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Nutritive Analysis of Coconut Residue (CR)-Composite Bread Fermented With Lactic Acid Bacilli (LAB) and Yeast and CR-Gluten-Free Biscuits

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Abstract: *Composite breads enriched with different forms of nutritive supplements are being tried globally to enhance the nutritive value of the ubiquitous bread. In the present study, baked products supplemented with coconut residue (CR) flour, a coarse fibrous residue obtained during the cold-press production of virgin coconut oil (VCO), were formulated. CR-Composite breads were made by mixing CR flour with whole wheat flour and fermented with lactic acid bacteria (LAB) as well as Baker's yeast. The CR-composite breads were evaluated for physical, nutritional and shelf life properties, and compared with the commercially available white bread. The nutritive content of both the types of composite bread were superior to the commercially available white bread, in addition to the presence of traces of micronutrient-selenium. They also showed better shelf-life due to their lower gluten content. Biscuit formulations were also tried using CR flour as substitute for wheat flour. As binders milk powder, soya flour and gram flour were used and three different biscuit formulations were made: CR-Gluten free Milk Biscuits, CR-Gluten free Soya Biscuits and CR-Gluten free Gram Biscuits. Selenium was also noted in our biscuits, which correlates with the amount of Selenium found in coconut meat. More importantly, the three types of CR-biscuits developed in this study did not have any gluten content owing to the absence of usage of wheat flour, making them ideal nutritious alternative for celiac disorders and lactose intolerance. Sensory evaluation of both types of baked products gave encouraging scores. This study attempted to formulate alternative and healthy baked products using CR flour without the use of chemicals associated with modern baking.*

Keywords: *Coconut residue, Coconut flour, LAB, Selenium, composite bread, gluten-free biscuits*

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I. Introduction

Bread is a fermented product made from wheat flour, water, yeast and salt by a series of processes involving mixing, kneading, proofing, shaping and baking [1]. Bread, despite its many variations and forms, is still an important staple food in both developing and developed countries, being convenient to consume and also serves as good source of basic nutrients [2]. According to the U.S. Census data and Simmons National Consumer Survey (NHCS), 319.24 million Americans used bread in 2017. In India, bread industry started as a small scale industry in late 1990s. With the changing socio-economic environment i.e. increased literacy rate (about 65%), higher per capita income, larger number of women going out for work to sustain family, higher living standard and increased tourist population, this industry is expected to grow 5- 10% in coming years. According to the government's estimate, there are about 1 lakh SSI units producing items worth Rs.3000 crores annually. (http://www.dcmsme.gov.in/reports/PP%20-%20BREAD%20&%20BISCUIT.htm). In India, bread has become one of the most widely consumed nonindigenous food [3]. High wheat import cost, geographical scarcity and high demand of wheat flour have led to the search for alternatives. For economic reasons as well as health reasons, many populations across the globe are now trying various combinations leading to the development of composite flour [4]. Composite flour has been defined in numerous researches as a combination of wheat and non-wheat flours for the production of leavened breads, other baked products, and pastas; or wholly non wheat flour prepared from mixtures of flours from cereals, roots, tubers, legumes, or other raw materials, to be used for traditional or novel products [5].

As bread is viewed as a convenient food, the focus in now to impart nutritional qualities to it by enriching it with locally-grown, indigenous nutrients and making it more a health food rather than just an easy to consume food. Coconut flour is one such component of composite flour that has unique taste and aroma and is rich in vitamins, minerals and dietary fibers, which might have potential application in baking products and human nutrition [6]. Coconut flour or coconut residue (CR) flour is obtained from Coconut Residue (CR), a coarse dry fibrous remnant left after the extraction of coconut milk in the cold press manufacturing process of virgin coconut oil. It has been considered as an inedible by-product of the coconut industry, and only a small part of it is utilized as fertilizer or feed for cows. Large quantities of CR are usually left to rot on the fields as waste material [7,8,9].

In our earlier study [10], we prepared composite bread using finger millets and got encouraging results. In the present study, we aim to formulate composite bread using composite flour of whole wheat and coconut residue, in a healthy way, without the use of chemical additives that are commonly associated with bread baking, and compare the physical, nutritional and rheological properties with the commercially available white bread. The study also explores the possibility of utilizing a potential agro-waste, Coconut Residue, as a dietary fibre and nutrient source.

II. Materials And Methods

Coconut residue used in this study was generously provided by Krishna Aura Coco Thyle Private Limited (K-ACT), Tamil Nadu, manufacturers of premium-grade, cold pressed, cold centrifuged, Virgin Coconut Oil. This was obtained as coarse white dry residue, which was then milled into fine powder. Locally available wheat grains were procured and ground into fine powder in flourmill. The powders were sieved through 2mm mesh (34 cm diameter sieve) to obtain the whole wheat flour and coconut residue (CR) flour, respectively. These flours were used in the formulation of CR-composite bread and CR-gluten-free biscuits developed in this study.

2.1 CR-Composite bread and CR-gluten-free biscuits formulations

Two different types of CR-composite bread formulations, fermented using Baker's yeast and lactic acid bacteria, respectively, were developed in this study, which are presented in **Table 1**, along with the formulation of commercially available bread, used as control in this study. Baking powder was added in both the formulations to improve the leavening ability. The control white bread had chemical additives: Preservative-282 (Calcium propionate), Acid Regulation-260 (Acetic Acid), Flour treatments Agents-510 (Ammonium Chloride), Antioxidant-300 (Phenolic Antioxidant) and Improver-1100 in small measures, which were noted from the label.

For the Baker's yeast fermented composite bread, whole wheat flour and CR flour were mixed in 4:1 proportions. Dry yeast was dissolved in warm water and stirred well. All ingredients were brought together, mixed and kneaded well and left for fermentation for one hour. The fermented dough was baked at 140°C for 40 minutes and then cooled and sliced. For the LAB fermented composite bread, whole wheat flour and CR flour were also mixed in 4:1 ratio. A commercially available sour curd in 200 ml pack was used as LAB source. All ingredients were brought together, mixed and kneaded well and left for fermentation for one hour. The fermented dough was baked at 140°C for 40 minutes and then cooled and sliced.

Three different CR-Gluten free biscuits were formulated in this study. For the gluten-free CR-Milk biscuits, CR flour, milk powder, baking powder, palm candy, and butter were used. Milk was used as binder. For the gluten-free CR-Soya biscuits, CR flour, soya milk powder, baking powder, palm candy, and butter were used. Soya milk was used as binder. For the third type, gluten-free CR-Gram biscuits, CR flour, bengal gram flour, baking powder, palm candy, and butter were used. Water was used as binder. The ingredients were mixed well and rolled into small balls. They were then flattened by gentle pressing and baked in a tray at 150°C for 15 minutes. The formulations developed in this study are shown in **Table 2**.

2.2 Quality evaluation of CR-Composite bread and CR-gluten-free biscuits

Physical properties such as colour, texture, and weight of the CR- composite bread and the CR-gluten free biscuits were noted . Biochemical analysis to evaluate the nutritive content was carried out on both the types of CR-composite bread and CR-gluten free biscuits. The tests included estimation of amount of moisture, protein, energy, crude fiber, fat, carbohydrate, and selenium, performed in accordance with Indian Standard Bakery products – Methods of analysis IS 12711: 1959 (Reaffirmed 1994), IS/ISO 5983-1:2005, IS 7219, AOAC Official method 928.08 & 943.01, DGHS Manual, 2005 & FSSAI Manual, Cereals & Cereal Products, 2016.

The two types of CR-composite breads and three types of CR-gluten free biscuits were evaluated organoleptically for color, flavor, texture and overall acceptability. Ethical clearance was obtained for the sensory evaluation and a 1-9 point hedonic rating test was performed to assess the degree of acceptability of these CR-flour baked products. One slice from each lot of bread and one piece of each type of biscuit was presented to 20 panelists as randomly coded samples. The taste panelists were asked to rate the sample for color, flavor, texture and overall acceptability on a 1- 9 point scale, where 1-dislike extremely; 2-dislike very much; 3-dislike moderately; 4-dislike slightly; 5-neither like nor dislike; 6-like slightly; 7-like moderately; 8-like very much; 9-like extremely. In addition, the shelf-life of the two CR-composite breads were compared with the white bread. The results obtained were compared with the data available on commercially available white bread and wheat biscuits, which were used as controls for this study.

III. Results And Discussion

3.1 Physical and Rheological properties

The loaf weight of CR-composite bread fermented using Baker's yeast weighed 230g while the one fermented using lactic acid bacilli (LAB) weighted 250g (**Fig.1 &Fig.2**). The commercially available white bread used as control weighed 200g. The increase in loaf weight in the composite bread compared to the commercially available white bread could be due to the decrease in gluten content owing to the use of CR flour, in comparison with the control bread made out of only wheat flour. Gluten is an inherent component of wheat grains. It is a protein composite which plays an important role in water absorption capacity, cohesiveness, viscosity and elasticity of dough, all of which contribute to the quality of bread. Gluten proteins contain two main components: the soluble gliadins and the insoluble glutenins. The gluten network of soluble gliadins and insoluble glutenins, formed during mixing and fermentation, contribute to the elasticity and extensibility, which helps in holding gas produced during fermentation, making the dough to rise and maintain its shape, even after baking. The Baker's yeast fermented CR-composite bread and the LAB fermented one had CR flour and whole wheat flour in 1:4 ratio. The decrease in gluten content in the composite flour had impact on the physical and rheological properties of the end product. Both the types of composite bread were brown in colour and the crust of yeast fermented CR-composite bread was slightly dark brown in colour than the LAB fermented one. The textures were slightly rough on surface and holes were seen inside, although with reduced porosity. The CR-composite breads were also dense in nature with less elasticity in comparison with the white bread, possibly due to CR flour, which is gluten-free.

The shelf-life of the CR-composite breads were also compared with the control white bread, by observing for visible changes on the surface for a week, in their packed condition. The control bread showed growth of green moulds on day four and by day 7, black mouldy growth covered most areas of the bread within the packing. In both the types of CR-composite bread, there were no visible growth observed on the surface upto day 7 (**Fig.3**). The CR-composite breads appeared drier than they were on day 1.

The three types of CR-gluten free biscuits were golden brown in appearance on baking (**Figs.4, 5 & 6**). The CR-based soya and gram flour compositions were more rough in texture than the CR-milk composition.

3.2 Nutritional properties

The results of the nutritional parameters of the two types of CR-composite breads in comparison with the commercially available white bread used as control are shown in **Table 3**. The nutritive content of both the CR-composite breads were comparatively higher than the control white bread. Both the CR-composite breads were comparable in the nutritive parameters tested. When compared to the white bread the CR-composite breads were high in fibre due to CR flour content which is highly fibrous. Arancon [11] has stated that CR flour consumption can increase fecal bulk and also play important role in controlling cholesterol and sugar levels in blood and prevention of colon cancer.

The CR-composite breads were rich in protein than white bread. Selenium, a micronutrient found in coconuts, was also noted in the CR-composite breads, indicating that the process of virgin coconut oil preparation has not taken away this mineral from the coconut meat.

The results of the nutritional parameters of the three types of CR-gluten-free biscuits in comparison with the whole wheat biscuits are shown in **Table 4**. The nutritive analyses of the three types of biscuits developed in this study were comparable with each other and were not remarkably different from one another. The values were also comparable with the commercially available whole wheat biscuits. The CR-biscuits that we developed were slightly higher in fat content owing to the use of clarified butter in our preparation. Additionally Selenium was also noted (8mcg/100g) in our biscuits, which correlates with the amount of Selenium found in coconut meat. More importantly, the three types of biscuits developed in this study did not have any gluten content owing to the absence of usage of wheat flour. This is particularly useful to those individuals who are allergic to Gluten. It provides a healthy alternative to those who have celiac disorders related to allergy to gluten. CR-Milk biscuits were gluten-free and were rich in protein, CR-Soya biscuits were not only gluten-free, but were also lactose-free, while the CR-Gram biscuits were gluten-free, lactose-free and soya-free. The CR-soya and gram biscuits additionally provide a healthy choice for lactose intolerants. The biscuits were also rich in fibre incorporating all the goodness of CR flour.

3.3 Sensory evaluation

The results of the sensory evaluation of the two types of CR-composite breads are shown in **Table 5.** The high fibre property of CR flour had perhaps impacted the crumb and appearance values of these composite breads, with their scores being marginally lower. LAB fermented CR-composite bread scored marginally higher in taste and aroma as well as in overall acceptability when compared to the Yeast fermented CR-composite bread. The results of the sensory evaluation of the three types of CR-gluten free biscuits are shown in **Table 6.** CR-Milk biscuit had higher score in overall acceptability. CR-Milk biscuit's score was also higher in flavour when compared to the other two CR-biscuits. The taste score of CR- Milk & Soya biscuits were higher than CR-Gram biscuits. CR-Soya biscuit's score was better in appearance and colour. In a study by Hossain et al.[6], similar encouraging results were obtained in sensory evaluation of cakes made using CR flour.

IV. Conclusion

Two types of composite bread comprising of Coconut residue (CR) and whole wheat flour, fermented using Baker's yeast and Lactic acid bacilli (LAB) were formulated and compared with the commercially available white bread. It demonstrated the superior nutritive content of both the types of composite bread in comparison with the control white bread. The higher fibre and protein content and presence of the miconutrient Selenium makes the CR- composite breads nutritionally superior.

Three types of gluten-free biscuits comprising of mainly CR-flour were also formulated in this study and were compared with commercially available whole wheat biscuits on various parameters. CR-gluten-free biscuits had higher fibre content compared to the whole wheat biscuits and CR-gluten-free milk biscuits had higher protein content when compared to other biscuits. Gluten-free biscuits developed from 100% CR flour are rich in nutrients and also serve as a cheap and healthy alternative for people with gluten related disorders/ allergies as well as for those with lactose intolerance. The sensory evaluation for both the types of baked products have shown encouraging results with good overall acceptance. This is the first study to have attempted to make different types of healthy baked products using CR flour, without the usage of common commercial food improvers and chemical additives. The study also successfully explored the possibility of utilizing a potential agro-waste, Coconut Residue, as a dietary fibre and nutrient source.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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Figures

Fig.1: CR-composite bread fermented using Baker's yeast

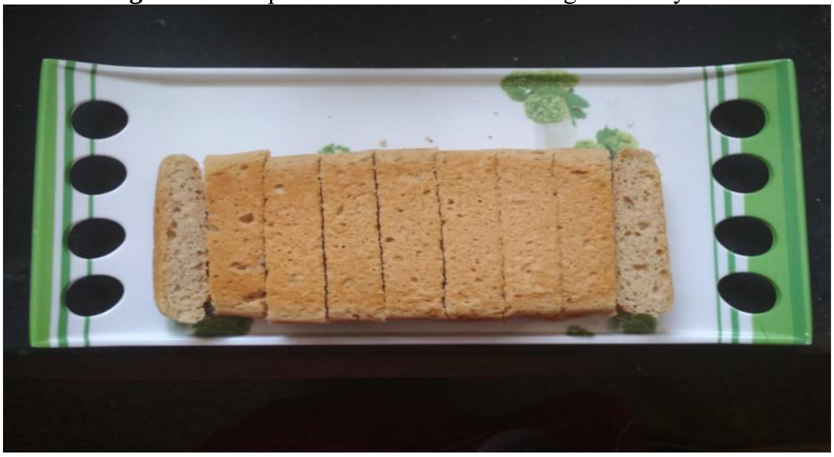

Fig.2: CR-composite bread fermented using Lactic acid bacteria (LAB)

Fig.3: Shelf-life after a week. Showed no visible changes of darkening or mould formation on surface of both types of CR-composite breads

Fig.4: CR-gluten-free milk biscuits

Fig.5: CR-gluten-free soya biscuits

Fig.6: CR-gluten-free gram biscuits

Table 1: Formulation of two types of CR-composite bread developed in this study in comparison with the Baker's formulation of white bread

S. No.	Ingredients (g)	CR-Composite bread fermented with Baker's yeast	CR-Composite bread fermented with Lactic acid bacteria (LAB)	White bread with Baker's formulation
1.	White flour (g)	-	-	200
2.	Coconut residue (g)	30	30	-
3.	Whole wheat flour (g)	120	120	-
4.	Skimmed milk powder (g)	15	15	34
5.	Baker's yeast (g)	7	-	6
6.	Sour curd (ml)	-	100	-
7.	Palm candy (g)	15	15	-
8.	Sugar (g)	-	-	36
9.	Salt (g)	2	2	4
10.	Baking powder (g)	3	3	-
11.	Cooking butter (g)	10	10	15
12.	Water (ml)	100	-	150

Table 2: Formulation of three types of CR-gluten-free biscuits

S. No.	Ingredients (g)	CR-gluten-free milk biscuits	CR-gluten-free soya biscuits	CR-gluten-free gram biscuits
1.	Coconut residue (g)	300	300	300
2.	Skimmed milk powder (g)	80	-	-
3.	Soya milk powder (g)	-	80	-
4.	Bengal gram flour (g)	-	-	80
5.	Cooking butter (g)	150	150	150
6.	Palm candy (g)	80	80	80
7.	Baking powder (g)	6	6	6
8.	Milk (ml)	30		-
9.	Soya milk (ml)	-	30	-
10	Water (ml)	-	-	30

Table 3: Nutritive properties of CR-composite breads in comparison with control white bread

S.No.	PARAMETERS	CR-composite bread fermented with Baker's yeast	CR-composite bread fermented with Lactic acid bacteria (LAB)	White bread with Baker's formulation
1.	Moisture Content (%)	41.6	40.8	37.5
2.	Fat (%)	3.96	4.13	2
3.	Crude Fibre (%)	2.65	2.33	0.20
4.	Protein (%)	7.58	7.77	7.30
5.	Carbohydrate (%)	42.9	43.5	51
6.	Energy (kcal/g)	238	242	216
7.	Selenium (%mg)	0.5	0.5	Not present

Table 4: Nutritive properties of the three gluten-free biscuits in comparison with the whole wheat biscuits

S.No.	PARAMETERS	CR-gluten- free milk biscuits	CR-gluten-free soya biscuits	CR-gluten-free gram biscuits	Whole wheat biscuits
1.	Carbohydrate(%)	42.3	45.9	41.1	62
2.	Sugars (%)	24.4	19.8	21.3	15
3.	Fat (%)	29.5	30.4	33.5	19.6
4.	Protein (%)	9.57	7.44	6.93	7.5
5.	Crude fibre (%)	10.2	9.87	8.18	9
6.	Energy (kcal/g)	473	487	494	455
7.	Selenium (%mg)	0.8	0.8	0.8	Not present

Table 5: Sensory evaluation of two types of CR-composite bread

SENSORY EVALUATION	Composite bread fermented with Baker's yeast	Composite bread fermented with Lactic acid bacteria (LAB)
Taste	8.1	8.5
Chewing ability	8.1	8.1
Texture	8.1	8.15
Aroma	7.9	8.05
Colour	8.1	8.2
Crumb	7.7	8
Appearance	7.9	7.8
Overall Acceptability	8.05	8.4

Table 6: Sensory evaluation of the three CR- gluten-free biscuits

SENSORY EVALUATION	CR-gluten- free milk biscuits	CR-gluten-free soya biscuits	CR-gluten-free gram biscuits
Appearance	8.3	8.4	8.3
Colour	8.2	8.5	8.3
Flavour	8.3	7.6	7.2
Texture	8.2	7.2	8.15
Hardness	8.05	7.5	8.05
Breaking strength	8.1	8.05	7.7
Taste	8.3	8.3	8.1
Overall Acceptability	8.2	7.9	7.8

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