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A Study on Development of Coconut Based Gluten Free Cookies

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ABSTRACT :*The present study was carried out with an aim of development and standardization of gluten free coconut based cookies. Raw material was subjected to proximate analysis and the cookies developed were then analyzed and compared on basis of nutritional, sensory, physical, storage, microbial safety and textural indices.Refined wheat flour was found to contain 11.11±0.37% moisture content, 0.68±0.07% ash, 1.34±0.05% fat, 11.42±0.52% protein and 0.55±0.03% fiber. Coconut powder contained 3.43±0.81% moisture content, 2.03±0.02% ash, 64.10±0.75% fat, 7.13±0.32% protein and 13.54±0.64% fiber.Gluten free cookies prepared were assessed for proximate analysis and found to contain 5.02±0.01% moisture, 1.60±0.15% ash, 44.27±0.83% fat, 7.83±0.09% protein, 5.84±0.16% fiber, 35.46±0.81% carbohydrates and an energy value equivalent to 571.02±1.00 kcal. While control cookies contained 4.83±0.29% % Moisture, 0.97±0.06% Ash, 25.33±0.76% Fat, 6.83±0.15% Protein, 0.287±0.02% Fiber, 62.743±1.11% Carbohydrates and 514.35±0.83 kcal of energy.On basis of sensory evaluation the overall acceptability of gluten free coconut cookies were found to be 7.33±0.70 and that of control cookies was 6.85±0.64. The parameters considered for sensory evaluation were appearance, color, aroma, taste and texture.Coconut cookies were found to be less harder (1913.30±1.69) than control cookies (2808.01±2.01) when tested for hardness with texture analyzer.*

I. INTRODUCTION

Cookies, among the bakery products, are most significant in the world. These are an important food product used as snacks by children and adults (Hussain *et al.,* 2000). Cookies differ from other baked products like bread and cakes because of their low moisture content which ensures that they are free from microbial spoilage and confer a long shelf life on the product (Wade, 1988).Long shelf life of cookies makes large scale production and distribution possible. Good eating quality makes them attractive for fortification and other nutritional improvement. Fortification is done up to some level to meet following objectives; to maintain the nutritional quality of foods, keeping nutrients levels adequate to correct or prevent specific nutritional deficiencies in the population or in groups at risk of certain deficiencies, to increase the added nutritional value of a product (commercial view) and to provide certain technological functions in food processing (Dukwal, 2004).“Substitution” refers to completely replacing certain ingredient with some other suitable ingredient especially done in cases where a particular ingredient is allergen. In the present study wheat is being replaced by coconut powder in preparation of gluten free coconut cookies. The reason being wheat contains gluten (a special type of protein that is commonly found in rye, wheat, and barley) which causes a disease called “Celiac” (NIDDK, 2008). Celiac disease (CD) is a permanent inflammatory disease of the small intestine triggered by the ingestion of gluten containing cereals. It is an immune-mediated disorder that affects primarily the gastrointestinal tract. It is characterized by chronic inflammation of the small intestinal mucosa that may result in atrophy of intestinal villi, malabsorption, and a variety of clinical manifestations, which may begin in either childhood or adult life. Intestinal symptoms can include diarrhea, abdominal cramping, pain, and distention, and untreated celiac disease may lead to vitamin and mineral deficiencies, osteoporosis, and other extra intestinal problems. Considerable scientific progress has been made in understanding celiac disease and in preventing or curing its manifestations by dietary interventions (http://www.healthcanada.gc.ca/*celiac*).

According to NIDDK (2008), the only treatment for celiac disease is a gluten-free diet. If you avoid gluten, your small intestine will heal. If you eat gluten or use items that contain gluten, celiac disease will continue to harm your small intestine. Complete avoidance of gluten enables the intestine to heal, and the nutritional deficiencies and other symptoms to resolve. Children tend to heal more quickly than adults. Following a strict gluten-free diet also reduces the risk of developing many of the serious long-term complications related to untreated celiac disease.There has been a significant amount of efforts done to serve people with this disease, which have turned in many gluten products. This study is succession of those efforts and intended to make coconut based cookies.In the present study coconut powder is used to replace wheat. Coconut is highly nutritious and rich in fiber, vitamins, and minerals. It is classified as a "functional food" because it provides many health benefits beyond its nutritional content.

Coconut oil is of special interest because it possesses healing properties far beyond that of any other dietary oil and is extensively used in traditional medicine among Asian and Pacific populations. Choice of coconut as base ingredient is due to its nutritional value. Coconut has been a traditional food in almost all the countries where it is grown (Jena and Das, 2006). The scientific name for Coconut is "Cocos nucifera Linn" belongs to the family "Palmacae".Early Spanish explorers called it coco, which means "monkey face" because the three indentations (eyes) on the hairy nut resemble the head and face of a monkey. Nucifera means "nut-bearing" (Phillip, 1994). Coconut is unique among horticulture crops grown in India as a source of food, drink, shelter and a variety of raw materials for industrial exploitation. The crop assumes considerable significance in the national economy in view of rural employment and income generation (Palaniappan and Subramanian, 2010). India accounts for 22.3% of world production. According to 2008-2009 data published by Coconut Development Board, India is one of the leading producers of Coconuts in the world producing 15729.75 Million nuts billion nuts in 1894.57 thousand hectare of area. Nearly one third of the world's population depends on Coconut to some degree for their food and their economy (http://coconut_board.nic.in/stat.htm). In India, coconut is consumed in the form of tender nuts, raw kernel, copra, coconut oil and desiccated coconut. Since dishes made from coconuts are rich in fat, protein and some vitamins, they counterbalance some of the deficiencies inherent in the predominantly starchy foods consumed in the countries concerned (Palaniappan and Subramaniam, 2010).Due to immense nutritional potential there have been significant efforts to asses it in diet as a major ingredients, efforts goes from whole coconut products(like coconut water, coconut milk powder, coconut press cake etc.) to its fortification in different food products (like cookies, sweets etc.).

Objectives of the present study:

There are no such cookies (coconut substituting wheat) available commercially. Till now there are products (cookies, biscuits, breads) which are fortified with coconut flour for fiber or other purposes but within particular ranges blended with different kind of flour. The study was carried out with following objective:

- To develop gluten free cookies for celiac patients.
- To assess coconut as main bakery ingredient by substitution of wheat flour with coconut powder
- To standardize the recipe for preparation of coconut cookies and evaluation of nutritional, sensory and textural quality of cookies.

Procedure used

II. CHEMICAL ANALYSIS

2.1.Moisture Content

Moisture content was estimated by using AOAC method (1995).Finely ground sample (2 g) was weighed accurately in a covered dish previously dried at 98-100°C, cooled in desiccator and weighed soon after reaching room temperature. Loosen cover and heated at 110°C in hot air oven for 2 hours. Immediately tightened the cover on dish, transferred to desiccator and weighed soon, after reaching room temperature. The resultant loss in weight was calculated as percentage moisture content on dry basis (A.O.A.C. 1995).

Moisture % = $[(W_1 - W_2) \times 100] \div W$

W = Weight of sample
W1 = weight of sample + weight of petri dish.
W2 = Weight of dried sample + weight of petri dish.

2.2.Ash

Ash was estimated by using standard method of AOAC (1995).5 gm sample was weighed and transferred in pre-weighed porcelain crucible. The weighed sample was charred till smoke ceases. The crucible was then transferred to muffle furnace maintained at 550^0C and incinerated until light grey ash was obtained (nearly for 5 or 6 hours). The crucible was then cooled in dessicator and weighed. The results were reported on dry weight basis.

Ash% = $[(W_1 - W_2) \times 100] \div W$

W = Weight of sample
W1 = weight of sample + weight of crucible.
W2 = Weight of ash + weight of petri dish (after ashing)

2.3. Crude Fat

Crude fat was estimated using standard method of AOAC (1995).A ground 5 g sample was weighed accurately and transferred to the thimble and defatted with petroleum ether in Soxhlet apparatus for 6-8 hours at

80°C. The residue was procured and ether is removed by evaporation. The loss in weight of thimble was estimated as loss of lipids from sample and expressed as per cent lipids in sample.
Fat % = [loss in weight of sample × 100] ÷ weight of sample

2.4.Protein

The crude protein content was estimated according to the Kjeldahl's method as described in AACC (2000) method No. 46-10. Two grams sample was weighed and put into the digestion tube. Twenty milliliters of concentrated sulphuric acid (98%) and 2 tablets of digestion mixture as catalyst were added into the digestion tube. The digestion was carried out for 3-4 h (till the digested contents attained transparent color). The digested material was allowed to cool at room temperature and diluted to a final volume of 50 ml. The ammonia trapped in H_2SO_4 was liberated by adding 40% NaOH solution through distillation and collected in a flask containing 4% boric acid solution, possessing methyl indicator and titrated against standard 0.1 N H_2SO_4 solution. The factors 6.25 and 5.70 were used for the conversion of percent nitrogen into crude protein contents of composite flours and wheat flours, respectively.

2.5. Crude Fiber

The crude fiber was estimated according to the procedure as outlined in AACC (2000) method No. 32-10. It was carried out by taking 3 g of each fat free flour sample and digested first with 1.25% H_2SO_4, washed with distilled water and filtered, then again digested with 1.25% NaOH solution, washed with distilled water and filtered. Then ignited the sample residue by placing the digested samples in a muffle furnace maintained for 3-5 h at temperature of 550-650 °C till grey or white ash was obtained.
The percentage of crude fiber was calculated after igniting the samples according to the expression given below.

$$\text{Crude fiber (\%)} = \frac{\text{Wt. loss on ignition}}{\text{Wt. flour sample}} \times 100$$

2.6. Carbohydrates

Carbohydrate content was calculated for cookies by difference method AOAC (1995) on dry using following formula:
Total carbohydrate = 100 – (fat + fiber + ash + protein)

2.7. Free fatty acid estimation

The profile of fatty acids in product sample was estimated according to the chemical titration method as described AOCS (1998), Official Methods. Titrimetry has been classically used to determine the acid value (free fatty content). This acid value is defined as the number of mg of KOH required to neutralize the fatty acids contained in 1 g of the fat. It is very easy to express the results in other units as mg fatty acids per g of sample etc. Reagents used includes, solvent mixture (95% ethanol/diethyl ether, 1/1, v/v), 0.1 M KOH in ethanol accurately standardized with 0.1 M HCl (pure ethanol may be also used if aqueous samples are analyzed) and 1 % phenolphthalein in 95% ethanol.0.1 to 10 g of sample was weighed in conical flask and was dissolved in at least 50 ml of the solvent mixture (if necessary by gentle heating). Titrated, with shaking, with the KOH solution (in a 25 ml burette graduated in 0.1 ml) to the end point of the indicator (5 drops of indicator), the pink color persisting for at least 10 s.The acid value is calculated by the formula: 56.1 x N x V / M
Where V is the number of ml of KOH solution used and N his exact normality, M is the mass in g of the sample.

2.8.Energy

Energy content was calculated for cookies by factorial method AOAC (1995) on dry using following formula:
Energy (kcal) = 4.0 × protein (g) + 4.0 × carbohydrate (g) + 9.0 × fat (g)

2.9. Water Activity

The water activity was measured using a Rotronic Hygro Lab water activity meter. Cookies were crushed into small pieces and a representative sample was placed into plastic cups and measured one at a time

III. PHYSICAL PARAMETERS OF THE COOKIE

3.1 Diameter

For the determination of the diameter, six cookies were placed edge to edge. The total diameter of the six cookies was measured in mm by using a ruler. The cookies were rotated at an angle of 90^0 for duplicate reading. This was repeated once more and average diameter was reported in millimeters (AACC, 2000).

3.2. Thickness

To determine the thickness, six cookies were placed on top of one another. The total height was measured in millimeters with a ruler. The measurement was repeated thrice to get an average value and results were reported in mm (AACC, 2000).

3.3.Spread ratio

Spread ratio was calculated as diameter (length) to thickness ratio (Shrestha and Noomhorm, 2002).

Spread ratio = Diameter / Thickness

IV. SENSORY EVALUATION OF COOKIES

The panelists rated the samples for different quality attributes on a 9-point hedonic scale (Ranganna, 1994). Nine panelists evaluated cookies samples. The following were the numerical scores assigned.

9: Like extremely
8: Like very much
7: Like moderately
6: Like slightly
5: Neither like nor dislike
4: Dislike slightly
3: Dislike moderately
2: Dislike very much
1: Dislike extremely

Panelists evaluated the cookies samples for their color, appearance, taste, texture, chewing ability and overall acceptability. Sensory scores of various panelists given on hedonic scale. Each sample was assigned a numerical values by the judges for a subjective factor i.e. color, appearance, taste, texture, chewing ability and overall acceptability under excellent (5), very good (4), good (3), fair (2) and not satisfactory (1) categories.

In the score sheet, maximum score was nine and it was considered as excellent, minimum score was 1 and it was considered as poor and the intermediate scores were fair (2,3,4), good (5,6) and very good (7,8).

Textural study

Cookies prepared were subjected to textural analysis using Texture Analyzer (TA-XT2). Hardness of cookies is defined as the maximum force (gm, kg, N) which a cookie can bear before breaking. Hardness of cookies was measured using (HDP/BSK blade set with knife) probe. The texture analyzer was switched 'ON' and then settings given for hardness measurement of cookies was adjusted which mentioned in application guide of texture analyzer. The probe was caliberated and then a test was runned by placing sample on the platform of the texture analyzer.

V. COOKIE BAKING

5.1 Control cookies

Wheat (soft wheat) is the most widely used cereal for cookie making in that it provides necessary gluten to the biscuit structure. Although gluten was found to be crucial in making cookies, it has been stated by Hou *et al.* (1996) that low gluten content and weak gluten strength is generally desired for good sugar-snap cookie. In addition, Souza *et al*. (1994) concluded that the total protein content is more important for sugar-snap cookie quality than is the composition of the protein (Pareyt *et al.*, 2008). The same measuring apparatus, mixing bowls and electrical mixers were used for preparing the control and coconut cookies. Formulation proportion of control cookies is given in Table 1.

5.2 Coconut cookies

Coconut cookies are made from shredded coconut powder, which is rich in fat and fiber. Shortening is omitted from the recipe due to high fat content of coconut powder and to some extent due to extra tenderizing effect produced by egg, which is used as binding agent in the recipe along with guar gum powder. Formulation proportion of coconut cookies is given in Table 2

VI. STATISTICAL ANALYSIS

Statistical analysis of the results was conducted using Minitab statistical software version 15 (Minitab Inc, State College, PA, USA). The data reported in all the tables are an average of triplicate observations and were subjected to one-way analysis of variance (ANOVA).

Table 1 Formulation proportion of control cookies

Raw material	Amount required
Flour	**225 g**
Baking powder	**2.50 g**
Vegetable shortening	**64.0 g**
Sugar	**130 g**
Water	**60 ml**
Salt	**2.16 g**

Table 2 Formulation proportion of coconut cookies

Raw materials	Amount required
Coconut powder	**200 gm**
Egg	**200 gm**
Sugar	**100 gm**
Baking powder	**1 gm**
Guar gum	**2gm**

PREPARATION OF COOKIES

Weighing of Ingredients
↓
Creaming
↓
Wheat flour
↓
Mixing
↓
Sheeting
↓
Cutting
↓
Baking
(208 ^{0}C / 10 Minutes)
↓
Cooling
↓
Weighing and Packing

Fig 3.1 Flow chart for preparation of control cookies

PREPARATION OF COCONUT COOKIES

Weighing of Ingredients
↓
Mixing (Egg +sugar)
↓
Mixing (egg + sugar + coconut powder)
↓
Mixing (addition of remaining ingredients)
↓
Resting time in freezer (20 mins)
↓
Sheeting
↓
Cutting
↓
Baking
(185 ^{0}C / 16 Minutes)
↓
Cooling
↓
Weighing and Packing

Fig3.2-Flow chart for preparation of coconut cookies

VII. RESULTS AND DISCUSSIONS

Basic raw material used was wheat flour and coconut powder. Cookies were analyzed for nutritional, physical, sensory evaluation and texture analysis. Free fatty acid and water activity analysis was also done to check stability of the product.

Proximate analysis of raw material

Refined wheat flour and coconut powder were assessed for proximate composition and the data regarding them were presented in Table 3.

Proximate analysis of wheat flour

Moisture content of wheat flour taken was found to be 11.11±0.37 %. According to PFA specifications, the moisture content should be 14% (maximum limit) and the experimental value of the wheat flour was found to go well with the prescribed limits. Kaur *et al.* (1996) reported that wheat flour not to have more than 14% moisture as the excessive moisture affects the keeping quality of flours. Sinha *et al.* (1993), Sinha and Singh, (1974), Adsule *et al.* (1985), Singh *et al.* (1990) and Raghuvanshi *et al.* (1993) reported that moisture content of

Indian wheat varied from 10 to 13%. Thus, indicating that wheat flour was suitable for further storage. According to PFA standards the ash content of flour should be less than 1%.the assessed sample was found to have an ash content of 0.68±0.07%. Ash content is an indicator of total mineral content present. Fat content of the flour used was found to be 1.34±0.05% which was in accordance with results presented by Popli and Dhindsa (1980), in their studies regarding wheat varieties commonly grown in Punjab and Haryana. According to PFA specifications protein content of refined wheat flour should be more than 9% which is below the protein content of the flour used proving its good quality on the index. The protein content of assessed flour was found to be 11.42±0.52%.

Proximate analysis of coconut powder

Coconut powder has lower moisture content and protein content while higher values for fat content and fiber content which were found to be 64.10±0.75% and 13.54±0.64% respectively for coconut powder compared to 1.34±0.05% and 0.55±0.03% respectively for refined wheat flour being assessed. Lower values for moisture content may be attributed to the fact that the coconut powder used was desiccated. High ash content was considered as an outcome of high mineral content of coconut meat (sodium, magnesium, potassium etc).

VIII. PROXIMATE ANALYSIS OF COOKIES

Cookies developed were assessed for proximate analysis and are compared, taking cookies made from refined wheat flour as control sample. Control cookies were made according to standard recipe while recipe for coconut cookies was standardized through trials. The data regarding proximate analysis of cookies is presented in Table 4.

Proximate analysis of control cookies made of refined wheat flour

Nutritional / proximate analysis of control cookies has been depicted in Table 4 Moisture content of control cookies was found to be 4.83±0.29% which goes well with the general observed trends for cookies. Ash content of control cookies was found to be 0.97±0.06%. The protein content of control cookies (6.83±0.15%) was found lower than that of flour (11.20%), this may be attributed to the addition of non-protein ingredients in the formulation. Fat content was found to be 25.33±0.76% attributed to the shortening added in the formulation. Crude fiber content of control cookies (0.287±0.02%) turns out to be lower than that of flour (0.55±0.03%), which was considered to be because of degradation in the development process and due to addition of non-fiber ingredients in the formulation. The value for fat and protein content are in close argument with result presented by Mushtaq *et al*. (2010).

Table 3 Proximate analysis of Refined Wheat Flour and coconut powder

Parameters	Wheat flour	Coconut powder
Moisture	11.11±0.37	3.43±0.81
Ash	0.68±0.07	2.03±0.02
Fat	1.34±0.05	64.10±0.75
Protein	11.42±0.52	7.13±0.32
Fiber	0.55±0.03	13.54±0.64
Carbohydrates	74.91±0.80	9.16± 1.81
Energy	357.35±1.56	647.48± 3.89

Values are mean± SD of three replicates

Table 4 Proximate analysis of cookies

Parameters	Control Cookies	Coconut cookies
Moisture (%)	4.83±0.29	5.02±0.01
Ash (%)	0.97±0.06	1.60±0.15
Fat (%)	25.33±0.76	44.27±0.83
Protein (%)	6.83±0.15	7.83±0.09
Fiber (%)	0.287±0.02	5.84±0.16
Carbohydrates (%)	62.743±1.11	35.46±0.81
Energy value (kcal)	514.35±0.83	571.02±1.00

Values are mean ± SD of three replicates

Proximate analysis of coconut cookies

Moisture content of the coconut cookies was found to be 5.02±0.01% which was higher than that of control cookies (4.83±0.29%). This may be due to high water absorbing capacity of coconut fiber that is stated in the range of 4.48-8.31(Singthong *et al*, 2011). Ash content coconut cookies (1.60±0.15%) was also found to be higher than that of control cookies, this was attributed to high ash content of coconut powder. Srivastava *et al. (2010),* also reported an increase in moisture content and ash content values with increasing percentages of coconut meal substitution in wheat flour biscuits. High fat content of coconut cookies (44.27±0.83%) was attributed to high fat content of coconut powder (64.10±0.75%) and addition of egg, which contains about 10.01% fat and 13% protein content (*http://archive.defra.gov.uk/foodfarm/food/industry/sectors/eggspoultry/documents/eggqual.pdf*), which also eliminated the need for addition of shortening in the formulation along with the addition of egg. Protein content of coconut cookies (7.83±0.09%) was also observed higher than control cookies (6.83±0.15%), though protein content of coconut powder (7.13±0.32%) was significantly less than refined wheat flour (11.42±0.52 %). This was attributed to the addition of significant amount of whole egg in the formulation. High amounts of fiber content of coconut cookies (5.84±0.16%) was explained by keeping in view relatively high fiber contents of coconut powder.

IX. ORGANOLEPTIC QUALITY OF DEVELOPED COOKIES

Organoleptic quality of control cookies made of wheat flour

The substitution of refined wheat flour will cause changes in texture, flavor, color, appearance, aroma and overall acceptability as in baked products consumer tend to prefer a light and fluffy product, development of which is mainly affected by gluten (Cummings, 2001).

Control cookies were subjected to sensory evaluation and the results obtained were satisfactory, above 6.47±0.83 for all the parameters with an overall acceptability value of 6.85±0.64 which lies in the 'very good' zone according to scale used.

Organoleptic quality of coconut cookies

Coconut cookies, the product developed, was assessed for sensory evaluation and was compared with control cookies. The results proved the worth of study and were found satisfactory with high value of overall acceptability (7.33±0.70). Data regarding the organoleptic quality of cookies is represented in Table 5.Values for taste (7.87±0.99) and aroma (7.40±0.91) were high, this is attributed to strong taste and distinctive aroma of coconut powder.Coconut cookies were attributed with a higher overall acceptability score than that of control cookies by the panelists and the strong flavor of coconut was liked. The results are presented in Table 4.3.

Table 5 Organoleptic quality of control cookies and coconut cookies

Parameter	Control Cookies	Coconut cookies
Appearance	**6.87±0.74**	**7.00±1.13**
Color	**6.93±0.88**	**6.80±1.08**
Aroma	**6.47±0.83**	**7.40±0.91**
Taste	**7.00±0.85**	**7.87±0.99**
Texture	**6.67±0.72**	**7.27±0.59**
Overall acceptability	**6.85±0.64**	**7.33±0.70**

Values are mean± SD of the scores obtained

X. PHYSICAL AND TEXTURAL STUDY OF DEVELOPED COOKIES; CONTROL AND COCONUT COOKIES

Spread Ratio

Cookie spread ratio is an important quality parameter, higher the spread ratio higher will be product yield. Spread ratio for control cookies was found to be 7.58±0.07 where as for coconut cookies, it was 6.18±0.07, which shows a decrease in spread ratio.

Hardness

Texture is an important factor of comparing the cookies as it greatly affects consumer acceptance of the product (Eisa, H. A., 2006), the gluten free cookies when consumed should give a cookies eating feeling to

consumer than only the product will be acceptable. An objective and instrumental method using texture analyser is used to test the texture of cookies.Hardness was measured using texture analyzer as maximum peak force (gm/cm^2) required to rupture the sample. Coconut cookies were found to be comparatively soft or less hard than that of control cookies. Hardness for control cookies was found to be 2808.01±2.01 while for coconut cookies it was 1913.30±1.69. This extra softness was attributed to high fat content of the cookies. Decreasing trend of hardness on addition of coconut meal was also observed by Srivastava *et al.* (2010), in his study on Effect of Virgin Coconut Meal (VCM) on the textural, thermal and physico chemical properties of biscuits. Control cookies were found to be harder than coconut cookies,the difference made by the structural strength provided by gluten in control cookies.

Table 6 Physical and textural quality of cookies

Parameter	Control cookies	Coconut cookies
Spread ratio	**7.58±0.07**	**6.18±0.07**
Hardness (gm/cm^2)	**2808.01±2.01**	**1913.30±1.69**

Water activity

The water activity level in food is of practical importance as it controls the onset and severity of mould spoilage. It is commonly observed that foods most likely to show rapid deterioration due to biological and chemical changes are usually those with high water content (Abdullaha *et al.,* 2000).Water activity is used in many cases as a Critical Control Point for Hazard Analysis and Critical Control Points (HACCP) programs. For many years researchers tried to equate bacterial growth potential with moisture content, they found that the values were not universal but specific to each food product (Abbas *et al*., 2009). It was Scott (1957), who established that it was the water activity, not water content that correlated with bacterial growth. It was firmly established that growth of bacteria is inhibited at specific water activity values. In general, water activity is the right measurement when microbial processes, including food spoilage, are of concern (Graintec, 2005).Water activity was determined instrumentally using Rotronic Hygrolab. The results obtained are presented in Table 7 and 8Water activity of refined wheat flour was determined to be 0.43±0.03 which was observed lower than that of coconut powder which was reported to be 0.52± 0.02.Water activity of control cookies was found to be 0.24± 0.01. Mushtaq *et al*. (2010), reported same values for water activity for control cookies of wheat flour in his study on "Impact of Xylitol Replacement on Physicochemical, Sensory and Microbial Quality of Cookies". Where as a comparatively higher value of water activity (0.383) was reported by Pongjanta *et al.*(2006), in his study on the topic "Utilization of pumpkin powder in bakery products".Water activity for coconut cookies was observed to be higher than that of control cookies (0.24±0.01). It was reported to be 0.33±0.01. Water activity for both kinds of cookies was in safety limits for microbial safety as Beuchat (1981), mentioned there is no microbial spoilage below a_w value 0.5. Cookies are generally compared on basis of their water activity as it will matter if the cookies are crisp, soft or soggy. Water activity plays an important role in shelf life of cookies, a higer water activity value (>0.8) will facilitate different microbial growth (Eisa, 2006). Water activity is one of the most important determinants of microbial growth including temperature and pH (Doyle, 2007).

Table 9 Water activity values of refined wheat flour and coconut powder

	Water activity
Refined wheat flour	**0.43± 0.03**
Coconut powder	**0.52± 0.02**

Values are mean± SD of the scores obtained

Table 8 Water activity values of control cookies and coconut cookies

	Water activity
Control cookies	**0.24± 0.01**
Coconut cookies	**0.33±0.01**

Values are mean± SD of the scores obtained

XI. FREE FATTY ACID ESTIMATION

Cookies made were subjected to free fatty acid estimation on different storage intervals that is at 0 days, 15 days and 30 days, the results are depicted in Table 4.7. An increase in free fatty acid content levels with storage was observed in both kinds of cookies. Fatty acid content for control cookies and coconut cookies ranged between 0.18±0.010 to 0.307±0.030 and 0.037±0.006 to 0.059±0.007 respectively. Increasing trends of

free fatty acid content on storage for wheat flour cookies were also reported by Nagi, *et al.* (2012) in his study on "Effect of Storage Period and Packaging on the Shelf Life of Cereal Bran Incorporated Biscuits".
Fig 11 represents free fatty acid content trend in both control cookies and coconut cookies.

XII. CONCLUSION

Results obtained were satisfactory and the developed coconut cookies showed good quality characteristics on all the parameters considered. The overall acceptability was found to be 7.33±0.70 on 9 point hedonic scale. Nutritionally coconut cookies showed higher values for fat (44.27±0.83%), fiber (5.84±0.16%), protein (7.83±0.09%) and energy value (571.02±1.00 Kcal) as compared with control cookies with fat 25.33±0.76% , fiber 0.287±0.02% , protein 6.83±0.15% and energy value accounting to 514.35±0.83 kcal.

Table 11 Free acid content of cookies on different storage intervals

Time	Control cookies	Coconut cookies
0 Days	0.18^{a}±0.010	0.037±0.006
15 Days	$0.21^{a,b}$±0.017	0.048^{c}±0.002
30 Days	0.307^{b}±0.030	0.059^{c}±0.007

Values are mean± SD of three replicates
Values with similar superscripts in column do not differ significantly ($p<0.05$)

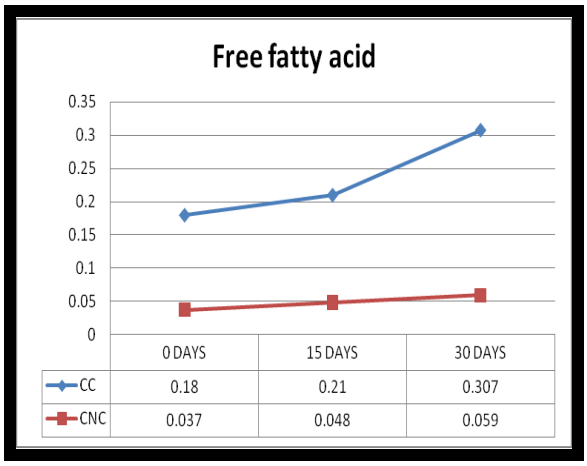

Fig 4.13 Free fatty acid content in control cookies (CC) and coconut cookies (CNC) as effected by storage

On the index of physical characteristics spread ratio of coconut cookies (6.18±0.07) was found to be lower than that of control cookies (7.58±0.07) and so is the case with hardness which acquires a value of 1913.30±1.69 for coconut cookies and 2808.01±2.01 for control cookies. The higher the spread ratio better it is. The hardness value shows extra softness of coconut cookies though on the index of sensory evaluation the texture was quite acceptable having a hedonic rating of 7.27±0.59.Free fatty acid content was observed to be increased on storage but was in permissible limits. For control cookies it remained between 0.18±0.010 and 0.307±0.030, while for coconut cookies the range was observed to be 0.037±0.006 to 0.059±0.007. Determined water activity values showed cookies were stable and safe when microbial spoilage is concerned. Water activity of control cookies was found to be 0.24± 0.01 and for coconut cookies it was 0.24±0.01.From the results it is concluded that gluten free, grain free cookies based on coconut powder as main ingredient were standardized and were found to be acceptable by the sensory panel and also on the index of nutritional quality, storage stability, microbial safety and physical and textural quality. Coconut do have potential to be used as main bakery ingredient and can provide a nutritional alternative to wheat for celiac patients and gluten free coconut based cookies can be successfully used for consumption.

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