DEVELOPMENT OF ORANGE SWEET POTATO *(Ipomoea batatas Lam.)* KETCHUP

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ABSTRACT

There is an increase need for food product development due to the continuing age in consumers' interests and demands. Sweet potato (SP), a common root crop in the Philippines, is commonly used as food crop and is usually eaten boiled or fried. The roots, stems and leaves of SP have been utilized for different food products such as jam, flour and animal feeds. This study aims to utilize the tuberous root of orange sweet potato variety into ketchup. Raw orange sweet potato (OSP) and the developed ketchup were subjected to proximate, total dietary fiber, Vitamin A analysis, physicochemical and microbiological analysis. The proximate analysis of the ketchup showed that OSP ketchup is a poor source of protein (0.53g/100g) and fat (none-detected). However, the ash content increased (2.1g/100g) and there is a decrease of carbohydrate content (18.77g/100g) due to the process of boiling. On the other hand, the moisture increased (78.6g/100g) due to addition and absorption of more water. The presence of the dietary fiber and vitamin A (2.8g/100g and 15.6 µgRE/100g, respectively) contributes to the nutritional composition of the OSP ketchup. The physicochemical analysis showed that titratable acidity particularly citric acid (0.54 %w/v) inhibits the microbial growth while water activity content (0.936 Aw) showed that the product is susceptible to microbial growth. The viscosity (58,980 cp) and pH (4.11 %w/v) is within the standard showing that it possesses the qualities of ketchup. However the total soluble solids (13.1%w/v) can still be improved. The sensory evaluation of the SP ketchup showed that majority of the panellist scored 7 (like moderately) means that OSP ketchup is acceptable. The microbial analysis showed that SP ketchup complied with the standards and could be considered safe. The result of this study has proved that sweet potato could be utilized and developed into a variety of food product like ketchup.

Keywords: *Ipomoea batatas L.*, ketchup, Dietary fiber

INTRODUCTION

Product development has been a part of food industry to innovate new products. Natural science and social science need to work hand in hand to apply the science of food processing to promote and market the product to the consumers (Wall and Winger, 2006). The interest of improving flavors of sauces and using it as seasoning for healthy and flavorful food are escalating nowadays (Paton and Smith, 2002). Unusually flavored condiment seem interesting, like the idea that ketchup can also be made from different raw materials. "Ketchup is a descriptive term for a number of different products which consists of various pulps from various strained and seasoned fruits" (Ghandi *et al.,* 2009). Mostly, ketchup is used as a base for some sauces and to improve the taste of food. It is therefore needed in a meal to present a condiment that can complement the food and improve eating preference.

A variety of tomatoes has always been associated with ketchup (Ehsandoost and Tabibloghmany, 2013). Nevertheless, other plants sources can also be utilized for this purpose. In the Philippines, banana ketchup, a spicy-sweet condiment, is the mostly consumed condiment because it complements the Filipino taste (Acurato *et al.,* 2015). Interesting formulations of ketchup has been developed over the years, such as mushroom, dragon fruit, sweet gourd and fish ketchup (Bhuiyan and Rana, 2012; Acurato *et al.,* 2015; Lou *et al.,* 2014; Afriliana *et al.,* 2014). The use of other raw materials like sweet potato in making ketchup therefore seem interesting for the development of healthier food substitutes.

Sweet potato, a starchy root crop typically cultivated in tropical and subtropical areas, is considered as one of the most important food crop in the world. In the Philippines, sweet potato ranks next to cassava in terms of area and production (Rao and Hermann, 1999). Sweet potato is an excellent source of ß -carotene, anthocyanins, total phenolics, ascorbic acid, folic acid, minerals and dietary fibre (Woolfe, 1992; Bovell-Benjamin, 2007; ILSI, 2008). Along with its nutritive and functional properties, sweet potato can be utilized unto different food products such as puree, jam, flour, noodles, ice cream, baked products, various snacks, and desserts (Collins and Walter, 1992; Dansby and Bovell-Benjamin, 2003; Truong, 1992; Truong *et al.,* 1995; Walter *et al.,* 2001; Woolfe, 1992).

Sweet potato as most widely produced food crop that is commonly used in developing food products is significant to further maximize the potential of formulating new products that can offer cheaper alternatives with considerable nutritional content and acceptable sensory qualities like sweet potato ketchup.

The main objective of the study is to develop ketchup from orange sweet potato. This study specifically aims to determine proximate composition (protein, fat, moisture, ash and carbohydrates), dietary fiber (soluble and insoluble), vitamin A, physicochemical properties (titratable acidity, total soluble solids, pH, viscosity and water activity), microbiological analysis (aerobic plate count, yeast and molds ad coliform) of raw OSP and OSP ketchup and consumer acceptability of the developed OSP ketchup. This study did not cover shelf life determination, packaging and effects of storage conditions on the developed food product.

THEORETICAL BACKGROUND

Theoretical Framework

Condiments and sauces are usually introduced as the important accessory of the culinary world (Food Business News, 2012). Traditionally, it is a food additive that is commonly used as an accompaniment of food which becomes a large part of the practice in preparing food that imparts and enhances flavour to dishes (Awolola, Dosumu, Oluwaniyi, Oyedeji, 2012; Etonihu, Nweze, Obelle, 2013 and Oboh, 2006). Some of the most common condiments that lend flavor to food are mustard, ketchup, vinegar, mayonnaise, chili sauce, soy sauce, and barbeque sauce (Brown, 2011). Ketchup is said to be the most popular condiment used in daily meals as flavoring ingredient in various culinary recipes and goes well with different foods as it improves their taste (Galkowska*et al.,* 2012). As the consumers' preference shifts to a healthier lifestyle, ketchup as one of the most utilized condiment due to its versatility and compatibility with food, has increased the demand of healthy foods like ketchup that are made from different raw materials which at the same time offers pleasant taste, aroma and texture.

Due to the ketchup versatility and compatibility with food it is one of the utilized condiment and as the consumers' preference shifts to a healthier lifestyle thus increasing the demand of healthy foods like ketchup that are made from different raw materials which at the same time offers pleasant tastes, aromas and textures

Sweet potato (*Ipomoea batatas* Lam.*)* a large, starchy, tuberous root vegetable is a perennial herbaceous dicotyledonous vegetable crop that belongs to the family of Convolvulceae (Dominguez, 1992; Scott, 1992; Millind, 2015). Sweet potato can be classified into the color of its flesh which are: White, Purple and Orange flesh (Millind, 2015). The purple sweet potato contains anthocyanins that have high heat and light stability compared to the white and orange sweet potato (Montilla *et al*. 2011). However, the Orange fleshed sweet potato (OSP) is higher in carotenoids and carotene (Jakahata, 1993). In the Philippines, reports indicated that there are 1,586 sweet potatoes and there are 30 sweet potato varieties released by the National Seed Industry Council (Altoveros and Borromeo, 2007). The orange fleshed sweet potatoes are more utilized compared to the white and purple fleshed sweet potato (Villareal and Griggs, 1982). Sweet potato is a good source of energy and is rich in ß -carotene, anthocyanin, total phenolic, dietary fiber, ascorbic acid, folic acid and minerals such as potassium, calcium, magnesium, sodium, phosphorus and iron (Woolfe, 1992; Bovell-Benjamin, 2007; ILSI, 2008; Millind, 2015) which plays a significant role in human daily nutrition needs.. Many of the compounds present in sweet potato are important because of their beneficial effects on health, thereforeit is highly desirable in the human diet and functions as a functional food (Katan and De Roos, 2004).

Dietary fiber is one of the nutritional sources in sweet potato which according to Kirkpatrick (2012) and Trinidad *et. al.*, (2012) it is defined as an edible component of plant foods which comes from the family of carbohydrates. According to researchers from University of California (2009) it is stated that dietary fiber is an important part of a healthy diet. Dietary fiber is further classified into soluble and insoluble fiber which is determined by its water binding capacity and other chemical properties (Roberfoid, 1993; Mellem, 2013). Soluble dietary fiber dissolves in water forming viscous gel like substance which retains water (Otles *et. al.,* 2014). One of the functions of soluble dietary fiber is to regulate digestion and absorption in the small intestine and binds with bile acids, increasing fecal excretion. It also helps in treating type 2 diabetes by normalizing the blood glucose and insulin levels and due to its viscous nature soluble dietary fiber helps to treat cardiovascular diseases by lowering blood cholesterol level. (Marlett*et. al.,*2002; Ahmed, 2015). The insoluble dietary fiber does not dissolve in water and do not form gels due to their water insolubility and fermentation is severally limited (Otles*et. al.,* 2014). Some of the benefits of Insoluble dietary fiber are absorption of water, regulatory intestinal affects, increases fecal bulk, excretion of bile acids, laxative effect, causes rapid peristaltic contraction and act against constipation (Knudsen, 2011; Angiolone and Collar, 2011; Perry and Ying, 2016). According to Wong and Jenkins (2007), most fiber containing foods include approximately one third soluble and two-third insoluble fiber. Due to the benefits of Dietary Fiber, it has been widely used as a food additive in confectioneries, biscuits, beverages, snack foods, frozen foods, imitation cheeses, canned meats and sauces (Hesser, 2009; Sodorova *et. al.,* 2007; Lummela *et. al.,* 2009; Pollard *et. al.,* 2009; Verardo *et. al.,* 2011).

Another nutritional content of a sweet potato is Vitamin A wherein according to Burri (2011) it is one of the important micronutrients needed by the body. Multiple fruits and vegetables which are naturally rich in vitamin have been used to increase the vitamin status (Low *et al.,* 2007; Burri and Turner, 2009). Some of the good sources of Vitamin A are carrots, mangos, spinach, pumpkin and orange sweet potato (Britton 1995; USDA ARS 2010; Hagenimana *et al.,* 1999; Teow*et al.,* 2007; Wu *et al.,* 2008). Fortification of food have also been successful in preventing vitamin a deficiency (Fiedler and Afidra 2010; Klemm *et al.,* 2010). Vitamin A deficiency is considered to be a serious health issue which is responsible for over 600,000 deaths per year mostly from young children or pregnant women (WHO 1995; West 2002; United Nations Childrens Fund [UNICEF] 2004; Black *et al.* 2008). Due to Vitamin A deficiency, high-dose Vitamin A supplement were distributed twice a year in order to prevent the said deficiency

(Pedro *et al.,* 2004; Aguayo *et al.,* 2005; Donnen *et al.,* 2007; Idindili *et al.,* 2007; Bezerra *et al.,* 2010).

Due to the avowed benefits and nutrient content of sweet potato, numerous studies have been conducted for its utilization in new product development. Sweet potato aside from being consumed as it is, it can be used in making flour and flour products such as noodles, bread and biscuit. Beverages are also a possible application for sweet potato such as juice or drink preparation (Coggins *et al.,* 2003). It is also utilized as fries, canned foods, and stabilizer in the ice cream industry and a sweetener for soft drinks (Antonio et al., 2008; FAO, 1990; Prain and Fano, 1991).

The interest of new varieties of ketchup made from different raw materials ranging from fruits, vegetables up to fishes are being explored. In a study conducted by Acurato *et al.,* (2015), dragon fruit ketchup in 15%, 20% and 25% ratio was utilized and the results determined that 25% ratio was preferred by the housewives and the overall dragon fruit ketchup is acceptable. In addition, another study that was conducted by Lou *et al.,* (2014), sweet gourd ketchup demonstrated that 0.3% Carboxymethyl cellulose formulation was found more suitable than starch in the improvement of quality attribute, nutritional value and potential commercial production of ketchup. Another variation on the said researches is the study of Bhuiyan and Rana (2012) about mushroom ketchup which focuses on the preservation of mushroom with the use vinegar and sugar in different ratio and it was found that sugar showed most prominent effect on overall acceptability of ketchup than vinegar. On the other hand, in the study of Afriliana *et al.,* (2014) study, it was determined that making fish ketchup made from bibisan fish hydrolyzate can shorten production time and does not require fermentation process by using biduri protease and papain and was found to be acceptable to the consumers. Thus, there is a possibility that sweet potato can be utilized as ketchup.

Conceptualize Framework

This study was carried out to utilize sweet potato into ketchup. In this study, the product was evaluated using the 9-point hedonic scale based on the following attributes: appearance, aroma, mouthfeel, taste and general acceptability by 75 untrained panelists in the Food Laboratory 1 of Colegio de San Juan de Letran. The results from the sensory evaluation were statistically analyzed using Analysis of Variance (ANOVA) at $p \leq 0.05$ level of significance.

The OSP ketchup was subjected to proximate analysis (protein, fat, moisture, ash, carbohydrates), dietary fiber and vitamin A analysis, physicochemical analysis (titratable acidity, total soluble solids, pH, viscosity and water activity) and microbiological analysis (aerobic plate count, yeast and molds and coliform).

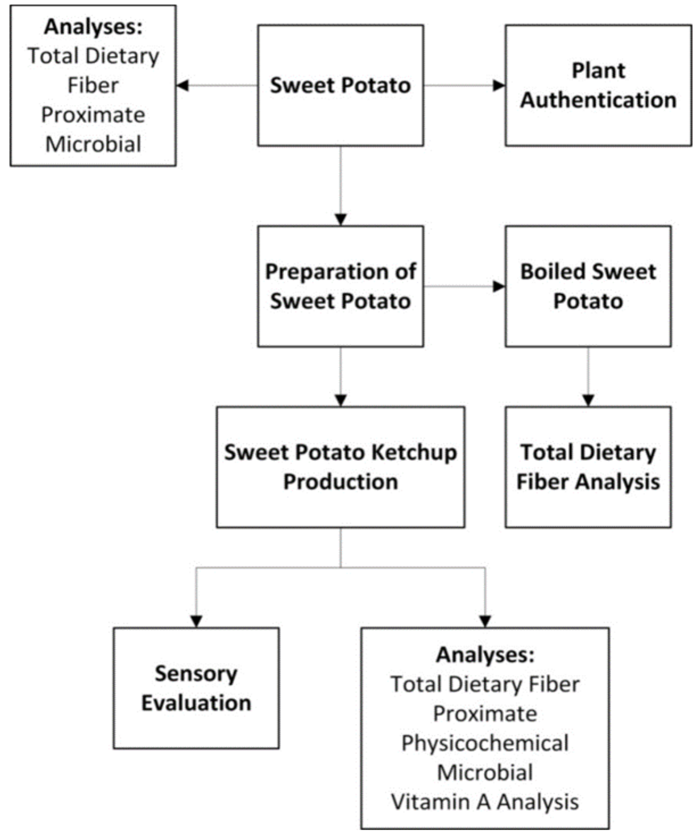

Figure 1: Schematic Diagram of Utilization of Sweet Potato (*Ipomoea batatas Lam.*) into ketchup

MATERIALS AND METHOD

Materials

Orange sweet potatoes (*Ipomoea batatas* L.) were obtained from a local farm in Tagaytay City, Cavite and samples was submitted to the Botany Department of the Philippine National Museum for authentication. Wet and dry ingredients such as: sugar, iodized salt, onion, garlic, pepper, cinnamon, and vinegar were bought from a local supermarket in Bacoor, City Cavite. The food grade chemicals used were citric acid and sodium benzoate was purchased from a supplier in Quezon City, Philippines. Digital balance (Metaltex), blender (SJB- 1.5LA), Kitchen Aid Mixer, large pot, knife, peeler, mixing bowl, colander, measuring spoons and cups, utility cups were requested and borrowed from Food Laboratory of the Colegio.

Preparation of the sample

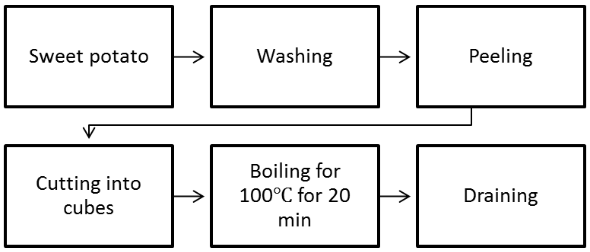

Figure 2: Schematic Diagram for the Pre-treatment of Sweet Potato

Figure 2 shows the pre-treatment procedure that was used for the sweet potato was adopted from the study of Cipirano (2008). The fully ripe and deep color fresh orange sweet potatoes were washed thoroughly in running water to remove dirt. It was peeled using either stainless knife or a peeler. All the black spots and cavities was removed from the sweet potatoes. Samples was cut into small pieces (approximately 2x4 cm) or cubed and subsequently boiled for about 20 minutes at 100 C. The sweet potato was drained, mashed and set aside.

Product Development

The process for the ketchup production was adopted from the study of Cipriano (2008) with minor modifications. The prepared peeled boiled sweet potato was placed in a container and set aside. In the preparation of spice, sugar and iodized salt was weighed and were mixed with 600ml of boiling water until the sugar and iodized salt was dissolved. From the mixture of sugar, iodized salt and boiling water the other spices specifically onion and garlic powder, white pepper, chili powder, and cinnamon were added and were mixed for about 5 minutes until dissolved and the preservatives particularly vinegar and sodium benzoate were added and mixed in. The over-all mixture was the result to the production of spice solution.

The prepared spice was blended with the boiled sweet potato with 250 ml of water. Food color was added and it was then mixed thoroughly with Mechanical mixer (Kitchen Aid).

Table. 1. Formulation of Sweet Potato Ketchup from Srivastava, 1982

Raw Materials	Sweet Potato KetchupFormulation
Mashed Sweet Potato	1.5kg
Onion Powder	51.8g
Garlic Powder	10g
White Pepper	2.4g
Cinnamon Powder	0.6g
Chili Powder	1.7g
Salt	45g
Sugar	135g
Vinegar	250 mL
Citric Acid	0.5 g
Sodium Benzoate	10.50 g
Red Food Color	20mL
Batch Weight	2,600 g

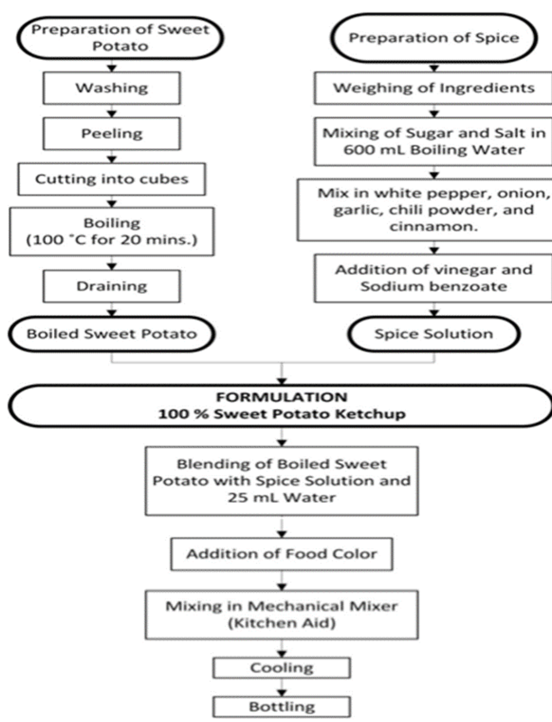

Figure 3: Preparation of the Sweet Potato Ketchup from Cipriano, 2008 with modification

Proximate Analysis

The proximate analysis of both the Orange Sweet Potato raw material and Sweet Potato ketchup was based on AOAC International, 19th edition. Moisture and ash content of the raw material and product was determined using Gravimetry method while Total Fat content was determined using Soxhlet Extraction. Protein content was determined using Keijdahl method while the Total carbohydrates was determined by computation using the values of the total percentage of % moisture, % ash, % protein, % fat minus 100. The Total dietary fiber of the orange sweet potato raw material and product was determined using enzymatic-gravimetry method. Lastly, the Vitamin A content of the sweet potato ketchup was determined using in-house HPLC.

Microbiological Analysis

The aerobic plate count, yeast and molds and coliform were determined using pour plate method based on Bacteriological Analytical Manual.

Aerobic Plate Count

First, melt the sterile solid agar medium by placing a tube of plate count agar in a beaker of boiling water and keep the melted medium in a water bath, between 44–46 °C, until used. Second, pipet the appropriate amount of undiluted or diluted sample (1 mL or 0.1 mL) into the sterile petri dish and prepare at least two plates for each different volume of undiluted or diluted sample used. Third, pour at least 10 to 12 mL of liquefied medium (½ of the contents of Plate Count Agar tube) into the dish by gently lifting the cover just high enough to pour and mix the melted medium thoroughly with the sample in the petri dish by swirling in a figure-eight motion with the petri dish on the bench top. Fourth, place the plates on a level surface and let them solidify for about 10 minute and invert the plates, place them in a plastic bag, and seal the bag. Fifth, place the bag in an incubator that has been pre-warmed to 35 °C and incubate the plates for 48 ± 3 hours at 35 ± 0.5 °C. During incubation maintain humidity within the incubator so that plates will not have moisture weight loss greater than 15% and a pan of water placed at the bottom of the incubator may be sufficient. However, for incubation in non-humidified incubators, make certain that the plastic bags are tightly sealed. Lastly, count all colonies on the plates promptly after incubation.

Yeast and Mold

First, the petri film Aerobic Plate Count Plate was placed on a flat surface and the top film was lifted and the pipette perpendicular to the plate and carefully dispense 1ml of sample or sterile hydrating solution onto the center of the bottom film. Second, release the top film and allow it to drop onto the liquid and lift plastic spreader using circular handle. Third, align the center of the spreader and do not slide the spreader across the film. Fourth, remove spreader and leave plate undisturbed in one minute to permit the solidification of gel. Fifth, incubate inoculated plates in a horizontal position (clear side up) at 20-25℃ for 2-3 days wherein plates may be stacked up to 20 high. Lastly, the plates were observed for growth at both 3-5 days.

Coliform

First, fifty gram of food was weighed into sterile high-speed blender jar and 450 mL of Butterfield's phosphate-buffered water was added and blended it for 2 min. If <50 g of sample are available, weigh portion that is equivalent to half of the sample and add sufficient volume of sterile diluent to make a 1:10 dilution. The total volume in the blender jar should completely cover the blades. Second, prepare decimal dilutions with sterile Butterfield's phosphate diluent or equivalent, however number of dilutions was prepared depending on the anticipated coliform density. Third, shake all suspensions for about 25 times in 30 cm arc or vortex mix for 7 seconds. Fourth, using at least 3 consecutive dilutions, inoculate 1 mL aliquots from each dilution into 3 LST tubes for a 3 tube MPN analysis (other analysis may require the use of 5 tubes for each dilution) wherein Lactose Broth may also be used and for better accuracy 1 mL or 5 mL pipet for inoculation was used. Fifth, do not use pipets to deliver <10% of their total volume, instead hold the pipet at an angle so that its lower edge rests against the tube and not more than 15 min should elapse from the time the sample is blended until all dilutions are inoculated in appropriate media. Fifth, incubate LST tubes at 35°C± 0.5°C. Sixth, examine tubes and record reactions at 24 ± 2 hours for gas and re-incubate gas-negative tubes for an additional 24 hours and examine and record reactions again at 48 ± 3 hours. Seventh, the confirmed test on all presumptive positive (gas) tubes was performed and from each gassing LST or lactose broth tube, a loopful of suspension to a tube of BGLB broth was transferred and pellicle should be avoided if present. Eighth, BGLB tubes at 35°C± 0.5°C was incubated and examined for gas production at 48 ± 3 hours. Lastly, most probable number (MPN) of coliforms was calculated based on proportion of confirmed gassing LST tubes for 3 consecutive dilutions.

Physicochemical Analysis

Total soluble solids of SP ketchup was measured using a the method of refractometry while the pH was measured using the method of electromtetry; Titratable acidity in terms of acetic and citric acid was determined using titrimetry method whereas Viscosity was determined using studied at room temperature using Brookfield DV-E viscometer with LV spindle number 62. Lastly, Water activity was determined using water activity equipment which is the NovasinaWater Activity Meter. All the methods used in this analysis were based on AOAC International, 19th edition.

Sensory Evaluation

The sensory evaluation was conducted by evaluating three samples with three digit codes by 75 untrained panellists based on the attributes: appearance, aroma, taste, mouth feel and general acceptability. Significant differences ($p < 0.05$) between the different formulations were confirmed by Duncan's Multiple Range Test (DMRT).

RESULTS

Table 2. Proximate Analysis of Raw Sweet Potato

PARAMETERS	RAWOSP (g/100g)
Moisture	65.9
Total Carbohydrates	30.7
Protein	1.6
Ash	1.5
Fat	0.31

Table 3. Total Dietary Fiber of Raw and Mashed Sweet Potato

PARAMETERS	RAWOSP (g/100g)	MASHED OSP (g/100g)
Total Dietary Fiber	3.0	6.3
Soluble	1.1	1.3
Insoluble	1.9	5.0

Table 4. Sensory Evaluation of Sweet Potato Ketchup

ATTRRIBUTES	SAMPLE A (Tomato)	SAMPLE B (Banana)	SAMPLE C (Sweet Potato)
Appearance	8.20 ± 1.07^{a}	7.85 ± 1.07^{ab}	7.65 ± 1.23^{b}
Color	7.75 ± 1.14^{a}	7.41 ± 1.25^{ab}	7.13 ± 133^{b}
Mouthfeel	7.93 ± 1.20^{a}	7.41 ± 1.09^{b}	7.22 ± 1.06^{bc}
Aroma	7.07 ± 1.36^{a}	6.89 ± 0.83^{ab}	6.64 ± 0.83^{b}
Taste	7.81 ± 1.27^{a}	6.96 ± 1.48^{b}	6.89 ± 1.07^{bc}
General Acceptability	7.63 ± 1.68^{a}	7.13 ± 1.29^{b}	7.01 ± 1.46^{bc}

*Values in a row with different superscripts are significantly different ($p < 0.05$)

Table 5. Proximate Analysis of Sweet Potato Ketchup

PARAMETERS	SP KETCHUP (g/100g)
Moisture	78.6
Total Carbohydrates	18.77
Protein	0.53
Ash	2.1
Fat	*ND

*ND means none-detected at the method limit of 0.025g/100g for total fat

Table 6. Total Dietary Fiber and Vitamin A content of Sweet Potato Ketchup

PARAMETER	SP KETCHUP	REQUIREMENT*
Total Dietary Fiber	2.8	
Vitamin A (μgRE/100g)	15.6	700**

*DOH-FNRI, 2015
**1 retinol equivalent (RE) = 1 μg retinol = 12 μg β-carotene or 24 μg other provitamin A carotenoids;1μg RE = 3.33 IU vitamin A

Table 7.Physicochemical Analysis of Sweet Potato Ketchup

PARAMETERS	SP KETCHUP	STANDARD*
Total Soluble Solids (%w/v)	13.1	25
pH (%w/v)	4.11	4
Titratable Acidity (%w/v) Citric Acid	0.54	0.7-1.2
Viscosity (cp)	58980	
Water Activity (A_w)	0.936	

*DOH-FDA, 2014

Table 8. Microbiological Analysis of Sweet Potato Ketchup

PARAMETERS	RAW OSP (CFU/g)	SP KETCHUP (CFU/g)	*DOH-FDA (CFU/g)	**PNS (CFU/g)
Aerobic Plate Count	6.0×10^{3}	2.7×10^{2}	104	30
Yeast and Mold	1.7×10^{2}	<100 est.	102	<10
Coliform	2.5×10^{3}	<10 est.	102	<10

*DOH-FDA (2013); **Philippine National Srandard for Banana Ketchup (2013)
est. = estimated;
<10 means zero count in 10-1 sample dilution;
<100 means zero count in 10-1 sample dilution

Table 9. Sweet Potato ketchup Costing

Raw Material	Quantity	Price (Php)	Quantity used	Total Price (Php)
Sweet Potato	1kg	112.00	1.5kg	168.00
Onion Powder	50g	16.50	51.8g	17.094
Garlic Powder	30g	23.00	10g	7.67
White Pepper	50g	10.50	2.4g	0.504
Cinnamon	30g	49.50	0.6g	0.99
Chili Powder	50g	12.50	1.7g	0.425
Salt	500g	22.10	45g	1.989
Sugar	1kg	56.00	135g	7.56
Vinegar	385ml	14.00	250ml	9.09
Citric Acid	1kg	82.00	0.5g	0.041
Sodium benzoate	1kg	140.00	10.50g	1.47
Red Food color	20ml	29.50	20ml	29.50
Total Raw Material cost: (Yield: 2.6 kg producing 8 bottles)				**Php 244.33**
Selling Price per bottle (320 g/ bottle): (5% mark up)				**Php 42.567**

DISCUSSION

Proximate Analysis of Raw OSP

The nutrient composition of raw sweet potato was shown on Table 2. The result showed that a raw sweet potato contains 65.9g/100g moisture content which is lower than the results of USDA (2009) and Alam (2016) with 77.28g/100g and 77.8g/100g of moisture content respectively. The total carbohydrate of a raw sweet potato contains 30.7g/100g wherein the study of Katayama *et al.* (2004) showed that the content of starch in sweet potato tubers depends on the geographic area, may range from 9.3 to 28.8 g/100 g. In terms of protein, raw OSP has 1.6g/100 g which is parallel to the report of Mais (2008) wherein typical protein content of sweet potato is ranging from 1.0g-14.2g/100g.

The revealed ash content of raw sweet potato which is 1.5g/100g is parallel with the results of the study of Sawicka *et al.* (2004) and Ukom *et al.* (2009) having 1.51g/100g and 1.02-1.70 g/100g ash content respectively. Moreover, 0.31g/100gwas the fat content of raw

OSPwhich is higher than in the result in the study of Tumhimbise *et al.* (2013) with 0.17g per 100g. The results of nutrient composition of raw sweet potato showed that the content of each parameter varies as compared to other studies depending on the aspects such as variety, geographic area, soil quality, climate, cultivation practices, maturity stage and storage practices (Alam, 2016; Cebulak, 2014; Gimbi, 2014).

Total Dietary Fiber

The total dietary fiber of a raw and mashed sweet potato was shown on Table 3.The raw OSP contains 3.0g/100g totaldietary fiber having 1.1g/100g soluble dietary fiber and 1.9g/100g insoluble fiber. However, mashed OSP contain 6.30g/100g total dietary fiber having 5.0g/100g insoluble dietary fiber and 1.3g/100g soluble fiber. The increase in the amount of the total dietary fiber in mashed OSP was due to thermal processing or household cooking which may alter the composition of these fibers (Azizah, 2005). It was supported by the study of Slavin (2013), that peeling of vegetables will lower the fiber content and cooking generally has negligible effect on fiber and may even increase the fiber content of a product if water is driven out in the cooking process. According to Dhingra (2012), heating generally changes the ratio soluble to insoluble fiber and also simple processes such as soaking and cooking tend to modify the composition and availability of nutrients which modifies the plant cell wall material that may have important physiological effects.

There may be a decrease in total dietary fiber but as computed using its result, the produced SP ketchup can give 0.952 g of dietary fiber per serving. It can still be a source of dietary fiber although it did not meet at least one third of the required daily intake of 20-25g of dietary fiber for adults ages 19-29 years old (FNRI-DOST, 2015). In the study of Mais (2008), the consumption of more dietary may be beneficial step towards a balance nutritional diet. The fiber content of sweet potato is also good for diabetics as it slows down the digestion of starches wherein it turns the glycemic index of SP and helps keep blood sugar levels within a manageable range (Dutta, 2015). Another benefit according to Dhingra *et al.,* (2012) and Slavin (2013) is that the consumption of dietary fiber increases stool bulk and slows down transit time through intestinal tract which may help prevent or relieve constipation.

Sensory Evaluation

Three different types of ketchup sample was subjected for sensory evaluation to 75 panelists wherein sample A and B represents the commercially available tomato and banana ketchup respectively and sample C represents the sweet potato ketchup. The results showed on Table 4 that in terms of appearance, color and aroma, sample A is significantly different from sample Cat 5% level of significance. On the other hand, in the three attributes mentioned, sample B is not significantly different from samples A and C. In terms of mouthfeel, taste and general acceptability, sample A is significantly different from samples B and C. However, sample B showed no significant difference with sample C. Majority of the scores given by the panelists is 7 which means like moderately.

Figure 4. Finished Product of Sweet Potato Ketchup

Proximate Analysis of Sweet Potato Ketchup

Table 5 showed the results after further processing of sweet potato into ketchup. The moisture content of raw OSP contains 65.9g/100g and it showed an increase after it was processed into ketchup which resulted to 78.6g/100g. It was reported that the moisture content of tomato ketchup varies between 45 and 80% (Bultossa, 2011). In agreement to the result obtained, Oke (2013) reported that various sweet potatoes having range of yellow to orange color cooked flesh having a moist texture can be used for ketchup making. The increase of the moisture content of SP ketchup could be due to addition and absorption of more water during processing.

The total carbohydrate content of raw OSP contains 30.7g/100g which decreased as it was processed into ketchup to 18.77g/100g. The result is similar in the study of Ikanone and Oyekanin 2014 which showed that boiling causes reduction in the total carbohydrate content of sweet potatoes. According to Adejumo (2015), there were losses in the carbohydrate content of sweet potato after boiling and frying which might be as a result of the diffusion of free sugar from food to oil or water during frying and boiling. Moreover it can be potential source of carbohydrates which is said to be an important source of energy (Cebulak, 2014; Ray, 2015).

The SP ketchup decreased in protein contentobtaining 0.53g/100g after processing. According to Dincer (2011), boiling reduced the amount of protein of sweet potato and sweet potato boiled with peel have highest value that may help the retention of protein content than that of boiled without peel (Adejumo, 2015). Moreover, both Burri (2011) and Gimbi (2014) agreed that besides sweet potato was also observed as a low source of protein. The ash content of SP ketchup increased resulting to 2.1g/100g which is similar to the study of Ozdemir (2011) wherein through process of boiling it increased the ash content of sweet potato. The result showed that there is a decrease in fat content until the time it was already not detected after it was process into ketchup. The result was closely related to the study of Meludu (2010) indicating that boiling reduces the fat content of sweet potato from 1g per 100g to 0g per 100g. Wherein according to Alam (2016) and Gimbi (2010), like other roots and tubers, sweet potato is well-known for it has poor and low source of fat content.

Total Dietary Fiber of Sweet Potato Ketchup

The result in Table 6 showed decrease in total dietary fiber content in sweet potato ketchup. Slavin (2013), reported that processing can either increase or decrease its fiber content like in the study of Meludu (2010) who reported that there is a decrease of fiber in sweet potato after it was boiled. A variety of changes takes place in the cell wall polysaccharides during processing and cooking which affects the physico-chemical properties of dietary fiber and also have nutritional effects wherein the cell membranes of the vegetables and there is a leakage of DM into the processing water resulting in increase in dietary fiber (Margareta, E. and Nyman, G.T., 2003).

Vitamin A Content of Sweet Potato Ketchup

According to Burri (2011), orange sweet potatoes are very good source of Vitamin A wherein the most common Vitamin A carotenoid is the beta carotene. In small quantity of orange fleshed sweet potato may contain 300 to over 3000µg per 100g fresh weight (Laswai, 2015). It has been reported that cooked orange-fleshed sweet potato consists of beta carotene ranging from 6.7-16.0g per 100g fresh weight basis (Huang *et al*., 1999; Namutebi *et al*., 2004; Bovell-Benjamin, 2007) wherein after the sweet potato was processed into ketchup it resulted to 15.6µgRE per 100g of vitamin A content which is shown in Table 6. The result obtained is supported by the study of Andrade (2009) and Bouis (2011) that further processing and cooking method (approximately 20% loss through boiling) which includes longer processing time, high temperature, exposure to light, and storage will easily destroy the Vitamin A content particularly the beta carotene. In line with this is another study which states that boiling process of sweet potato showed that it may be one of the factors that vitamin A was reduced (Burri, 2011). Moreover, the retention can still be obtain and improve by simple modifications such as cooking with the lid on, reducing the time of processing, cooking and storage time (Bouis, 2011) and it can still be a potential source of vitamin A. However, the commercially available ketchup contains lower amount of Vitamin A, having 0% for banana ketchup and only 2% for tomato ketchup. Other sources of vitamin A in the SP ketchup are the ingredients used like onion powder, chili powder and cinnamon (Gebhardt and Thomas, 2010).

Physicochemical Analysis of Sweet Potato Ketchup

The analysis showed that after processing there is only 13.1%w/v of total soluble solids in the sweet potato ketchup which is below the standard of ketchup with the minimum of 25%w/v as reported by DOH -FDA in 2014. According to El-Desouky (2010), total soluble solids content is an important factor for the production of tomato ketchup wherein the higher total soluble solids the better will be the end product. However in the study of Fawzia (2009), the total soluble solid was met because it used a ratio of tomato and sweet potato in the production of ketchup. The sweet potato ketchup showed pH of 4.11 which is near with the studies of Palomares (2013) obtaining the pH of 4.0 for banana ketchup, and in Acurato, (2015) and Janette et al. (2007) who found out that the pH range of tomato ketchup is 4.1-4.3. According to Ahmed (2009) pH is one of the factors influencing the quality of tomato ketchup where low pH is a factor included in the preservation system of a food, control of pH and the application of a margin of safety are required for these foods (Carrasco, 2012).

The result of titratable acidity as citric acid of 0.54%w/v did not comply in the standard of FDA (2013) which ranges from 0.7-1.2. In accordance with the result, Haile (2014) stated that titratable acidity is important to inhibit microbial growth and this titratable acidity is due to the added preservatives. The rheological property of sweet potato ketchup was studied at room temperature using Brookfield DV-E viscometer with LV spindle number 62 resulted to 58,980 cp at 0.5 rpm which is within the standard viscosity of ketchup that ranges 50,000 to 70,000 cp (OEC, 2014). The viscosity of fluid foods is usually considered an important texture parameter and physical property related to the quality of food products such as tomato paste and ketchup (El-Desouky, 2010). Some of the parameters that contribute to the flow behavior of tomato ketchup are the raw material used and its processing conditions (Bayoda *et al.,* 2008).

The analysis showed that the ketchup has water activity value of 0.936 A_w. As stated in Carrasco (2012), the growth of most microorganisms is hindered at below 0.86. The result showed that the product is susceptible to microbial growth in line with the study of Acurato (2015) which showed 0.992 A_w for tomato ketchup.

Microbiological Analysis of Sweet Potato Ketchup

The results showed that the SP ketchup contains aerobic plate count of $2.7x10^2$ CFU/g, yeast and molds of <100 estimated and coliform of <10 estimated. It also showed that it is significant on the aerobic bacteria population may be due to the processing method and its storage. However, the cooking temperature and preservatives added may be one of the factors that destroyed and or controlled the growth of the coliforms and yeast and molds that made it not significant based on the standards given. Theresult showed similarity to the study of Bultossa (2011) which stated that the substances added in the ketchup like vinegar, sugar, salt and spices made the product acidic in nature that inhibits the growth of bacteria, could denature the protein, and preserve the ketchup for its required storage. Therefore, these factors can give a potential preservative effect to the ketchup and it showed that the SP ketchup complied with standards of DOH-FDA (2013) and Palomares (2013) which could be considered safe for consumption.

Cost Analysis of Sweet Potat*o* Ketchup

The cost of SP ketchup is comparable with the cost of commercially available Tomato and Banana Ketchup. Comparatively, SP ketchup costs Php 42.567 higher than a commercially available Banana Ketchup having Php 30.00 but cheaper than commercially available Tomato ketchup which cost Php 49.00.

CONCLUSION AND RECOMMENDATION

The result of this study has shown that sweet potato is a good source of essential nutrients and a source of dietary fiber and vitamin A, and could be considered safe. It also proved that sweet potato could be utilized and developed into a variety of food product like ketchup.

The study focuses on the Total Dietary Fiber, Vitamin A, Proximate, Physicochemical and Microbiological characteristic of Sweet Potato and the Sweet Potato ketchup, it is recommended to analyze the shelf-life determination, effects of storage condition on the developed food product, packaging and other mineral content present. It is also recommended to use smaller mesh size to reduce particle size and grainy mouthfeel and as well as to use different raw material to be utilize unto ketchup. In terms of sensory evaluation, it is recommended to use different carrier like French fries.

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