25= nitrogen conversion factor, W=weight of the test sample in grams, 14= atomic mass of nitrogen

3.7.3 Determination of crude fat

Soxhlet extraction method was used as described by AOAC (1996). About 2 g of each flour sample was mixed with about 40 ml of petroleum ether (extraction solvent) in thimbles which were later fixed in a soxtec equipment. Fat extraction was done by boiling the samples for about an hour. The solvent was distilled off and the fat extracted, dried in an air- oven at 100^{o}C for about 30 minutes. The oil collected in the beakers was weighed, the crude fat content was then calculated as follows;

$$\%\ \text{Crude fat} = \frac{\text{W1} - \text{W2}}{\text{W0}} \times 100$$

Where W0 = Weight of the sample (g), W2 = weight of the empty beaker (g), W1 = weight of beaker and fat (g)

3.7.4 Determination of crude fiber

The crude fiber was determined by the method described by Kirk and sawyer (1991). About 0.5 g of the flour was weighed and placed into a 600 ml flask, 50 ml of the acid detergent fiber was added and the resultant mixture boiled for 1 hour, the mixture was then filtered over a funnel connected to a vacuum pump using a sinter glass. The sinter glass crucibles were taken to an oven maintained at 100 ^{o}C for 45 minutes to drive off the moisture, the crude fiber was obtained as the difference between the weight of the empty sinter glass and that after the removal from the oven. The total fiber content was then calculated as follows:

$$\% \text{ Crude fiber } = \frac{\text{W1} - \text{W2}}{\text{W3}} \times 100$$

Where W1 is the weight of dry sinter glass and sample (g), W2 is the weight of the sinter glass and sample (g), W3 is the weight of the sample.

3.7.5. Determination of ash content

About 2 g of sample was ignited in a muffle furnace at 500 - 600^{o}C for 6 hours as recommended by AOAC (1999). Ash remained as a residue in crucibles. Ash in crucibles was cooled in the desiccator for about 30 minutes and weighed. Ash content was calculated as a percentage of the total.

$$\%\text{Ash content } = \frac{\text{W3} - \text{W1}}{\text{W2} - \text{W1}} \times 100$$

Where W1 is weight of crucible, W2 is weight of sample and crucible, W3 is weight of ash and crucible.

3.7.6. Determination of the total carbohydrate content

The total carbohydrate in each sample was determined by the difference method (Be Miller, 2003). The difference that remained after subtracting the values of moisture, protein, fat and ash from 100 was the total carbohydrate content.

% Total carbohydrate= 100- (% Moisture content +% Crude protein+% Total fat + %Ash+%Crude fibre)

3.8 Preparation of soup mix

The powder was used to prepare the soup by mixing 90 g of potato peel-based soup flour with 300 ml of boiled cold water. The mixture was heated for 7 minutes with consistent stirring. The resultant soup was then used for sensory evaluation.

3.9 Sensory analysis of the potato peel soup

Sensory acceptability was assessed using a 9-point hedonic scale using an untrained consumer panel of 30 people (Kemp, Hollowood and Hort, 2009) to evaluate the flavor, thickness, taste, mouth feel, appearance and overall acceptability of the product.

4.0. Statistical analysis

The results obtained from the assessed properties were summarized using Microsoft Excel to obtain the means ± standard deviations of three determinations. The means were subjected to ANOVA (analysis of variance) to test the significant difference at 5% level of significance. The consumer acceptability results (means) were subjected to ANOVA to test significant difference at 5% level of significance.

RESULTS AND DISCUSSION

4.1. Functional and physicochemical properties of the potato peel flour

The results on the functional and physicochemical properties of the potato peel flour are summarized in Table 5. The results indicated that potato-based soup flour from peels heated at 61ºC had an increasing oil absorption capacity from 10 minutes to 20 minutes and then decreased with further increase in time to 30 minutes. The potato soup flour from the peels heated at 61ºC for 20 minutes had the highest (261.22%) OAC followed by flour from peels heated for 5minutes. The increase in the oil absorption capacity was due to the physical entrapment of the oil within the protein isolates and non-covalent bonds such as hydrophobic, electrostatic and hydrogen bonds are the forces involved in lipid proteins interaction (Lawal,2004). The potato soup flour from peels steamed decreased gradually from 258.3 % to 205.4% from 5 minutes to 15 minutes. The potato soup flour from peels steamed for 5 minutes had the highest (258.3%) oil absorption capacity. The decrease in the oil absorption capacity of the flours was due to the destabilization of the weak bonds of the proteins caused by the high temperature used during the steaming process of the increasing time ranges.

Water absorption capacity refers to the water retained by a food product following filtration and application of mild pressure of centrifugation. The water absorption capacity of the potato soup flour from the peels heated at 61º C increased with increase in time from 10 minutes to 20 minutes and then decreased with further increase in time to 30 minutes. The potato soup flour from peels heated at 61ºC for 20 minutes had the highest (365.3%) water absorption capacity. The potato soup flour from peels steamed increased with the increase in time from 5 minutes to 10 minutes and then decreased with further increase in time to 15 minutes. The potato soup flour from peels steamed for 10 minutes had the highest (295.5%) water absorption capacity. The increase in the WAC at a specific temperature for varying times was due to the increase in the amylose leaching, solubility and loss of the starch crystalline structure. The decrease in the water absorption capacity was due to the disruption of the starch during the increasing time ranges. Thus, the flour from potato peel samples among the flours from the heated and steamed potato peels with the highest water absorption capacity was chosen for use in the soup formulation.

Swelling power is a measure of hydration capacity, because the determination is a weight measure of swollen starch granules and their occluded water. Swelling power of the potato soup flour from peels heated at 61ºC increased with increase in time from 10 minutes to 20 minutes and then decreased with further increase in time to 30 minutes. The potato soup flour from peels heated at 61°C from 20 minutes had the highest (2.2%) swelling power. The swelling power of potato soup flour from peels steamed decreased gradually with increase in time from 5 minutes to 15 minutes. The potato soup flour from peels steamed for 5 minutes had the highest (2.3%) swelling power. The increase in the granule swelling was caused due to the heating of starch molecule in excess water hence disruption of the starch crystalline structure causing the linking of the water molecules to the exposed hydroxyl groups of amylose and amylopectin by hydrogen bonding. The decrease in the swelling power was due to the increase in the thermal stability of granules during the drying process which happened at 100°C in the oven due to some changes within the amorphous and crystalline phase of granules.

Water solubility index of the potato soup flour from peels heated at 61°C decreased with increase in time from 10 minutes to 20 minutes and then increased with increase in time at 30 minutes. The potato soup flour from peels heated at 61°C at 30 minutes had the highest (10.7%) water solubility index among the heated samples. The water solubility index of the potato soup flour from peels steamed increased gradually with increase in time from 5 minutes to 10 minutes and then decreased with further increase in time. The potato soup flour from peels steamed for 10 minutes had the highest (15.1%) water solubility index among the steamed samples. The decrease in the WSI was due to the loose association of amylose and amylopectin in the starch granules and weaker associative forces maintaining the granular structure. The increase in the WSI due to increase in time may be attributed to increase in number of small fragments of amylopectin or amylose that may have leached out through starch granules of the flour after the hydrothermal treatment.

Water absorption index is the ability of the flour to associate with water. Water absorption index of the potato soup flour from peels heated at 61°C increased gradually from 5.2 to 5.5% with increase in time from 10 minutes to 30 minutes. The potato soup flour from peels heated at 61°C at 20 and 30 minutes had the highest (5.5%) water absorption index. The water absorption index of the potato soup flour from the peels steamed increased from 4.0 to 4.8 % with increase in time from 5 minutes to 15 minutes. The water absorption index of the potato soup flour from peels steamed for 15 minutes had the highest water absorption index of 4.8% among the steamed samples. The increase in the water absorption index was due to the presence of starch hence increasing the starch gelatinization and fibre content in the flours (Dlamini and Solomon,2016).

Table 5: Functional and physicochemical properties of the potato peel flour

SAMPLE	OAC (%)	WAC (%)	SP (%)	WSI (%)	WAI (%)
RF	222.7 ± 15.34^{bc}	275.8 ± 34.06^{b}	2.4 ± 0.04^{a}	15.0 ± 1.90^{a}	3.6 ± 0.08^{f}
H30	205.6 ± 20.10^{c}	337.3 ± 2.98^{a}	2.1 ± 0.05^{cd}	10.7 ± 0.86^{bc}	5.5 ± 0.15^{a}
H20	261.2 ± 13.87^{a}	365.3 ± 13.89^{a}	2.2 ± 0.09^{bc}	7.4 ± 2.48^{c}	5.5 ± 0.20^{a}
H10	195.4 ± 13.77^{c}	287.0 ± 26.93^{b}	2.1 ± 0.03^{cd}	9.6 ± 0.46^{c}	5.2 ± 0.24^{b}
ST15	205.4 ± 24.76^{a}	290.0 ± 10.95^{b}	1.9 ± 0.02^{e}	14.1 ± 1.62^{ab}	4.8 ± 0.11^{c}
ST10	247.4 ± 6.27^{ab}	296.5 ± 9.81^{b}	2.1 ± 0.08^{d}	15.1 ± 0.75^{a}	4.4 ± 0.18^{d}
ST5	258.3 ± 9.50^{c}	280.1 ± 17.03^{b}	2.3 ± 0.12^{ab}	9.3 ± 4.80^{c}	4.0 ± 0.12^{e}

(RF= reference sample, H30 = heating for 30 min, H20 = Heating for 20 min, H10 = heating for 10 min, ST15 =Steaming for 15 min, ST10 = steaming for 10 min, ST5 = steaming for 5 min). The values are means ± sd. Means in the same column with different superscripts are significantly different ($p < 0.05$).

4.2 Pasting properties of the potato peel flour

The results of Rapid Visco Analyzer (RVA) of potato peel soup flour are presented in Figure 1.

From the Figure 1, the peak paste viscosity of the potato peel soup flour did not show a showed peak curve. The peak viscosity curve showed that the reference sample had the highest peak viscosity (1849cp), followed by flour from the 10-minute heated potato peels with 457cp among the heated flour samples and flour from the 5-minute steamed potato peels with 641cp among the steamed flour samples. The flours with the high peak viscosity show an indication of high starch content which makes the flour more suitable for products requiring high gel strength and elasticity.

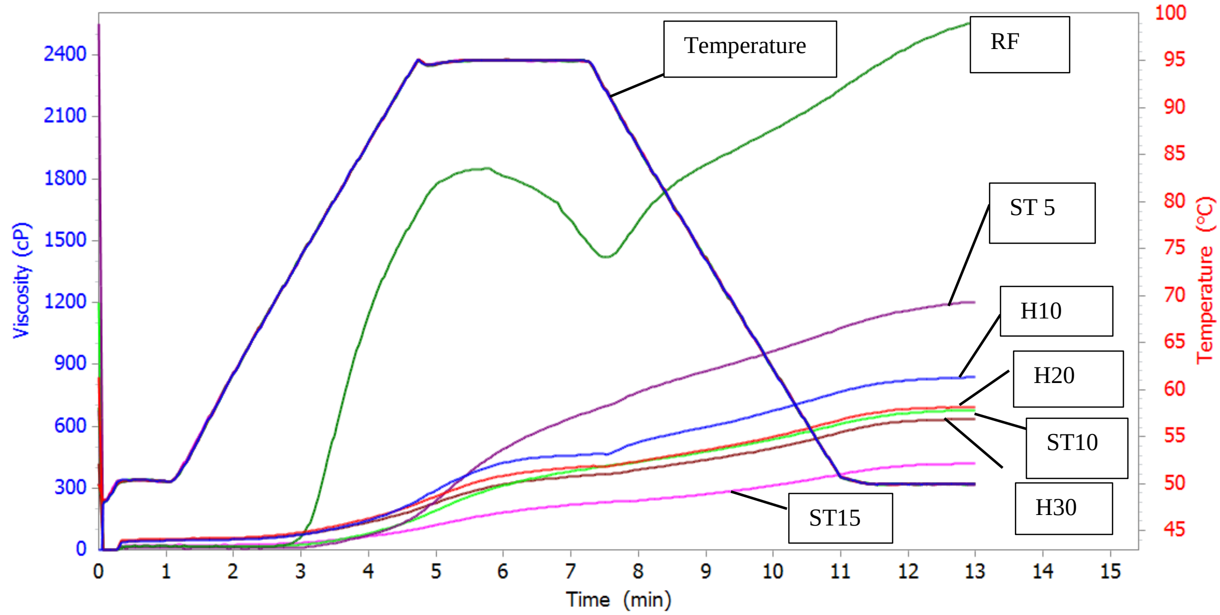
The trough is the minimum viscosity value in the constant temperature phase of the RVA profile and measures the ability of paste to withstand breakdown during cooling. The trough viscosity ranged from 1419 cp to 184cp.The trough viscosity among the flour from the heated peels increased from 426 to 321cp with increase in time. The potato soup flour from peels heated for 10 minutes had the highest (426cp) trough viscosity among the flour made from the heated potato peels. The trough viscosity among the flour from the steamed peels increased from 50cp to 184cp with increase in time. The potato soup flour steamed for 5 minutes had the highest (501cp) trough viscosity among the flours made from the steamed potato peels. The flour from the reference sample had the highest (1419cp) trough viscosity among all the potato peel soup flours. The large values of trough viscosity show little breakdown of sample starches.

The breakdown viscosity is the index of the stability of starch. The breakdown viscosity ranged from 430cp to 31cp.The breakdown viscosity among the flours from the heated peels increased from 36cp to 31cp with increase in time from 10 minutes to 20 minutes then decreased further to 30 minutes. The potato soup flour from peels heated for 20 minutes had the highest (36cp) breakdown viscosity among the heated samples. The breakdown viscosity among the flours from the steamed peels increased from 140 to 35cp with increase in time from 5 minutes to 15 minutes. The potato soup flour steamed for 5 minutes had the highest(140cp) breakdown viscosity among the flours made from the steamed potato peels. The flour from the reference sample had the highest(430cp) breakdown viscosity among the potato peel soup flours. The lower breakdown viscosity shows greater resistance to heat and shear expected of flours with lower peak viscosities and the higher the breakdown viscosity, the lower the ability of starch sample to withstand heating and shear stress during cooling.

Setback viscosity, defined as the difference between the breakdown viscosity and the viscosity at 50^{o}C, determines the tendency of starch to retrograde. The setback viscosity of the potato soup flour from the peels ranged from 1135cp to 235cp.The setback viscosity of the flour made from heated potato peels increased from 411cp to 312cp with increase in treatment time from 10 minutes to 30 minutes. The potato soup flour from peels heated at 61^{o}C for 10 minutes had the highest (411cp) setback viscosity among the flours from the heated samples. The setback viscosity of the flour made from steamed potato peels decreased from 702cp to 235cp with increase in time from 5 minutes to 15 minutes. The potato soup flour steamed for 5 minutes had the highest (702cp) setback viscosity among the flour from steamed potato peels. The potato soup flour from the reference sample had the highest(1135cp) setback viscosity among the potato soup flours. The higher the setback value, the lower the retrogradation during cooling and the lower the staling rate of the products made from the flour. The lower the setback viscosity during the cooling of the paste indicate greater resistance to retrogradation.

Final viscosity which indicates the ability of the material to form a viscous paste ranged from 2554cp to 419cp.The final viscosity of the flour made from the heated potato peels increased from 837cp to 633cp with increase in time from 10 minutes to 30 minutes. The potato soup flour from peels heated at 61^{o} C for 10 minutes had the highest(837cp) final viscosity among the flour from the heated samples. The final viscosity of the flour made from steamed potato peels decreased from 1203cp to 419cp with increase in time from 5 minutes to 15 minutes. The potato soup flour from peels steamed for 5 minutes had the highest(1203cp) final viscosity among the flours from the steamed potato peels. The potato soup flour from the reference sample had the highest (2554cp) final viscosity among the potato soup flours.

Peak time is the measure of cooking time and ranged between 5.73 to 7.00 minutes. The flours from the heated and steamed potato peels all had peak times of 7.00 minutes and the reference sample having the lowest peak time of 5.73 minutes. This indicates the minimum time required to cook the flour.



(RF= reference sample, H30 = heating for 30 minutes, H20 = Heating for 20 minutes, H10 = heating for 10 minutes, ST15 =Steaming for 15 minutes, ST10 = steaming for 10 minutes, ST5 = steaming for 5 minutes)

Figure 1: Pasting properties of potato peel flour samples.

4.3 Proximate composition of the potato peel flour

The proximate composition of the formulated potato peel flour is shown in Table 6.The proximate composition results of the soup flour showed that the soup flour had a high fibre content of 5.94 % which was enhanced by the onion powder which was added on the 2.5% fibre content in the potato peel as recorded in Arapoglou *et al*., 2009.Crude fibre slows down the release of glucose into the blood and decrease intercolonic pressure hence reducing the risk of colonic cancer(Gibney,1989).The ash content was also increased from 1.3% in the potato peel as recorded in Arapoglou *et al*.,2009 to 10.28% due to the addition of other ingredients which were added hence increasing its mineral content. The ash content of a food sample gives an idea of the mineral elements present in the food.it indicates the composition of inorganic constituents after organic materials (fats, protein and carbohydrates and moisture) have been removed by incineration. It is essentially the mineral content of a food sample. The fat and protein content were also highly increased from the 0.3% and 1.8% respectively in the potato peel according to Arapoglou *et al*.,2009 to 3.10% and 13.89% respectively due to the addition of milk powder and chicken bouillon flavourant. The carbohydrate content of the soup flour increased to 56.72% from 10.6% in the potato peel according to Arapoglou *et al*.,2009 because of the addition of the other ingredients like milk powder, onion powder, corn starch hence the high increase. The carbohydrate content of these flour samples is an indicator that the products made from them will be good sources of energy. The soup flour had a moisture content of 7.08 % which is a recommended moisture content of flours below 8% as according to Jay (1978) which is desirable for dried foods since it retards both microbial growth and browning reactions. The American Association of Cereal Chemists (AACC,2001) approved methods for determining various properties of flour specify that the higher the moisture content, the lower the amount of dry solids in the flour. The flours with moisture content higher than the specified are not stable at room temperature and as such organisms present in them will start to grow thus producing off odours and flavours.

Table 6:Proximate composition of the potato peel soup flour

Parameter	**Composition (%)**
Moisture	7.08±0.25
Ash	10.28±0.22
Crude protein	13.89±0.33
Fat ether extract	3.10±0.40
Crude fibre	5.94±0.50
Carbohydrates	59.72±0.97

Results based on % wet basis

4.4. Sensory evaluation of the potato peel soup

The sensory evaluation results are summarized in Table 7. The results indicated that the potato soup from flour with formulation two obtained from potato peels steamed was most accepted and received the highest acceptability score for appearance, colour, thickness, mouth feel and overall acceptability.

The consumer scores for appearance and colour showed that potato soup from flour with formulation two obtained from potato peels steamed had the highest score of 6.800 and 6.600 respectively and potato soup from flour with formulation two from potato peels heated at 61^{o}C had the lowest score of 6.067 and 6.033 respectively. The results also showed that generally the soup samples were slightly liked by the consumers. This was because the soup samples all had potato peel flour as the major ingredient. The potato peel flour was brown in color which is not appealing to consumers. The color was dark because the peels contain a lot of fibre hence a characteristic of all high fibre containing product to have dull colors (Khalifa *et al.*2015).

The consumer scores for thickness showed that the potato soup from flour with formulation two obtained from peels steamed had the highest score of 6.967 than the other soup samples and potato soup from flour with formulation two obtained from potato peels heated at 61^{o}C had the lowest score of 6. 533.The high scores were due to high water absorption index of the potato peel flours which were chosen from the other flours which influences the quality of the soup (Kaushal, Kumar and Sharma,2012). The scores were not significantly different because the same amount of flour and water was used during the preparation of the soup samples.

The consumer scores for flavor showed that potato soup from flour with formulation one from potato peels heated at 61^{o}C had the highest score of 6.828 than the other soup samples and the potato soup from flour with formulation one obtained from peels steamed at 106^{o}C had the lowest score of 6.138.The consumer scores for taste showed that the potato soup from flour with formulation one obtained from peels heated at 61^{o}C had the highest score of 6.414 than the other soup samples and flour with formulation two obtained from peels heated at 61^{o}C had the lowest score of 5.767.The variations in flavour and taste scores of the soup samples were due to the different content of potato peels(75% and 80% content of peel flour) and other ingredients like the flavourant which were added during the formulation.

The consumer scores for mouth feel showed that the potato soup from flour with formulation two obtained from peels steamed had the highest score of 6.833 than the other soup samples and potato soup from flour with formulation two obtained from peels heated at 61^{o}C had the lowest score of 5. 700.This was because panelists identified a burnt aftertaste and sour mouth feel which might have been caused by the drying temperatures and the undetermined glycoalkaloid content of the flour. Sandiness in the soup sample was also identified by the panelists due to the large particle size of the flour.

The consumer score for overall acceptability showed that the potato soup from flour with formulation two obtained from peels steamed had the highest acceptability score of 6.967 than the other soup samples and the potato soup from flour with formulation two obtained from peels heated at 61^{o}C had the lowest acceptability score. This is because of the identified sour taste, sandy mouth feel texture and burnt flavor which may have been due to the temperature (100^{o}C) in the oven during the drying process.

Table 7:Sensory attributes of the potato peel soup samples

Sample code	**Appearance**	**Colour**	**Thickness**	**Flavour**	**Taste**	**Mouthfeel**	**Overall acceptability**
F2S	6.800 ± 1.58^{a}	6.600 ± 1.43^{a}	6.967 ± 1.27^{a}	6.267 ± 1.82^{a}	6.033 ± 1.85^{a}	6.833 ± 1.18^{a}	6.733 ± 1.62^{a}
F1S	6.621 ± 1.70^{a}	6.345 ± 1.75^{a}	6.931 ± 1.45^{a}	6.138 ± 2.04^{a}	5.966 ± 1.86^{a}	6.310 ± 1.77^{ab}	6.690 ± 1.65^{a}
F1H	6.276 ± 1.67^{a}	6.276 ± 1.49^{a}	6.862 ± 1.52^{a}	6.828 ± 1.46^{a}	6.414 ± 1.77^{a}	6.172 ± 1.60^{ab}	6.414 ± 1.73^{a}
F2H	6.067 ± 1.31^{a}	6.033 ± 1.92^{a}	6.533 ± 1.33^{a}	6.267 ± 1.66^{a}	5.767 ± 1.79^{a}	5.700 ± 1.78^{b}	6.333 ± 1.03^{a}

Values are means ± standard deviations (n=30 panelists). Values in the same column with different superscripts are significantly different ($p < 0.05$). The scale used ranges from 1: dislike extremely to 9: like extremely. F1S =Formulation 1 steamed, F2S =Formulation 2 steamed, F1H = Formulation 1 heated, F2H = Formulation 2 heated

CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Heat treatments of potato peels have an influence on physicochemical and functional properties on the resultant flour.

Flour from potato peels is suitable for use in the production of soup. Soup from formulation with 75% flour from the steamed potato peels was the most acceptable.

5.2. Recommendations

The colour of the potato flour should be improved so as to increase consumer acceptability as colour influences and attracts consumers towards products.

Further research should be done to find methods that can be used to first reduce the glycoalkaloid content of the potato peels so as to increase the safety of flour for consumption by the consumers.

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APPENDICES

APPENDIX 1: Sensory evaluation sheet used in evaluation of consumer acceptability of the soups

Date: ……………………………………. Time ……………………………….

You are provided with samples of potato peel soup coded 694,538,422 and 209.Assess for the taste, colour, flavor, thickness, mouthfeel, appearance and overall acceptability with respect to the scale described below. Express the extent to which you like the samples.

NB: Please ensure that you rinse your mouth with water provided before the next sample. Also stir the sample gently before tasting and feel free to give any comment about any of the samples.

Description **Score**

Like extremely ………………………. 9

Like very much ………………………. 8

Like moderately ………………………. 7

Like slightly ……………………… 6

Neither like nor dislike ………………. 5

Dislike slightly ………………………. 4

Dislike moderately …………………… 3

Dislike very much ……………………. 2

Dislike extremely ……………………. 1

Sample code /attribute	**Taste**	**Colour**	**Flavor**	**Thickness**	**Mouthfeel**	**Appearance**	**Overall acceptability**
694							
538							
422							
209							

Any comment(s), (Please attach a sample code).

……………………………………………………………………………………………………

YOUR PARTICIPATION IS HIGHLY APPRECIATED.

Appendix 2: Photographs showing processing treatments done and equipment used

Stirring during heating process

Steaming of potato peels

Drying in the oven

Above: dried reference sample,

Down(L): Dried steamed sample(R):

Dried heated sample

Hammer mill used for milling

Milled potato peel flour