PRODUCTION AND EVALUATION OF COOKIES FROM WHOLE WHEAT AND DATE PALM FRUIT PULP AS SUGAR SUBSTITUTE

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PRODUCTION AND EVALUATION OF COOKIES FROM WHOLE WHEAT AND DATE PALM FRUIT PULP AS SUGAR SUBSTITUTE

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Abstract

Production and evaluation of cookies from whole wheat flour and date palm fruit pulp as sugar substitute was studied. Whole wheat grains (WW) were cleaned and milled into flour. Date palm was cleaned, deseeded, dried and milled into flour. Composite flour of whole wheat and date palm meal were formulated in the following ratios: 90:10, 80:20, 70:30, 60:40, 50:50, which were used to produce cookies using refined wheat flour as control (W), Functional properties and proximate analysis were carried out on the flour samples. Proximate analysis, physical properties, microbial analysis and sensory evaluation of cookies were carried out. Data obtained were statistically analyzed by ANOVA and mean separation by Fishers LSD. The use of date palm fruit pulp as sugar substitute in cookie production improved the properties of the flours such as swelling index, oil absorption capacity, pH and viscosity as they were comparable to the control (refined wheat flour -W-). There were no significant difference in emulsion capacity, gelatinous temperature and bulk density of all the flour samples. The proximate composition of the samples generally increased with increase in incorporation of date palm pulp with the exception of carbohydrate and protein. The proximate composition of cookies increased with increase in percentage palm pulp in the cookies and the samples were comparable to the control (W) except in protein content where the control was very high. The physical properties of cookies produced from composites were comparable to the control with the exception of break strength which decreased with increase in date palm pulp incorporation. The organoleptic characteristics of $WWDP_3$ (whole wheat – date palm in the ratio of 70:30) was rated overall best in all the parameters tested. The incorporation of date palm pulp in cookies should not be less than 30%. Cookies samples stored for six (6) weeks had microbial loads less than the maximum count recommended in literature.

Keywords: Wheat Flour, Date Palm, Cookies, Proximate, Physical properties and Sensory

1.0 Introduction

Cookies are one of the best known quick snack products (Farheena *et al.;* 2015). Olaoye *et al.;* (2007) described cookies as nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in an oven. They are popular examples of bakery product of ready-to-eat snack that possess several attractive features including wide consumption, more convenient with long shelf-life and have the ability to serve as vehicles for important nutrient (Ajibola *et al.;* 2015). Cookies are chemically leavened product (Hanan, 2013). Generally, the name cookies are used in the USA and biscuit is used in the European countries (Sivasankar, 2002). Cookies and other bakery products have now become loved fast food products for every age-group, because they are easy to carry about, tasty to eat, cholesterol-free, containing digestive and dietary principles of vital importance and reasonably cheap (Farheena *et al.;* 2015). They can be made from hard dough, hard sweet dough or soft dough. Examples of biscuits made from the above mentioned types of flour include crackers, rich tea and short cake respectively (Kulkarni, 2007; Olaoye *et al.;* 2007; Nwosu, 2013; Farheena *et al.;* 2015). Cookies are characterized by a formula high in sugar and shortening and low in water. They differ from other baked foods like bread and cakes because they have low moisture content, making them comparatively free from microbial spoilage and having long shelf (Hanan, 2013).

The main ingredients of cookies are wheat flour, fat (margarine) and sugar and water, while other ingredients such as milk, salt, aerating agent, emulsifier, flavor and colour can be included. They can also be enriched or fortified with other ingredients in order to meet specific nutritional or therapeutic needs of consumers (Ajibola *et al.;* 2015). Flour used in making cookies is basically from wheat or composite flour which forms the basic ingredients of bakery products including bread, rolls, cakes, cookies and other bakery products (Giwa and Ikujenlola, 2010). However, the flours used in production of many bakery products are bleached (or refined flours) which some researchers call 'slow poison' (Erleen, 2011) owing to their associated side effect on health on long time consumption. Some call them "glue of the gut" (Erleen, 2011) and discourage people from consuming them or reduce their intake of foods prepared from these flours because of the associated health risk (Erleen, 2011). However, recent epidemiological studies have shown that the consumption of whole wheat grains and whole wheat flour sometimes called graham flour and grain-based products is associated with the reduced risk of oxidative stress related to chronic diseases and age related disorders, such as cardiovascular diseases, carcinogenesis, type II diabetes and obesity (Lilei *et al.;* 2013). Most biscuits in the market are made from bleached flour, however whole grain flours from whole Kernel grains conceal an array of health benefits attributed to the presence of antioxidants such as vitamin C, vitamin E (tecopherols and tocotrienols) and Carotenoids (Lilei *et al.;* 2013). Bleaching of flour leads to loss of minerals and vitamins and causes the production of alloxan. Alloxan is used to induce diabetes in rats. Sugar is the second major ingredient used in cookie production. Sugar has its own associated problem of inducing metabolic problems such as type II diabetes, obesity etc hence it contains a whole lot of calories with no essential nutrients.

Date Palm fruit (*Phoenix dactylifera L*) locally called 'debino' in Hausa language, from the family of Arecaceae (Al-daihan Bhat, 2012) is a sweet edible fruit. The fruit is a drupe in which an outer fleshy part consists of pulp and Pericarp surrounding a shell of hard endocarp with a seed inside (Farheena *et al.;* 2015). Date fruit contains more than 70% sugar mainly glucose and fructose and therefore are high energy food sources (Dada *et al.;*2012), thus making it an ideal replacement for sugar (sucrose) in the cookies recipe, which is also of great nutritional benefit to diabetics and other metabolic health related patients. Besides, date fruit is rich in fibre (Hamza *et al.;* 2014), very rich in antioxidant flavonoids such as beta-carotene, lutein and zeaxanthin. They are also excellent source of iron, calcium, copper, magnesium, potassium, and minor source of vitamins A, and B_2 (Dada *et al.;* 2012; Farheena *et al.;* 2015).

Therefore, considering the nutritional constituents of whole wheat flour and date palm fruit as a substitute for sugar, cookies baked with this combination will not only be an ideal snacks/food for diabetics and other metabolic health related patients but will also become a good functional food of great nutritional benefit. The objective of this paper is to produce cookies from the formulated recipe (whole wheat flour and substitution of sugar with date palm fruit pulp at different ratios), evaluate the functional properties of the blends, proximate composition, Physical properties, Sensory attributes and monitor the Storage stability (Shelf-life) of the cookies produced, using qualitative and quantitative analysis techniques

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2.0 Materials and Methods

2.1 Material Collection

The Date Palm Fruit (Dried date) was purchased at Ama-Hausa, Douglas, Owerri Imo State. Other ingredients such as the whole wheat, milk, egg, salt, margarine (fat), baking powder, sugar were purchased at Eke-Ukwu market, Owerri main market, Imo State.

2.2 Methods

2.2.1 Preparation of Date Palm Fruit Pulp (DPFP)

The Date Palm Fruit pulp (powder) was produced by first, washing the date palm fruits with water to remove adhering dirts, followed by removing of the seeds (De-pitting) of the fruit manually and cut into small pieces with the aid of knife and weighing the dried date palm fruit. The pulp with pericarp was then oven dried at 75ºC for 6 – 8 hours and subsequently milled using hand milling machine and sieved through a 0.35mm mesh sieve to obtain fine homogenized particles as shown in below (figure 2.1). The date palm fruit meal was sealed in a cellophane bag and stored at room temperature.

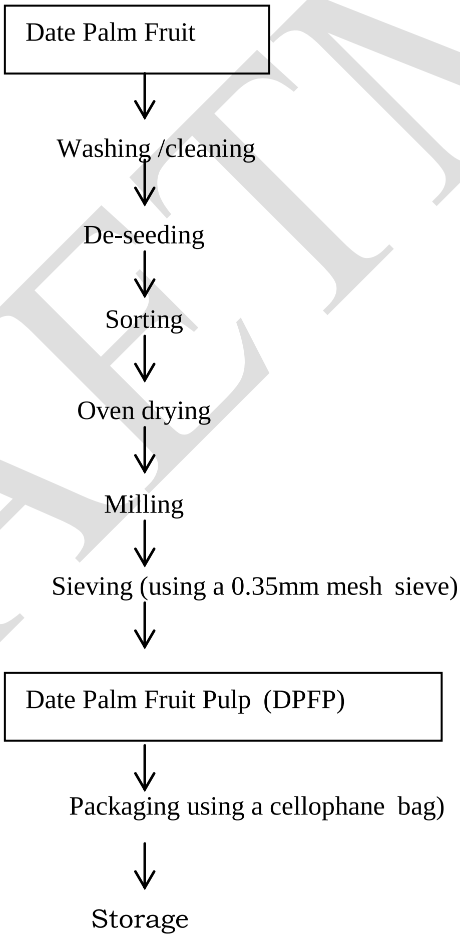

Figure 2.1: *Flow Chart for Production of Date Palm Fruit Pulp*

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2.2.2 Preparation of Whole Wheat Flour

Whole wheat flour was obtained by cleaning to remove dirts, stones and other extraneous materials, milling the wheat grain (wheat berry) to powder and sieving through a 0.35mm mesh sieve to obtain fine homogenized flour (Figure 2.2). The flour was sealed in a cellophane bag and stored.

2.2.3 Cookies Flour Formulation Ratios

Sugar (sucrose) was substituted with date palm fruit pulp (DPFP) in the following ratios: 90:10; 80:20; 70:30; 60:40 and 50:50 of whole wheat flour: date palm fruit meal. 100% whole wheat flour with standard recipe and control using normal flour and standard recipe were produced also as control for comparison

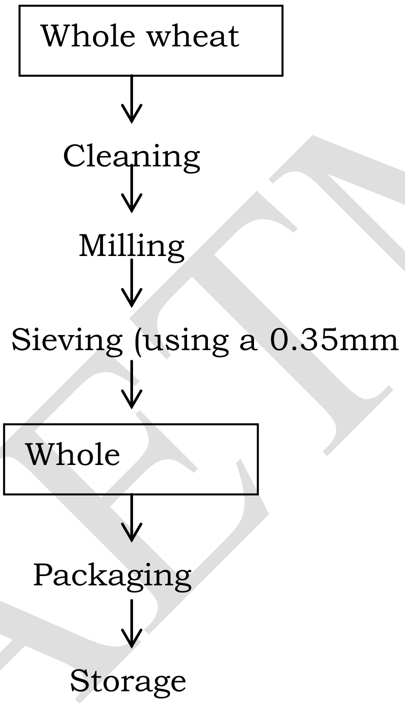

Figure 2.2: *Flow chart for Production of Whole Wheat Flour*

2.3 Cookies Production with Whole Wheat Flour/Date Palm Fruit Blend

The ingredients (the whole wheat flour and date palm fruit pulp) were measured into a bowl. Using the rubbing method, fat, milk and salt were added and rubbed for 30 minutes. In a separate bowl, egg and water were mixed and added to the flour based mixture and kneaded and made into dough. The dough was rolled and flattened into a uniform thickness of about 3.5mm before cutting out to shapes using a hand-cutter. The cutout dough was baked at 150ºC for 30 minutes in the oven. After baking, the cookies were cooled to room temperature, packed in low density polyethylene (LDPE) bags and sealed in a plastic transparent container.

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2.4 Formulation / Blends Combination used for the Preparation Of The Cookies

Blend 1: Whole wheat flour (100%) with sugar added according to standard cookie recipe, for comparison.

Blend 2: Whole wheat flour (ww): Date palm fruit pulp (DP) 90:10 → $WWDP_1$

Blend 3: Whole wheat flour (ww): Date palm fruit pulp (DP) 80:20 → $WWDP_2$

Blend 4: Whole wheat flour (ww): Date palm fruit pulp (DP) 70:30 → $WWDP_3$

Blend 5: Whole wheat flour (ww): Date palm fruit pulp (DP) 60:40 → $WWDP_4$

Blend 6: Whole wheat flour (ww): Date palm fruit pulp (DP) 50:50 → $WWDP_5$

Blend 7: Wheat flour (100%) with sugar added according to standard cookie recipe served as standard control.

2.5. Determination of Functional Properties of the Flour Blends

2.5.1 Bulk Density

The bulk density of the flour samples were determined by weighing 50g of the sample into 100ml graduated cylinder, then, gently tapping the bottom several times on a laboratory bench, until no further diminution of the sample level. After this, the final volume is expressed as glml (Nwosu, 2011).

$$\text{Bulk Density (g/ml)} = \frac{Weight\ of\ sample\ (g)}{Volume\ of\ sample\ (ml)}$$

2.5.2 Wettability

The AOAC, 2006 method was used. The samples were weighed and in each case, 1g was introduced into 25ml graduated measuring cylinder with a diameter of 1cm and a finger was placed over the open end of the cylinder. The mixture was inverted and clamped at a height of 10cm from the surface of a 600ml beaker containing 500ml of distilled water. The finger was removed to allow the test sample to be dumped. The wettability was taken as the time required for the sample to become completely wet.

2.3.3 Viscosity

The AOAC, 2006 method was adopted. In each sample, 10g of the flour sample was suspended in distilled water and mechanically stirred for 2 hour at room temperature. Therefore, the viscosities of the sample were measured using Oswald type viscometer.

2.5.4 Foam Capacity and Stability

Foaming capacity and stability of the powdered (flour) samples were studied according to the AOAC, 2006 method. Two grams of the samples were weighed from each of the sample and blended with 100ml of distilled water using warring blender (mixer) and the suspension was whipped at 1600 rpm (revolution per minutes) for 5 minutes. The mixture was then poured into a 100ml measuring cylinder and its volume was recorded after 30 seconds.

Foam capacity was expressed as percentage increase in volume thus:

$$\text{Foam Capacity} = \frac{Volume\ after\ Whipping - Volume\ before\ Whipping}{Volume\ before\ Whipping} \times 100$$

Triplicate measures were taken for each samples and mean value recorded. The foam stability of the sample was recorded at 15, 30, 60, 120 seconds after whipping to determine the foam stability (FS).

$$\text{Foam Stability (FS)} = \frac{Foam\ Volume\ after\ time}{Initial\ Foam\ Volume} \times 100$$

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Table 2.1: *Ingredients (recipes) for Preparation of Standard Cookies*

Ingredients	Quantity / Proportion
Flour (g)	200
Margarine (g)	80
Sugar (g)	60
Whole Egg (ml)	50 (1 whole egg)
Water (ml)	30
Salt (g)	2
Baking Powder (g)	2
Flavour	4 (drops)

2.5.5 Gelation Temperature

The method of AOAC (2006) was adopted in the determination of gelling temperature. In each cause, 10g of the sample was dispersed in 100ml of distilled water in a 250ml beaker. A thermometer was clamped on a retort stand with its bulk submerged in the suspension with a magnetic stirrer and the system heated. The heating and stirring continued until the suspension began to gel and the corresponding temperature was recorded. The temperature at boiling point was recorded.

2.5.6 Emulsification Capacity (E.C)

The AOAC, 2006 method was used. From each sample, 2g were blended with 25ml of distilled water at room temperature for 30 seconds in a warring blender at 1600rpm. After complete dispersion, 25ml of vegetable oil was gradually added and the blending continued for another 30 seconds. Then the mixture was transferred into a centrifuge tube and centrifuged at 1600rpm for 5 minutes. The volume of oil separated from the sample was read directly from the tube after centrifuging.

Calculation: The emulsion capacity was expressed as the amount of oil emulsified and held per gram of sample.

i.e Emulsion capacity (E.C) = $E/Y \times 100$

Where:

X = Height of emulsified layer

Y = Height of the whole solution in the centrifuge tube

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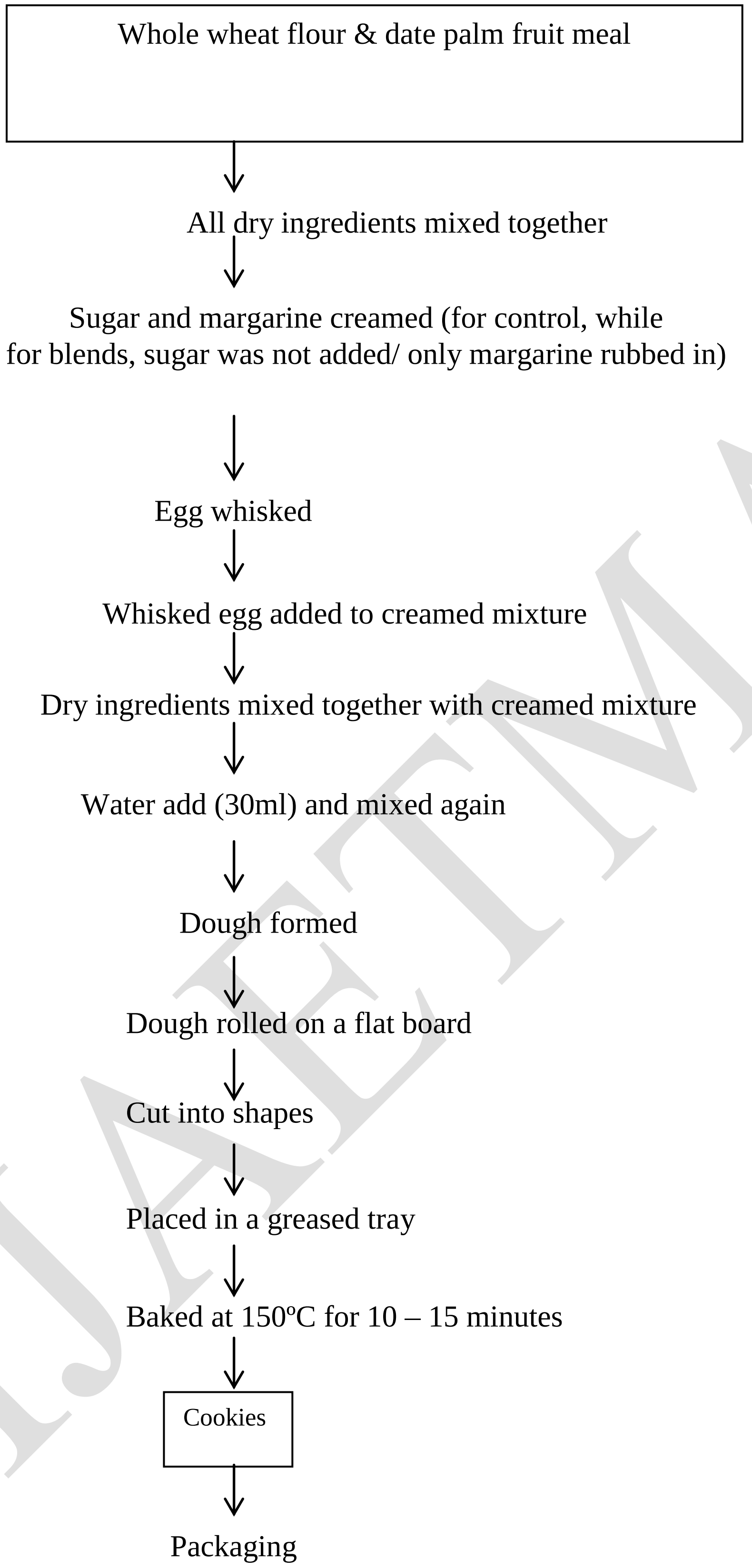

Figure 2.3: Flow chart for production of cookies

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2.5.7 Gelatinization Temperature

Five grams of each sample was suspended in test tubes, heated in a boiling water bath with continuous stirring, and 30 seconds after gelatinization was visually noticed, the temperature of the samples were taken as the gelatinization temperature (Matthew *et al*., 2015).

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2.5.8 Water / Oil Absorption Capacity

The AOAC, 2006 method was used, from each sample, one gram was weighed into a conical graduated flask and 10ml of water or oil was added to the weighed sample. A warring whirl was used to mix the sample for 30 seconds. The sample was allowed to stand at room temperature for 30 minutes and then transferred to a graduated centrifuged tube and centrifuged at 5000rpm for 30 minutes. After wards, the mixed sample was transferred from the graduated tube into a 10ml measuring cylinder to know the volume of the free water or oil.

The absorption capacity was expressed as grams of oil or water absorbed per gram of sample.

Calculation: Water/Oil absorption capacity of the sample was calculated as:

Water/Oil Absorption Capacity =

Total Oil / Water absorbed – Free Oil/Water x Density of Oil/Water

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2.5.9 Swelling Index Determination

Three grams of each of the sample was transferred into clean, graduated (50ml) cylinder and the volume noted. Distilled water (30ml) was added to the flour sample, the cylinder was swirled and allowed to stand for 60 minutes while change in volume (swelling) was recorded every 15 minutes. The swelling power of the sample was calculated as a multiple of the original volume as done by Ukpabi and Ndimele (2000).

2.5.10 pH Measurement

The pH values of the samples were determined by suspending 10g of each sample in 100ml of distilled water in 250ml beaker. It was then thoroughly mixed and stirred and the pH was taken. This was triplicated and the average calculated (Matthew *et al.,* 2015).

2.6. Determination of the Proximate Composition of Cookies

2.6.1 Determination of Moisture Content

The moisture content was determined by weighing out 2g of the samples into a dry crucible of known mass, charred into the oven at a temperature of 105ºC for 3 hours. The samples were cooled in a dessicator and weighed using an electronic analytical balance. The whole process was repeated that is they were returned into the oven for further drying, cooling and repeated weighing until a constant mass was obtained.

The difference in mass (weight of % moisture lost) was calculated as % moisture content =

$$\frac{w_2 - w_3}{w_2 - w_1} \times 100$$

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Where:

W_1 = weight of empty crucible

W_2 = weight of crucible + sample before drying

W_3 = weight of crucible + sample after drying to constant mass.

2.6.2 Determination of Ash Content

Ash content was determined by furnace incineration, by weighing out two (2) grams of each of the sample into a porcelain crucible of know mass, heated in moisture extraction oven (muffle furnace) at 550ºC for 3 hours until it completely ashed that is turned white and free of carbon. The sample were then removed from the furnace, cooled in a dessicator to a room temperature and reweighed immediately. The weight of the ash (residual ash) was then calculated as:

$$\% \text{ Ash} = \frac{Weight\ of\ Ash}{Weight\ of\ Original\ Sample} \times \frac{100}{1} \quad \text{.......................3.2}$$

Or

$$\frac{W_2 - W_1}{Weight\ of\ Sample} \times 100$$

Where:

W_1 = Weight of Empty crucible

W_2 = Weight of crucible + Ash

2.6.3 Determination of Crude Fat Analysis

The solvent extraction method of AOAC (2000) was used. A soxhlet extraction unit was set-up with a reflux condenser. A small round bottom flask was weighed after washing and drying and half filled with light petroleum ether (boiling point 40 – 60ºC) and fixed into the unit. 2g of each of the samples were wrapped in whatmann filter paper and gradually lowered into the thimble which was filled to the cleaned, dried and weighed round bottom flask containing 120ml of N-hexane. Fat was extracted for 6 ours using the petroleum ether and was recovered by distillation. After evaporating off of the solvent, the flask was dried in the oven at 105ºC, cooled in a desiccator and weighed in order to determined the amount of lipid extracted. By difference, the mass of oil extracted was determined and thus expressed as

$$\% \text{ Crude Fat} = \frac{Mass\ of\ Fat}{Mass\ of\ Sample} \times 100$$

2.6.4 Determination of Crude Protein Analysis

The microkjeldhal method, (N x 6. 25) as described by AOAC (2000) was used. The total Nitrogen was determined using the conversion factor of 6.25. 2 g of the samples were boiled in 10ml of concentrated H_2SO_4 in the presence of selenium catalyst (one table spoonful). Boiling was done under a fume cupboard until a clear solution was formed. The digest was transferred into a volumetric flask containing a 100ml of distilled water and 10ml of it was mixed with equal volumes of 45% NaOH solution and was poured into a kjeldhal distillate apparatus. After distilling the mixture, the distillate was collected in a 100ml of 4% boric acid solution containing 3 drops of a mixed indicator (methyl red and bromo cresol green).

A total of 50ml of distillate was collected and titrated against 0,02N H_2SO_4 solution. Titration was done from green to a deep red end point. A reagent blank was determined as described above but without the sample. The protein content (N_2) was calculated using the formula:

$$\% \text{ Nitrogen} = \frac{V_S - V_B \times N_Q \times 0.01401}{W} \times 100$$

Where:

V_S = Volume (ml) of acid required to titrate sample

V_B = Volume (ml) of acid required to titrate blank

N_A = Normality of acid

W = Weight of Samples in grams

% Crude Protein = N_2 x conversion factor …………………3.4.1

⇨ 100% Nitrogen in protein = Conversion factor

$$\therefore \quad \frac{100}{16} = 6.25$$

Where: N_2 = Nitrogen

2.6.5 Determination of Crude Fibre Analysis

This was done according to AOAC (2000) method. 2g of each sample was defatted and boiled in 200ml of 1.25% H_2SO_4 solution for 30 minutes under reflux. The boiled sample washed with a hot water severally using a two-fold musclin cloth to trap the particles which were retuned back to the flask and boiled again in 200ml of 1.25% NaOH solution for another 30 minutes under the same condition and was again washed severally with hot water and then allowed to drain dry before being transferred to a weighed crucible where it was dried in an oven at 105ºC to a constant weight.

It was subsequently placed in muffle furnace at 550ºC for 4 hours and finally cooled in a dessicator and reweighed. By diference in mass, the mass of the fibre was calculated by the expression.

$$\% \text{ Crude Fibre} = \frac{W_1 - W_2}{W_3} \times 100$$

Where:

W_1 = Weight of sample before incineration

W_2 = Weight of sample after incineration

W_3 = Weight of original sample

Or

$$\% \text{ Crude Fibre } \frac{W_2 - W_1}{Weight\ of\ Sample} \times 100$$

Where:

W_1 = Weight of Crucible + sample as Ash (i.e crucible + Ash)

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W_2 = Weight of Crucible + Sample after boiling, washing & drying

2.6.6 Determination of Carbohydrate Content Analysis

The Nitrogen free method described by AOAC (2000) was used. The carbohydrate was calculated as weight by difference between 100 and the summation of other proximate parameters as Nitrogen free extract (NFE) percentage carbohydrate.

$$\% \text{ Carbohydrate (NFE)} = 100 - (M + P + F + A + F_2)$$

Where

M	=	Moisture
P	=	Protein
F	=	Fat
A	=	Ash
F_2	=	Crude fibre

2.6.7 Determination of Caloric Value

The caloric value was calculated in kilo-calories per 100g (kcal/100g) by multiplying the crude fat, protein and carbohydrate values by "Atwater" factors of 37, 17 and 17 respectively.

2.6 Sensory Analysis

The organoleptic properties of the cookies including: Taste, Colour, Texture, Aroma and Overall acceptability / acceptance

Were assessed by a 20 member panelists screened among staff and students, who were instructed regarding the evaluation procedures in both written and verbal formats prior to the cookies evaluation. Each panelist was given the cookie sample to taste and compare

Nine (9) point hedonic scale was used where 9 represented "like extremely", 5 represented neither like nor dislike and 1 represented dislike extremely.

2.7 Statistical Analysis: The sensory scores were subjected to the analysis of variance (ANOVA) using Microsoft Excel Package 2007 and the treatment means separated using Fishers Less Significant difference (LSD) test.

2.8 Evaluation of the Physical Properties of Cookies

2.8.1 Determination of Diameter and Weight of Cookies

The modified method according to Ayo *et al.*, (2007) was used to determine the diameter and weight of cookie. The weight of the baked cookies was determined by weighing each cookie unit on electronic weighing balance. The cookie unit was randomly selected and weighed several times and the average taken. The cookie diameter was determined by measuring each cookie unit randomly picked using a calibrated ruler, and the average taken.

2.8.2 Determination of Cookie Spread Ratio

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The spread ratio was determined using the method of Giami *et al.,* (2005).Three rows of well formed cookies were made and the height measured. Also the same were arranged horizontally edge to edge and sum diameter measured. The spread ratio was calculated as diameter per height (McWatters *et al.,* 2003).

2.8.3 Determination of Thickness of Cookies

The method according to Mcwatters *et al*., (2003) was used. The thickness of cookies was measured by placing six cookies on top of each other, followed by triplicate reading recorded by shiffling cookies. All the measurements were done in three replicates of six cookies each and all the readings were divided by six to get the value per cookie.

2.8.4 Breaking Strength

Breaking strength was determined using the method described by Okaka and Isieh (1990). A representative sample of cookies from each formulation (of same average weight) was placed centrally between two parallel wooden bars, with interval in between, so that the cookies can be placed balanced, objects of known weights were then placed incrementally until the cookie fractured. The least weight that caused the breaking of the cookie was regarded as the breaking strength of the cookie. Five representative samples were analyzed from each formulation.

2.9 Evaluation of Microbial Stability of the Cookies

Consumers are increasingly demanding consistently high food quality, and have corresponding expectations that such quality will be maintained at a high level during the period between purchase and consumption. These expectations are a consequence not only of the primary requirement that the food should remain safe, but also of the need to minimize unwanted changes in sensory quality. The quality needs are reflected in the labelling requirements to which food manufacturers must conform. In general, microbiological changes are of primary importance for shelf life of products, and chemical and sensory changes for medium to long life products; all the three types of change can be important for short-to-medium life products. Shelf life is defined as the time during which the food product remain safe, be certain to retain desired sensory, chemical, physical and microbiological characteristics when stored under certain conditions.

2.9.1 Microbial Changes

Growth of a specific microorganism(s) during storage depends on several factors, the most important being the initial microbial load at the time and start of storage, the physiochemical properties of the food, such as moisture content, pH, presence of preservatives; the processing method used in the production of the food, and the external environment of the food, such as the surrounding gas composition and storage temperature (Davis, 2014)

Pour plate method as described by Allen *et al.,* 2004; Ray and Bhunia 2007 was used. One gram each of the cookie sample was dissolved in 10ml of sterile peptone water and mixed thoroughly by swirling. This was

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further diluted to obtain 10^{-2} and 10^{-3} concentration. Then 0.1ml dilution was transferred from each dilution bottle into the corresponding plates and 15ml of sterile nutrient agar medium was poured and mixed thoroughly with the inoculum by rocking the plate. The plates were incubated at 38°c for 24 hours after which the colonies formed were counted and expressed as colony forming units per gram (cfu /g). A total viable count is achieved when 30-300 colonies exist on a single plate (Davis, 2014).

2.9.2 Mold Count

The pour plate method as described by Goldman and Lorrence (2008) was used. The sample dilution weighing 0.1ml was transferred from each dilution into corresponding plate and 15ml of sterile Sabourand Dextrose Agar (SDA) medium was poured, and mixed thoroughly with the inoculum by rocking the plate. The plates were incubated at ambient temperature for three days after which colonias formed were counted and expressed as colony forming unit per grams (cfu/g) (Allen *et al.*, 2004; Ray and Bhunia 2007).

3.0 Results and Discussion

3.1 Functional properties of Whole Wheat and Date Palm Pulp Flour Blends

The results of the functional properties of whole wheat – date palm pulp were presented in Table 3.1. Ezeama (2012) defined functional properties of food as those physic –chemical properties or characteristics of food components that determines the usefulness and success of ingredients in food systems.

3.1.1 Water Absorption Capacity

The water absorption capacity of whole wheat flour and date pulp blend ranged between 1.124g/ml to 1.91g/ml. The water absorption capacity decreased from 1.91g/ml in refined wheat (W) to 1.124g/ml in 50% whole wheat flour: 50% date palm pulp ($WWDP_1$). Water absorption capacity decreased with increase in date palm pulp substitution. The reduction in water absorption values observed and substitution with increased date palm pulp could be due

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TABLE 3.1 FUNCTIONAL PROPERTIES OF WHOLE WHEAT DATE PALM PULP (WWDP) FLOUR

Samples	Water absorption capacity (g/ml)	Oil absorption capacity (g/ml)	Emulsion capacity (g/ml)	pH	Viscosity (μ) Nsm^{-2}	Gelatinization Temperature (^{o}C)	Swelling Index (g/ml)	Wettability (Sec)	Bulk density (Kgm^{-3})
$WWDP_1$	1.124±0.05^{b}	1.350±0.03^{a}	1.886±0.05^{a}	5.92±0.05^{e}	1.30±0.05^{c}	64.00±2.00	0.59±0.04^{a}	13.00±3.00^{d}	0.69±0.03
$WWDP_2$	1.139±0.05^{b}	1.339±0.03^{a}	1.851±0.05^{a}	5.95±0.05^{e}	1.50±0.05^{a}	63.00±3.00	0.55±0.05^{a}	16.00±5.00^{d}	0.67±0.01
$WWDP_3$	1.145±0.05^{b}	1.336±0.03^{ab}	1.933±0.04^{a}	6.03±0.09^{d}	1.40±0.05^{b}	64.50±1.53	0.56±0.06^{a}	24.70±2.52^{c}	0.63±0.00
$WWDP_4$	1.154±0.04^{b}	1.328±0.03^{b}	1.886±0.03^{a}	6.12±0.06^{c}	1.40±0.05^{b}	62.30±3.00	0.60±0.06^{a}	31.70±2.52^{d}	0.72±0.05
$WWDP_5$	1.69±0.03^{b}	1.322±0.03^{b}	1.876±0.04^{a}	6.16±0.05^{c}	1.50±0.05^{a}	67.00±3.00	0.45±0.01^{c}	40.00±0.00^{c}	0.69±0.02
WW	1.175±0.05^{a}	1.322±0.011^{b}	1.923±0.03^{a}	6.19±0.07^{b}	1.40±0.05^{b}	61.60±2.52	0.48±0.02^{b}	58.70±12.50^{b}	0.68±0.01
W	1.191±-0.03^{a}	1.319±0.04^{b}	1.97±0.03^{a}	6.28±0.06^{a}	1.30±0.05^{c}	67.00±2.009	0.61±0.06^{a}	116.70±40.50^{c}	0.66±0.01
LSD	0.025	0.019	0.20	0.042	0.055	-	0.052	18.03	-

Values are mean ± SD of triplicate determination. Samples with different superscripts within the same column were significantly ($p\leq0.05$) different.

Samples = $WWDP_1$ = 50% whole wheat flour – to – 50% date palm pulp

$WWDP_2$ = 60% whole wheat flour – to – 40% date palm pulp

$WWDP_3$ = 70% whole wheat flour – to – 30% date palm pulp

$WWDP_4$ = 80% whole wheat flour – to – 20% date palm pulp

$WWDP_1$ = 90% whole wheat flour – to – 10% date palm pulp

WW = Whole wheat flour

W = Refined wheat flour

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to the low protein content of the date palm (2.3 to 5.6% according to Abdel Moneim *et al.*, 2012). Madu (2007) stated that water absorption capacity enables bakers to add more water to dough and so improve handling characteristics and maintain freshness of the baked products. Also water absorption capacity is the ability of protein in a product to associate and retain water which increases water absorption capacity with increased protein content (Madu, 2007). That is to say that the addition of date palm fruit to whole wheat flour increased the sugar content and increased protein and significantly reduced the water absorption capacity of the different flour ratios used in this work thereby making the dough handling very difficult. There were significant ($P \leq 0.05$) differences in water absorption capacity values of the flour blends which could be attributed to the quantity of the date palm fruit pulp in each sample.

3.1.2 Oil Absorption Capacity

The oil absorption capacity values for the samples increased from 1.319g/mlin W to 1.350g/ml in $WWDP_1$. This shows that the increase in substitution of date palm fruit pulp increased the oil absorption capacity of the flours. There was no significant ($P \leq 0.05$) difference among $WWDP_1$, $WWDP_2$, and $WWDP_3$ and also W, WW, $WWDP_5$, $WWDP_4$, $WWDP_3$ respectively (Table 4.1). It could be attributed that the higher the oil absorption capacity of a flour sample, the better the cookie quality. Oil absorption capacity characteristic is required in ground analogue, doughnut, pancakes, baked foods and soups. Absorption of oil by food products improves mouth feel and flavor retention. Oil retention also improves the quality of cookies because oil contributes to the soft texture of cookies (Jacob and Leelavathi, 2007).

3.1.3 Emulsion Capacity

The emulsion capacity of the samples ranged between 1.851g/ml to 1.971g/ml. The addition of date palm pulp had varied effects on emulsifying capacity of flour. Its effect on emulsifying capacity was highest when there was 30% date pulp substitution in $WWDP_3$. There was no significant ($P \leq 0.05$) difference between emulsion capacity of all the flour samples(Table 4.1)

3.1.4 pH

The pH of the samples ranged from 5.91 to 6.28. The pH values decreased from 6.16 in $WWDP_5$ to 5.92 in $WWDP_1$.This shows that the addition of more quantity of date palm pulp to whole wheat reduced the pH of the flour. There were significant ($P \leq 0.05$) difference in pH of all the samples. Acidic products are more shelf stable than non-acidic counter parts (Ikpeme *et al.*, 2010). And all the samples were acidic and could shelf stable.

3.1.5 Viscosity

The viscosity of the samples ranged between 1.30Nsm^{-2}. in $WWDP_1$ to 1.40Nsm^{-2} in W. There were no significant difference in the viscosity of the following flour blends W and $WWDP_1$, $WWDP_5$, $WWDP_2$ and WW, $WWDP_3$ and $WWDP_4$ respectively (Table 3.1).

3.1.6 Gelatinization Temperature

The whole wheat flour had the least gelatinization temperature of (61^{O}C) while the refined wheat flour had the highest gelatinization temperature (67^{O}C). Gelatinization temperature of $WWDP_{1,}$ $WWDP_2$, $WWDP_3$, $WWDP_{4,}$ and $WWDP_5$ were higher than that of whole wheat flour. This could mean that the substitution of date palm pulp to flour increased the gelatinization temperature of the composite flours. There were no significant ($P \leq 0.05$) differences in the gelatinization temperature of all the samples but W and $WWDP_5$ have the similar gelatinization temperatures (67.0^{O}C).

3.1.7 Swelling Index

The refined wheat flour (W) had the highest swelling index value (0.61g/ml) though the whole wheat flour (WW) had a lower swelling index value (0.48g/ml) but $WWDP_5$ has the lowest value (0.45g/ml). There were significant ($P \leq 0.05$) difference in the swelling index of some samples (Table 4.1). Sample W, WWDP1, $WWDP_{2,}$ $WWDP_3$, and $WWDP_4$ were significantly ($P \geq 0.05$)similar but were significantly ($P \leq 0.05$) different from WW and $WWDP_{5.}$

3.1.8 Wettability

Wettability of the samples ranged from 13.00s in $WWDP_1$ to 116.70s in $WWDP_2$. The higher the incorporation of date palm palm pulp in whole wheat flour, the lower the wettability o fthe composite flour samples. The whole wheat flour (WW) and the refined flour (W) had higher wettability values (58.70s and116.70s) than the substituted flours samples (Table 3.1). There were no significant ($P \geq 0.05$) difference in wettability of $WWDP_3$, $WWDP_4$ and $WWDP_5$, $WWDP_{1,}$ and $WWDP_2$ respectively but there was significant ($P \leq 0.05$) difference between these samples and the rest of the samples. Wettability values as observed in samples with high date palm pulp proportion reduced the time for the flour to become completely wet (Mishra and Chandra, 2012).

3.1.9 Bulk Density

The bulk density of the samples was highest in $WWDP_5$ (0.69kgm^{-3}) and lowest in $WWDP_3$ (0.63kgm^{-3}). High bulk density values were observed in sample incorporated with date palm fruit pulp with the exception of $WWDP_3$ (0.63kgm^{-3}). There was no significant ($P \geq 0.05$) difference in the bulk density of all the samples. Low bulk density of flours has been reported to be useful for food formulation when used and such products have less retrogradation and that bulk density is a measure of heaviness of a flour sample (Oladele and Aina, 2009).

3.2 Proximate Composition of Flour Blends and Cookies

The proximate composition of flour blends and cookies are shown in Tables 3.2 and 3.3.

3.2.1 Moisture

The moisture contents of the flour blends ranged from 4.70% to 19.00%. The lowest moisture content was from $WWDP_4$ (4.70%) followed by $WWDP_1$ (9.33%). Other flour samples had high moisture content (Table 3.2). There were no significant ($P \geq 0.05$) difference in $WWDP_2$ and $WWDP_3$; W, WW, $WWDP_2$ and $WWDP_5$; W, $WWDP_5$ and $WWDP_1$and $WWDP_4$ respectively. The reduction in moisture content in $WWDP_1$ could be as a result of a higher proportion of date palm pulp in $WWDP_1$. This result is in line with the findings reported by other researchers that high incorporation of date palm pulp binds water due to high sugar content, hence lower moisture content. The moisture contents of the cookies (Table 3.3) ranged from 3.00% t 9.17%. The highest value was observed in $WWDP_2$ and the lowest value for $WWDP_5$. There were significant ($P \leq 0.05$) difference in the moisture contents of all the cookies made from the substituted samples. The control (W) and whole wheat (WW) samples were significantly ($P \geq 0.05$) similar.

3.2.2 Ash

The ash content of the samples (Table 3.2) ranged from 0.87% to 1.95%; which shows the presence of some minerals in the blends (Eneche, 1999). $WWDP_{1.}$, $WWDP_2$, $WWDP_3$, $WWDP_4$ and $WWDP_5$ had ash content values that were greater than those of whole of whole wheat flour(WW) and refined wheat flour (W). This could be due to higher mineral content in date fruits. High mineral content has been reported to increase ash content (Dada *et al*., 2012).

The results of ash contents of cookies (Table 3.3) ranged from 1.63% in whole wheat flour sample (WW) to 3.07% in $WWDP_1$. The addition of date palm pulp in the recipe had increased the ash content of the cookies: Date palm fruits according to Abdel Moneim *et al*., (2012) have appriciable high mineral content. The Whole Wheat (WW) and refined wheat cookies (W) had low values (1.63% and 2.22%) of ash contents respectively.

3.2.3 Crude Fibre

The crude fibre content of the various flour blends (Table 3.2) ranged from 1.03% in (W) to 2.27% ($WWDP_1$). There were no significant difference($P \leq 0.05$) in crude fibre content of the following.

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TABLE 3.2 PROXIMATE COMPOSITIONS OF FLOUR BLENDS

Samples	Moisture (%)	Ash (%)	Crude fibre (%)	Fat (%)	Carbohydrate(%)	Protein (%)	Caloric value (K Cal)
$WWDP_1$	9.33±5.30[cd]	2.50±1.00[a]	2.27±0.24[a]	11.50±1.05[a]	67.50±0.40[d]	6.90±0.00[b]	401.10±0.12[b]
$WWDP_2$	19.00±5.50[ab]	1.95±0.43[a]	2.16±0.15[a]	9.50±0.12[a]	59.64±0.06[e]	7.75±0.00[b]	355.06±0.10[e]
$WWDP_3$	22.7±9.60[a]	1.83±1.03[a]	2.00±0.19[b]	10.02±1.60[a]	59.91±0.04[e]	6.54±0.32[b]	343.98±0.11[g]
$WWDP_4$	4.70±5.20[d]	1.83±0.58[a]	1.89±0.18[b]	8.50±0.55[b]	73.38±0.61[a]	9.70±0.01[b]	408.82±0.15[a]
$WWDP_5$	11.00±1.50[bc]	1.63±1.10[a]	1.50±10[c]	6.00±0.26[b]	69.32±0.53[c]	10.55±0.10[a]	373.48±0.17[c]
WW	15.00±4.00[b]	0.87±0.68[a]	1.31±0.21[d]	4.50±0.38[bc]	69.49±2.61[c]	8.88±0.07[b]	353.78±0.14[f]
W	11.00±0.00[bc]	1.35±0.88[a]	1.03±0.010[e]	3.18±0.28[c]	71.59±1.73[b]	11.85±0.00[a]	362.38±0.18[d]
LSD	5.9250	2.446912	0.144123	2.672109	0.391506	2.8954	0.035236

Values are mean ± SD of triplicate determination. Samples with different superscripts within the same column were significantly ($p \leq 0.05$) different.

Samples = $WWDP_1$ = 50% whole wheat flour – to – 50% date palm pulp

$WWDP_2$ = 60% whole wheat flour – to – 40% date palm pulp

$WWDP_3$ = 70% whole wheat flour – to – 30% date palm pulp

$WWDP_4$ = 80% whole wheat flour – to – 20% date palm pulp

$WWDP_1$ = 90% whole wheat flour – to – 10% date palm pulp

WW = Whole wheat flour

W = Refined wheat flour

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TABLE 3.3 PROXIMATE COMPOSITION OF COOKIES

Samples	Moisture (%)	**Ash** (%)	**Crude fibre** (%)	**Fat** (%)	**Carbohydrate** (%)	**Protein** (%)	**Caloric value (KCal)**
$WWDP_1$	7.70±0.29[c]	3.07±0.18[a]	2.39±0.43[a]	25.33±2.02[b]	55.31±0.05[a]	6.20±0.00[d]	474.01±1.54[c]
$WWDP_2$	9.17±3.25[a]	2.97±0.45[b]	2.28±0.33[a]	26.00±1.35[b]	51.83±0.07[e]	7.75±0.00[c]	472.32±1.75[c]
$WWDP_3$	6.50±1.50[d]	2.87±0.33[c]	2.19±0.19[a]	30.00±2.50[a]	52.14±0.06[c]	6.30±0.00[d]	503.20±1.61[a]
$WWDP_4$	5.70±1.26[e]	2.57±0.16[d]	1.83±0.04[ba]	28.50±2.25[a]	52.12±0.63[d]	9.28±0.08[b]	502.10±1.88[b]
$WWDP_5$	3.50±1.00[f]	1.98±0.85[f]	1.72±0.08[b]	25.50±1.00[b]	52.12±1.24[d]	9.72±0.13[b]	476.86±1.76[c]
WW	8.50±2.00[b]	1.63±0.46[d]	1.59±0.04[b]	23.00±1.35[c]	53.43±0.03[b]	11.85±0.00[a]	468.12±1.27[cd]
W	8.70±0.76[b]	2.22±0.72[e]	1.50±0.36[b]	23.00±0.75[c]	53.43±0.97[b]	11.15±0.00[a]	465.32±1.52[d]
LSD	0.203909	0.078872	0.462303	1.908000	0.006117	0.662000	5.803096

Values are mean ± SD of triplicate determination. Samples with different superscripts within the same column were significantly ($p \leq 0.05$) different.

Samples = $WWDP_1$ = 50% whole wheat flour – to – 50% date palm pulp

$WWDP_2$ = 60% whole wheat flour – to – 40% date palm pulp

$WWDP_3$ = 70% whole wheat flour – to – 30% date palm pulp

$WWDP_4$ = 80% whole wheat flour – to – 20% date palm pulp

$WWDP_1$ = 90% whole wheat flour – to – 10% date palm pulp

WW = Whole wheat flour

W = Refined wheat flour

Flour blends: $WWDP_1$ and $WWDP_2$ and $WWDp_3$ and $WWDP_4$ but they were significantly ($P \leq 0.05$) different from the rest of the flour samples. Control (W) had the least crude fibre content which could be due to its refined nature. Samples from date palm fruit composites had higher crude fiber content, which is in line with the report by Ahmed (2005) who stated that date palm had crude fibre range of 6.4% to 11.5%.

The fibre content of the cookies ranged from 1.50% to 2.39% (Table 3.3). $WWDP_1$ had the highest crude fibre content. There were no significant ($P \geq 0.05$) in crude fiber content of $WWDP_1$, $WWDP_2$, $WWDP_3$ and $WWDP_4$; and $WWDP_4$, $WWDP_5$, WW and W respectively.

Fibre aids in lowering blood cholesterol level and slows down the process of absorption of glucose, thereby helping in keeping blood glucose level in control (Hamza *et al*., 2014). It also ensures smooth bowel movements and thus helps in easy flushing out of waste products from the body, increase satiety and hence impacts some degree of weight management (Mickelson *et al*., 2009). It is worthy of note in this study for its health significance. And therefore means that the addition of date palm pulp in flour is of nutritional importance especially to diabetic patients (Hamza *et al*, 2014).

3.2.4 Fat

The fat content of the blends (Table 3.2) ranged from 3.18% (W) to 11.50% ($WWDP_1$). The percentage of fat in the blends increased as more date palm pulp was added. Date palm fruit contains fat (0.2 – 0.5%) as stated by Ahmed *et al.*, (2005), and whole wheat (WW) has higher fat content than refined flour (W) hence the higher fat content of WW and date palm fruit composites. There were significant ($P \leq 0.05$) differences between W and all the composite flours.

The fat content of the cookies (Table 3.3) ranged from 23.00 in whole wheat flour (W) to 28.50% in $WWDP_4$. The fat contents of the cookies were observed to be high in the samples baked with date palm pulp substitution, while the whole wheat flour (WW) and the refined flour (W) cookies had the lowest fat content. The fat contents of W and WW were significantly ($P \leq 0.05$) different from all the samples containing date palm pulp. This shows that the fortification of flour with date palm is a welcome development for the improvement of the nutritional importance of cookies for children and other consumers within other age brackets.

3.2.5 Carbohydrate

As shown in Table 3.2, there were significant ($P \leq 0.05$) difference in all the carbohydrate contents of the flour samples. The carbohydrate content in the blends ranged from 59.64% ($WWDP_3$) to 73.38% ($WWDP_4$). The carbohydrate contents in al the blends were above 59%. The refined wheat flour (W) and the whole wheat flour (WW) had higher carbohydrate contents than the substituted blends.

The carbohydrate contents of the cookies were generally high, and ranged from 51.83% ($WWDP_{2)}$ to 53.43% (W) (Table 3.3) . Unlike crude fiber values, fat values and ash values, the highest value of carbohydrate content was observed in refined wheat flour (W) and whole wheat flour (WW). The unsubstituted cookies were made with sugar addition (as in normal recipe) which could be the reason for the high carbohydrate. Despite the fact that the differences in the carbohydrate contents among the cookies samples were significant, the percentage of carbohydrate was generally high in the various cookies that were contained with date palm.

3.2.6 Protein Content

The protein contents of the flour samples (Table 3.2) ranged from 6.54% to 11.85%. No significant ($p \geq 0.05$) differences was observed among the following samples W and $WWDP_5$ and $WWDP_1$, $WWDP_2$, $WWDP_3$, $WWDP_4$ and WW respectively. Protein content was highest for (W) and lowest for $WWDP_3$. The high protein content in (W) could be because of its high gluten content. The reduction in protein content in flour blends and whole wheat could be due to its high fibre content which could have a diluting effect on the protein content of the flours. According to Adbel Monein (2012), date palm fruit has lower protein content (2.3-5.6%).

The protein contents of the cookies (Table 3.3) ranged from 6.20% to 11.15%. There were significant($P \leq 0.05$) difference among the samples. It is also worthy of note that the highest protein content was recorded in refined wheat flour (W) and whole wheat flour (WW) which means that substitution reduced the protein content of the samples. The lowest value (6.20%) was observed in $WWDP_1$.

3.2.7 Calorific Value

The calorific value for the samples (Table 3.2) ranged from 343.98KCal ($WWDP_3$) to 408.82KCal ($WWDP_2$). The observed high calorific value in flour with date palm fruit pulp could be due to the fact that date palm fruit contains sugar like fructose and dextrose (Dada *et al.*, 2002).

The calorific values for the cookie samples ranged from 465.32kCal in (W) (whole wheat flour) to 503.20kCal in $WWDP_3$ (Table 3.3). The lowest calorific values were obtained from W and WW. The cookies containing date palm fruit had higher calorific values as also stated above by Dada *et al.*, (2002). The calorific values were significantly ($P \leq 0.05$) different for all the cookies.

3.3 Organoleptic Properties of Cookies

The organoleptic properties of the cookies produced from the flour blends are shown in Table 3.4 .

3.3.1 Aroma

The aroma of the cookies ranged from 5.10 to 7.25, that is the sample were neither liked nor disliked (score approximately 5.0) or moderately liked (score approximately 7.0). The results obtained showed that addition of higher proportion increased the aroma. There was no significant ($P \leq 0.05$) difference in the aroma of the composite samples but there was significant ($P \leq 0.05$) difference between the aroma of the composite samples and the controls (WW and W). Based on Hedonic Scale the aroma value for the composite samples showed that the consumers neither liked nor disliked the cookies produced from date palm pulp. This is likely because, the cookie is a new product that the consumers were not used to. (Iwe, 2002).

3.3.2 Colour

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The values of the colour of the cookies ranged from 6.25 (score approximately 6.0 – slightly liked) to 7.30 (score approximately 7.0 – moderately liked). The addition of higher date palm pulp in the Flour blends: $WWDP_1$ and $WWDP_2$ and $WWDp_3$ and $WWDP_4$ but they were significantly (P≤ 0.05) different from the rest of the flour samples. Control (W) had the least crude fibre content which could be due to its refined nature. Recipe made the colour more acceptable by the panelists. Colour of cookies produced from date palm pulp substitution were darker and more preferred by the panelists because they were all moderately liked (score approximately 7.0).The darker the colour of this cookies could be due to high carbohydrate content of date palm pulp (44% to 88%) which reacted with heat during baking, hence the cookies were more acceptable. Colour attribute is a major criterion that affects the quality of the baked products. Colour is a very important parameter in judging properly baked cookies that not only reflect the suitable raw materials used for the preparation but also provides information about the formulation and quality of the product (Ikpeme *et al.*, 2010).

3.3.3 Crispiness

The crispiness of the cookies were slightly liked to moderately liked. There was significant (P≤0.05) difference in crispiness of all the cookie samples. The refined flour and the whole wheat flour (WW) were rated higher in crispiness. The addition of date palm fruit to the recipe used in the production of cookies had varying effect on the crispiness of the samples. The crispiness of $WWDP_1$ was moderately liked (Score approximately 7.0) which was rated best. Crispiness is a desired characteristic that makes customers subscribe to purchasing any cookie (Lusas and Rooney 2001).

3.3.4 Taste

Significant (P≤0.05) differences were observed in the taste of cookies produced from date palm pulp substituted samples and those of non –substituted samples (W and WW). Sample W was the best in terms of taste (very much liked score approximately 8.0) and was significantly similar to WW samples (moderately liked).

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TABLE 3.4 Sensory/Organoleptic Acceptability of Cookies

Samples	Aroma	**Colour**	**Crispiness**	**Taste**	**Texture**	**Overall acceptability**
$WWDP_1$	5.50±1.73^{b}	7.30±2.03^{a}	6.80±1.54^{a}	5.30±1.73^{b}	6.75±1.65^{a}	5.40±1.27^{bc}
$WWDP_2$	5.65±1.79^{b}	7.00±1.56^{ab}	6.25±1.45^{a}	6.15±1.18^{b}	6.90±1.33^{a}	6.25±1.45^{a}
$WWDP_3$	5.65±1.35^{b}	7.10±1.62^{ab}	6.75±1.53^{a}	5.60±1.85^{b}	6.00±1.89^{ab}	6.45±1.32^{a}
$WWDP_4$	5.35±1.42^{b}	6.90±1.59^{b}	6.00±1.95^{b}	5.00±1.59^{b}	7.351.18^{a}	6.45±1.19^{a}
$WWDP_5$	5.10±0.91^{b}	6.80±1.19^{b}	650±1.24^{ba}	3.55±1.63^{b}	6.45±1.19^{ab}	6.05±1.53^{ac}
WW	6.85±1.14^{a}	6.25±1.12^{b}	6.75±1.62^{a}	7.40±1.19^{a}	7.05±1.53^{a}	4.65±1.23^{c}
W	7.25±1.02^{a}	6.40±1.50^{b}	6.60±1.69^{a}	7.85±1.31^{a}	5.00±1.59^{b}	7.45±0.91^{a}
LSD	1.41	1.44	1.45	3.42	1.51	1.55

Values are mean ± SD of triplicate determination. Samples with different superscripts within the same column were significantly ($p\leq0.05$) different.

Samples = $WWDP_1$ = 50% whole wheat flour – to – 50% date palm pulp

$WWDP_2$ = 60% whole wheat flour – to – 40% date palm pulp

$WWDP_3$ = 70% whole wheat flour – to – 30% date palm pulp

$WWDP_4$ = 80% whole wheat flour – to – 20% date palm pulp

$WWDP_1$ = 90% whole wheat flour – to – 10% date palm pulp

WW = Whole wheat flour

W = Refined wheat flour

Samples produced from date palm pulp substitution were slightly liked (score approximately 6.0), neither liked nor disliked (score approximately 5.0) and disliked slightly (score approximately 4.0) for $WWDP_5$ (Table 3.4). The lower rating for $WWDP_5$ could be due to lower percentage date palm pulp which was used to sweeten the cookies.

3.3.5 Texture

The texture of the cookies ranged from 5.00 (Neither liked nor disliked in the refined wheat flour (W) to 7.35 (moderately liked score approximately 7.0) in $WWDP_4$. There was no significant ($P\leq0.05$) difference between the texture of sample WW and all the samples containing date palm pulp which were either moderately liked or slightly liked according to the panelists.

3.3.6 General Acceptability

The general acceptability of all the cookies were rated neither liked nor disliked (score approximately 5.0) to very much liked (score approximately 8.0). $WWDP_5$ was rated lowest while W (which was the control) was the highest. The general acceptability of the composite cookies ranged from neither liked nor disliked to slightly liked. $WWDP_3$ and $WWDP_4$ were highly acceptable by panelists as they were moderately liked. Hence, substitution of date palm pulp in cookies formulation should not be less than 20% and not more than 40% respectively.

3. 4 Physical Properties of Cookies

3.4.1 Diameter

The diameter of the cookies ranged between 2.70cm to 3.37cm. The diameter of $WWDP_1$ and $WWDP_2$; and $WWDP_2$, $WWDP_3$, $WWDP_5$, WW and W samples were significantly ($P\geq0.05$) similar. The diameter of cookies obtained from the date palm pulp incorporation decreased from 3.37cm in $WWDP_1$ to 2.23cm in $WWDP_5$ with decrease in percentage of date palm fruit in the recipe. Hence, the addition of date palm pulp in the recipe for production of cookies affected the diameter of the cookies.

3.4.2 Thickness

The cookies thickness ranged from 0.55cm to 0.79cm. $WWDP_5$ has the highest thickness and the least thickness was recorded in WWDP4. The less thin the cookies the lesser its ability to withstand stress.

3.4.3 Weight

The weight of the cookies samples ranged between 1.88g to 3.35g. The 100% refined wheat flour (W) was heaviest and bulkiest among the samples. This could be because the 100% wheat flour had more gluten which is responsible for increased dough development and elasticity (Badifu, *et al.*, 2005). The whole wheat (W) and

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composite cookies had lower weights (approximately 2.0g – 3.0g). There was significant ($P \leq 0.05$) difference in weights of all the samples with the exception of $WWDP_3$ and $WWDP_4$ which are similar.

3.4.4 Spread Ratio

The spread ratio was lowest (4.63) for whole wheat (WW) and highest (5.55) for refined wheat flour (W). The spread ratio of some of the samples was significantly ($P \leq 0.05$) different (Table 3.5). Samples $WWDP_1$ and WW; $WWDP_2$, $WWDP_3$ and $WWDP_4$ were significantly ($P \geq 0.05$) similar. Cookie spread represents a ratio of diameter to thickness. Thus sugar affects diameter (sugar dissolution) and thickness (inhibiting gluten development). Cookies having higher spread ratio are considered most desirable (Handa *et al.*, 2012). Also, larger cookie diameter and higher spread ratio are considered as the desirable quality attributes. Spread ratios of cookies prepared with date palm fruit increased.

3.4.5 Break Strength

Control (W) samples had the highest break strength (1703g) followed by WW which had 1690g. The higher the percentage of date palm in the cookies the lower the break strength. The various break strength values for different samples were significantly ($P \leq 0.05$) different. Greater breaking strength indicates greater hardness of cookies structure (Anis *et al.*, 2014). Hardness of cookies is one of the major indices in the assessment of cookies quality (Yee *et al.*, 2014).

3.5 Shelf Stability of the Most Accepted Composite Cookie $WWDP_3$ (70% Whole Wheat Flour: 30% Date Palm Pulp)

Total microbial count reflects the condition in which the food was produced, stored or abused by handling and can be used to predict the shelf life or keeping quality of the product. The spoilage of many foods may be due to the total viable counts reached which is from 10 – 10 X 10^6 cfu/g in the product (Ray and Bhunia 2007).

The microbial load on Nutrient Agar (N.A) and Sabroud dextrose agar (SDA) were 1.20 X 10^3cfu/g and 1.70 X 10^3 cfu/g respectively for the first day of the production of the cookies (Week 0), 2.10 X 10^3 cfu/g and 3.70 X 10^3 cfu/g respectively for the third week after the production of the cookies (Week 3) and 2.50 X 10^3 and 4.10 X 10^3 respectively for the sixth week after the production of the cookies. It was reported that the maximum bacteria (aerobic) plate count for cookies is 5.30 X 10^4 cfu/g and, 5.0 X 10^3cfu/g for mould counts (Allen *et al.*, 2004; Ray and Bhunia 2007). The results obtained for the various storage periods of the cookies especially after six weeks was lower than the range recorded by Ray and Bhunia (2007). This implied that the cookies could be stored for as a longer period if well stored.

Table 3.6 Microbial Load of $WWDP_3$ Stored For 6 Weeks.

Sample	***Week***	***Total Viable Bacteria (cfu/g) (N.A)***	***Mould Count (SDA) (cfu/g)***	***Moisture Content During Storage (%)***
$WWDP_3$	0	1.20×10^3	1.70×10^3	8.105
	3	2.10×10^3	3.70×10^3	9.662
	6	2.50×10^3	4.10×10^3	12.105

$WWDP_3$ = 30% Date Palm Pulp and 70% Whole Wheat Flour

Bacteria usually require at least 0.91 water activity (a_w) and fungi require at least 0.7a_w, while below 0.6 a_w microorganisms cannot be able to survive (Croguennec, *et al.*, 2016 and Jeantet, *et al.*, 2016). However, moisture content during the third week (8.105 – 9.662%) and sixth week (8.105 – 12.105%) of storage of the cookies increased. The gain in moisture could be due to the hydroscopic nature of the date palm pulp, dried food product, storage environment and also the nature of the packaging material (Fellow, 2009). The increase in microbial load as the storage period extended might be due to corresponding increase in moisture content during storage and availability of nutrients present in the cookies. Also, there was no preservative added to inhibit microbial growth and low acid nature of the products.

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TABLE 3.5 PHYSICAL PROPERTIES OF COOKIES

Samples	Diameter (cm)	**Thickness (cm)**	**Weight (g)**	**Spread Ratio**	**Break Strength(g)**
$WWDP_1$	3.37±0.38[a]	0.71±0.03[b]	1.88±0.19[f]	4.68±0.25[d]	573±110[c]
$WWDP_2$	2.57±0.21[ab]	0.63±0.03[d]	2.52±0.06[d]	5.10±0.05[b]	880±115[bc]
$WWDP_3$	2.47±0.06[b]	0.58±0.02[e]	3.15±0.27[b]	4.96±0.13[bc]	956±40[bc]
$WWDP_4$	2.43±0.06[b]	0.55±0.01[f]	3.15±0.27[b]	5.08±0.07[b]	1070±746[b]
$WWDP_5$	2.23±0.06[b]	0.79±0.04[a]	2.75±0.40[c]	4.89±0.13[c]	1286±592[ab]
WW	2.47±0.06[b]	0.71±0.03[b]	2.25±0.11[e]	4.63±0.12[d]	1690±121[a]
W	2.27±0.06[b]	0.67±0.01[c]	3.35±0.06[a]	5.55±0.49[a]	1703±189[a]
LSD	0.36845	0.00155	0.085723	0.139534	417.279

Values are mean ± SD of triplicate determination. Samples with different superscripts within the same column were significantly ($p \leq 0.05$) different.

Samples = $WWDP_1$ = 50% whole wheat flour – to – 50% date palm pulp

$WWDP_2$ = 60% whole wheat flour – to – 40% date palm pulp

$WWDP_3$ = 70% whole wheat flour – to – 30% date palm pulp

$WWDP_4$ = 80% whole wheat flour – to – 20% date palm pulp

$WWDP_1$ = 90% whole wheat flour – to – 10% date palm pulp

WW = Whole wheat flour

W = Refined wheat flour

4.0 Conclusion

The use of date palm fruit pulp as sugar substitute in cookie production improved the properties of the flours such as swelling index, oil absorption capacity, pH, viscosity as they were comparable to the control (refined wheat flour W). There were no significant difference in emulsion capacity, gelatinous temperature and bulk density of all the flour samples. The proximate composition of the samples generally increased with increase in incorporation of date palm pulp with the exception of carbohydrate and protein. The proximate composition of cookies increased with increase in percentage palm pulp in the cookies and the samples were comparable to the control (W) except in protein content where the control was very high. The physical properties of cookies produced from composite were comparable to the control with the exception of break strength which decreased with increase in date palm pulp incorporation. The organoleptic characteristics of $WWDP_3$ was rated overall best in all the parameters tested. The incorporation of date palm pulp in cookies should not be less than 30%. Cookies samples stored for six (6) weeks had microbial loads less than the maximum count recommended in literature. This has shown that date palm fruit could be used for substitution of sugar in production of quality cookies and also as sweetener in other bakery products. I recommend that further work be undertaken to improve the protein content of cookies made with wheat and date palm fruit composite flours.

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