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Production of Gluten–Free Breakfast Cereals Based on Red Rice by Extrusion Process

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Abstract: ***Ready-to-eat breakfast cereals (RTE-BC) is either extruded product from flour (or) flaked corn, wheat (or) rice commonly used as breakfast in western countries. Cereal fortification helps to eliminate many nutritional deficiencies in various developed nations including United States. Recent techniques used to make bio-available vitamins and minerals in breakfast cereals to overcome the nutritional deficiencies such as iron, calcium etc. The main objective of this study was development of readt to eat foods from cereals for breakfast using extrusion. Trial no.6 because of its Good consistency and sensory properties. Among all other trials the red rice and quinoa 42% is found to be effective in nutritional facts and consistency. Typically, breakfast cereals include flaked, puffed, shredded, granula, extrude and baked product Oryzapunctata (red rice) and Chenopodium quinoa (quinoa seed), two gluten free food grains help to replace the wheat which contains gluten and used for the production of breakfast cereals. Quinoa is good example for the functional food that aims to lower the risk of various debilitating diseases and identify the presence of phyto-hormones of as several advantages for human nutrition over other plant foods. The Orzyapunctata (red rice) with high antioxidant content can be supplemented in the form of breakfast cereal so as to reduce the usage of artificial antioxidant BHT (butylated hydroxyl toluene).***

Keywords: Breakfast cereals, Red rice, Quinoa, Stevia, Ready-to-eat, Oryzapunctata.

I. INTRODUCTION

Ready-to-eat breakfast cereals are commonly eaten with milk (or) cream in Western Counties, sweeteners such as sugar syrup are added to it. The modern concept of making breakfast cereals gained a great entrepreneurial possibility in the market. Ready-to-eat breakfast cereals in market are provided in the form of flaked with corn, wheat, rice that has been broken and baked.

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Then pressed into flakes, puffed made by cooked wheat (or) rice from pressure chamber. Flaked cereals also made from extruded pellets. Wheat (or) Rice flour ground along salt, Finally, the flaked cereals were treated to restore vitamin lost through cooking and sweet flavouring agent is additionally added to increase the taste of food. sugar and malt syrup is used to form dough and extruded [1].

A. Quinoa

Quinoa are dicotyledonous plants, referred to as pseudo cereals. Quinoa is a stable food in various regions of America. It has the capacity to resist frost and drought, and is also suitable for temperate regions. Quinoa is bitter in taste due to the presence of saponins in the outer layer [2]. The study of the paper deals about the bio-availability of a protein present in the quinoa seeds. Quinoa is holding essential amino acids and proved to be gluten free, protein rich, also high in fibre and essential micro and macro nutrients such as, calcium, phosphorus, vitamin E and antioxidants [3].

B. Red Rice

Red rice basically nutritious and has nutty flavour. It is a wild variety of rice with low yield. Usually when red rice is cooked it bleaches out and make the dish pink. Unlike other rice, red rice is shows higher nutritional benefits [4]. Anthocyanin present in the red rice prove the reduction in gluten content of rice compared to commercial white and black rice. Red rice is rich in magnesium and antioxidants [5].

C. Stevia

Stevia is sweet leaf, the leave chemical known as steviol. Stevia can be used either fresh (or) dried, it sweetens the beverage, desserts and commercially marked as artificial sweeteners (or) non-caloric sweeteners. Stevia proven to be 300 time sweeter than table sugar with non- glycaemic values. Generally, leaves are cooked. The dried leaves either powdered (or) mixed along with herbs for making beverages. It has positive effect on treating diabetics and regulating blood glucose level. Other than diabetics it's also aids in curing inflammation, hypertension obesity as well. It also regulates calcium influx into blood vessels [6].

II. MATERIALS AND METHODS

A. Raw Material Characterization

The Raw materials used for this process are red rice (*Oryzapunctata*), quinoa *(Chenopodium quinoa)*, stevia (*Stevia rebaudiana*).

B. Red Rice

Red rice is basically hygroscopic in nature. Initially it is washed before drying to remove dirt, soil and dust.

The dried sample is cooled moisture is reduced less than 25%. The sample rice is weighed and moisture is measured. The moisture in brought down and kept in desiccator, allowed to cool down. Then grained into flour [5].

Table 1: Final Moisture

Sample	Trial 1	Trial 2	Trial 3	Trial 4
Temperature	60°C	65°C	70°C	75°C
Initial weight	15g	15g	15g	15g
Final weight	14.6g	14.2g	14.0g	13.9g

Moisture % = (W1 – W2) / W2 *100
W1 – Weight of sample before drying
W2 – Weight of sample after drying

Figure 1 and 2: Red Rice and Red rice flour

C. Quinoa

Quinoa grains are also tested for moisture content before making flour in the same process cleaned and dried and moisture content is tested. The expected moisture content is around 8%. The Quinoa is washed, cleaned and dried using hot air oven at 80°C for 180 min. The product is grained to make flour [7].

Figure 3 and 4: Quinoa and Quinoa Flour

D. Stevia

The leaves are harvested and washed with clean water and shade dried until the expected moisture content is to be 25 - 30°C [8].

E. Extraction of Stevioside with Water

The dried ground leave was extracted by using hot water at various ratio has been tried. (1:15, 1:25, 1:35, 1:45, 1:55, 1:65 and 1:75 (w/v)). Stevia crude leaves extract having Stevioside was filtered using filter paper (Whatman No.4). The extracted elute containing stevioside is concentrated by using evaporator. The products obtained from above results the higher percentage is obtained in 1.35 ratio.

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Figure 5: Extracted Stevioside

Table 2: Sensory Profile

Sample	Sweetness	Bitterness	Aroma	Colour
Stevia extract	7	4	7	Turbid
Sucrose 40°Brix	9	0	2	Clear

These experiments were to optimize the red rice, quinoa and stevia in making breakfast cereals. All the raw materials were blended to form dough followed by extrusion and drying. Finally, sensory evaluation was carried out.

F. Formulations

Table 3: Formulation used

Trial	T1	T2	T3	T4	T5	T6
Wheat flour(g)	50	40	30	20	10	0
Red rice flour(g)	14	20	27	32	37	42
Quinoa flour(g)	14	20	27	32	37	42
Stevia Extract(g)	15	13	9	9	9	9
Salt(g)	1	1	1	1	1	1
Cocoa powder(g)	6	6	6	6	6	6

Stevia because of its bitter nature at higher concentration the optimized usage level of stevia is kept at 9 grams. Also salt and cocoa is kept 1g and 6g respectively for all the subsequent trials.

G. Trial 1

Wheat flour is major component taken in 60% and red rice and quinoa flour is taken 14g. cocoa powder is added 6g and salt is added 1g of impart the chocolates flavour and stevia is added as a sweetener also salt added very minor concentration its act as binder in baked product and it's also reduce as water activity (WA) and impart the flavour.

Figure 6: Trail 1mixture

H. Trial 2

In trial 2 wheat 10 grams, Red rice, reduce flour and quinoa flour is increased by 5 grams each.

Figure 7: Trial 2: Dough Formed using trail 2 Formulations

I. Trial 3-5

From trail 3 to 5 the composition of wheat flour is decrease gradually while composition of red rice and quinoa increased. Because of the increase in red rice flour colour of dough is rich in red colour. The stevia sweetener concentration kept same showed better sweetness without expressing bitter taste.

Figure 8: Trial 3-5: Dough Formed using Trail 3-5 Formulations

J. Trial 6

In this trail wheat flour is completely removed the usage red rice and quinoa flour optimize correctly. This trail showed the best trail output. Acceptable Trial: The acceptable trial is Trial no.6 because of its Good consistency and sensory properties.

Figure 9: Trial 6: Dough formed using Trail 6 Formulations

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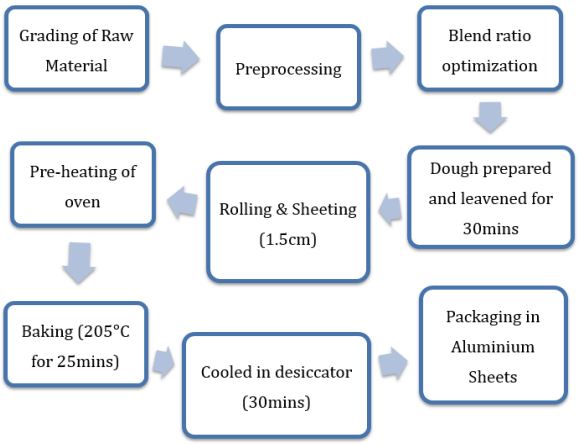
K. Extrusion and Baking

The dough is rolled and extruded based on the desired shapes and size. The shaped dough particles kept in pan greased with either vegetable oil or butter or wax paper the oven should preheated and Optimised temperature should be 205°C for 25mins. The baked product is taken from the oven and its kept to bring its higher temperature to the normal temperature in desiccator which is maintained at less than 30ºC [9].

L. Flow Chart



M. Physical Attributes of Breakfast Cereals

a. Bulk Density (BD):

The method developed by Deshpande and Poshadri was followed to determine the bulk Density [10].
BD (Kg/cm^3) = Mass of baked cereal (Kg)/ Volume of baked cereal (cm^3)

b. Moisture Percentage (% wet basis):

The baked cereal moisture contents were determined by AACC official method

% Moisture (wet basis) = W_1-W_2/W_1×100
Where, W_1 = Initial weight of sample before drying
W_2 = Final weight of sample after drying

c. Expansion Ratio (ER)

Baked product radial expansion was measured in mm with the use of a Vernier calliper divided by the die diameter. Expansion ratio was calculated using this equation

ER = (D/d)

Where,

D=diameter of baked cereal in mm
d=diameter of die in mm

d. Milk Absorption Capacity (MAC)

A sample is placed in milk at 8°C for 3 minutes was drained from the cereals and absorption is tested.

Milk 30 ml
Sample 4g
MAC (%) = {(Drained baked cereal weight (g) - initial baked cereal weight(g)}/Initial baked cereal.

e. Water Absorption Percentage (WAP)

The standard amount of flour mix(100g) is taken and standardized burette is taken and filled with water, keep on adding water from the burette till a dough with consistency suitable for baking forms.

f. Determination of Gluten Content (Hand washing method)

Flour (25g) is taken and dough is made. The dough is kept in water for 1 hour, then washed in tap water until all the starch get washed. The gluten ball collected and dried.

Gluten on dry basis = (Weight of dry gluten×100×100)/25 × (100 - moisture content)

g. Sensory evaluation

Baked cereals were considered acceptable if their mean score for overall acceptance was above 6 (like slightly).

Table 4: Sensory Evaluation Score

7	Very much liked
6	Much liked
5	Liked
4	Neither like nor dislike
3	Disliked
2	Much disliked
1	Very much disliked

N. Nutritional Analysis

a. Determination of Carbohydrates

It is determined by anthrone method, 100mg of sample is weighed and hydrolysed the anthrone reagent(4ml) is added to sample and kept in water bath for 10 min. The cooled sample is measured using spectrometer at 630nm.

b. Determination of Lipids

Weigh the sample (5g) and placed in thimble 350ml of Petroleum Ether is added and setup is kept for 5 hours. Final sample is weighed.
Calculation = {(Initial weight - Final weight) / Initial weight)} × 100

c. Determination of Proteins

The protein estimation is carried out by Bradford method. The sample is treated with coomassie brilliant blue G250 and observed at 595nm using spectrophotometer.

d. *Determination of Ash*

5g of sample is weighed and placed under 550-600°C until light grey ash resulted or to constant weight then cooled in a desiccator and the weight was noted.

Ash % = (Weight of ash ÷ Weight of sample) ×100

III. RESULTS AND DISCUSSION

A. Proximate Analysis of Raw Materials

The results of the proximate analysis of red rice, quinoa is shown in Table. Quinoa flour had the highest protein with 13.8 %respectively. Red rice and quinoa flours were also rich in total dietary fiber 14.3% and 6.2% and high in ash content with 2.2% and 2.1% for red rice and quinoa, respectively.

Table 5: Proximate Analysis of Raw Materials

Composition	Red rice	Quinoa
Moisture(g)	15.0 ± 0.1	19.1 ± 0.1
Protein(g)	6.3±0.3	13.8±0.2
Fat(g)	4.9±0.1	9.7±0.1
Dietary fiber(g)	2.7±0.3	16.4±0.2
Ash(g)	3.4±0.6	3.4±0.1

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B. Physical Attributes of Breakfast Cereals

a. Bulk Density

The bulk density of the breakfast cereals is analysed and found to be 0.016-0.036 kg/cm cube.

b. Moisture Percentage

The average moisture content of the baked product is found to be 6.4% (wet basis).

c. Expansion Ratio

The mean value of expansion ratio is found to be 0.2 to 0.3 mentioned in table 6.

d. Bowl Life

The bowl life of the Breakfast cereal was found to be

Table 6: Bowl life of a Flake

TRIAL	BOWL LIFE IN SECONDS
1	87
2	89
3	87
4	91

e. Milk Absorption Capacity

The Milk absorption value ranges from 0.2 – 0.6%.

f. Water Absorption Percentage

The water absorption percentage of dough is found to be in table 7

Table 7: Water absorption

TRIAL	WAP %
1	61
2	57
3	55
4	52
5	50
6	48

NOTE: The dough from trial 6 was taken for the production of RTE-BC is found to be 48%

g. Gluten Content

The gluten content of the dough from various trials was analysed by hand washing method.

Table 8: Gluten Content in Various Trails

TRIAL	GLUTEN CONTENT%
1	6
2	4.9
3	3.7
4	2.1
5	1.2
6	0

C. Sensory Evaluation

A sensory analysis is imperative for the success of a newly developed food product in the market. Colour change in baked product was due to the decomposition of pigments and product expansion which caused colour to fade and to react with chemical and other components in process such as Caramelization of carbohydrate. Using hedonic scale, the sensory evaluation is done and over all acceptability of baked cereal as found to be 6 (much liked).

D. Nutritional Evaluation

The total carbohydrate of breakfast cereal was found to be 67.8g. The protein content was found to be 14g and lipid content of BFC was found to be 7.3g. The **total ash** quantity was found to be **2.29%.**

Figure 10: Extruded product (Final)

IV. CONCLUSION

In this trail 6 wheat flour is completely removed the usage red rice and quinoa flour optimize correctly. This trail showed the best trail output. Acceptable Trial: The acceptable trial is Trial no.6 because of its Good consistency and sensory properties. Among all other trials the red rice and quinoa 42% is found to be effective in nutritional facts and consistency. The development of breakfast cereals can make nutritional positive among the working population and children population.

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