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Preparation of Novel Analog Rice Produced from Different Carbohydrates Resources and Defatted Soy flour

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Abstract:

This work is an attempt to provide a product similar to rice in shape and eating characteristics to reduce the rise in prices. As a result of reducing the cultivated area of rice due to the high water needs and the conditions of water poverty that many countries of the world suffer from in the presence of new climate changes. By using different cheap carbohydrate sources (broken rice fraction powder BRFP, broken pasta fraction powder BPFP, maize flour MF, white sweet potato puree WSPP and defatted soybeans flour DSF) in different 6 blends . using the thermal extrusion technology. The fortification was made with defatted soy flour in the alternative rice mixtures in relative to the control sample (white rice).The chemical composition of the alternative rice mixtures were studied and it was noted that protein, fat, fiber and ash were higher in the alternative rice mixtures compared to control, where it were (7.3%, 0.8%, 0.6% and 1%) respectively in control, while, it reached in(B1-B6) values were (13.3%, 1.3%, 2% and 1.9%) respectively in B3. Physical properties of each tested samples were studied, the thousand-grain weights increased from 16.4 g in the control to 18g identified in sample B3, and the percentage of amylose increased from 19% in the control to 23.3% identified in sample B3 while other samples were same trend. Cooking properties, increase weight%, water absorption%, volume increase% and cooking loss% were also studied, B1 and B2 were similar to the control in all cooking properties but rest of the samples decreases in cooking properties with increasing in cooking loss (TSS). Sensory attributes of analog rice samples were few decreasing but good scores, as B1, B2 samples were similar to control in all sensory properties. By studying texture properties, firmness, cohesiveness, hardness and chewiness, it was noted that there was a slight difference in the tested samples in relative to control. The current research concluded that it is possible to prepare an analog rice product from cheap raw materials that seemed to be very similar to the original rice in eating properties.

Keywords: Analog rice, alternative rice, low-carbohydrate mixtures, use of broken grains, climate change

1. Introduction

Diversification of staple food consumption is one effort to maintain food security. Staple foods are derived either from vegetables or animal products, and paddy staples include cereals (such as rice, wheat, maize, millet, barley, oats, rye, spelt, emmer, triticale and sorghum), starchy tubers or root vegetables (such as potatoes, cassava, sweet potato, yams, turnips, rutabagas or taro),(U.N. and FAO 2010).At a global level, cereal grains are the major source of energy and carbohydrates (including dietary fiber) and one of the major plant protein sources in the human diet (McKevith B. 2004). Staple foods are well known as reasonable, regularly available, energy-rich and essential for daily life.

Mainly staple foods are resulted from cereals, such as rice, maize, wheat, and barley. (Zhang Y. et al. (2017). Over 50% of the world's population depends on rice as their primary source of grain, and although it is simple to grow and a staple diet in many nations, Rice, a crop that is reliable for human consumption, is one of the most important foods in developing countries (Priya and others 2019).In many countries, rice is planted because it can endure damp circumstances that other crops cannot, rice is planted in many countries (Saleh et al., 2019). Food diversification is an option to ensure national food security, Pudjihastuti et al. (2019). Unfortunately, the program's attempts to raise rice prices and imports did not have the desired impact. Rice has a high-water requirement. It may produce up to three times as much as other crops like maize. Today one of the most significant global environmental issues of the twenty-first century is climate change. This resulted in a lack of rain and a shortage of water. In addition, these nations must have measures to rationalize water consumption due to the problem of desertification emerging in several nations, including Egypt. Food security and productivity will be impacted by this. Additionally, it is predicted that all crops would need more irrigation and their yields will decline. Thus, due to climate change and water shortages brought on by the development of GERD (Grand Ethiopian Renaissance Dam), all these issues would exacerbate the strains on Egypt's rice production (Elbasiouny and Elbehiry, 2020).

Therefore, the primary goal of the present study was to alter rice management practices and to consider producing analogous rice using other kinds of crops. As a result of food demand is larger than food production; the global food balance is likewise on the verge of being unbalanced (Gandhi and Zhou, 2014 and Fukase and Martin, 2017). As a result, the creation of analog rice is attracting the interest of numerous researchers. Rice production has become analog or mechanical rice production became as a result of labor shortages and increased labor expenses in rural areas where commercial agriculture has replaced subsistence farming Fukai et al.(2019). Analog rice is defined as non-paddy rice manufactured from locally accessible resources with a high carbohydrate content, such as white sweet potato *(Ipomoea batatas*), cassava, corn, and grains, and has a general appearance similar to rice, according to Sumardiono et al.(2014) and Machmur et al.(2011). An alternate paddy rice replacement known as "analog rice" is one that is at least as valuable as paddy rice. Because it is less expensive and simpler to use, the single screw extruder is a type that is frequently employed in the food industry. Analog rice, cookies, and other items are more frequently produced in single-screw extruders using hot extrusion (Budijanto and Dewi,2015) Due to a higher level of starch gelatinization during the hot extrusion process, analog products typically have a texture that is more akin to the original. In order to gelatinize, hydrogen bonds in the amorphous area must first be broken, and then must be hydrated with water.

As analog rice is made from different carbohydrates resources or non-rice raw materials, the habit of eating rice needs to be promptly balanced by the consumption of non-rice materials. In order to satisfy the human body's need for energy and protein, analog rice is depicted as a grain with the shape of a rice grain but made of non-rice sources (Sukamto, 2018). Additionally, analog rice can be made expressly to serve as a functional food for those with diabetes, hypercholesterolemia, and other conditions as well as those who are overweight. Non-rice plants that can serve as sources of carbohydrates include cassava, sorghum, corn, and sweet potato. These plants are ideal for use as the principal ingredients in the preparation of analog rice. (Budijanto and Dewi,2015).The rice kernel that breaks during milling is known as broken rice. In comparison to head or second-grade head rice, the broken rice pieces make up 20–30% of milled rice

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and are sold at a very low price (Raina et al. 2005). This underutilized by-product of the rice milling industry can be used to improve financial outcomes and find new uses for rice-broken kernels (Singh and Prasad 2015). Important ingredients like starch and oil in broken rice has a protein content of 8–10%. The lysine concentration of rice proteins, which is between the highest cereals in proteins at 3-4%, makes them nutrient-dense. (Shih et al .1999). Along with other useful, nutritional, and health-related benefits, the mixing of soybean and rice results in a good and well-balanced protein intake (Marengo et al. 2016).

Defatted soy flour has a protein digestibility score of 60 and contains roughly 50% protein (Garg and Singh 2010). Defatted soybean has been utilised in the creation of a variety of foods, including pasta and macaroni products, since it is high in lysine and isoflavone (an antioxidant) , (Roccia et al. 2009) . Numerous grain varieties could be combined to add nutrients and functionalities to produced analog rice, as a new high-value product. The terms "analog rice," "enriched rice," or "reformed rice" were first used by several authors Priya et al. (2019); Saleh et al. (2019) ; Pudjihastuti et al. (2019) ; Fukai et al. (2019) and Sumardiono et al. (2014) More than 70% of people worldwide consume rice, according to World Rice Production, (2019), Mbanjo et al., (2020)which includes populations in Asia and the Middle East, (Kobayashi et al. 2018 and Aprillya et al. 2019). During these phases of analog rice produce, the amylose is released, granules are ruptured, and a colloidal gel structure is created (Wani et al. 2012).

The ratio of amylose to amylopectin influences the gelatinization process. To achieve a successful gelatinization process, the optimal amylose: amylopectin ratio is 1:3 to 1:5. The development power will decrease if the amylose content is too high, but the rice will become more resilient if the amylopectin content is too high (Akdogan, 1999). The viscoelasticity of the product’s gelatinization is increased by higher temperatures, retention times, and screw rotation speeds, while the color's primary value is decreased. Navale et al.(2015) and Sumardiono et al.(2018).

High fiber content might give the rice produced a crisp texture Wójtowicz et al. (2014). Broken rice is enhanced with additives and transformed into analog rice. Analog rice is anticipated to have comparable nutritional content to paddy rice. Analog rice products

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have been created by researchers with enhanced nutritional and functional characteristics that offer health advantages like antidiabetic, antioxidant, antihypertensive, and anticancer. Granulation and extrusion are used to process analog rice. It has a form similar in shape to that of naturally occurring rice and is comprised of materials based on carbohydrates. Analog rice can be made from starchy substances other than rice, such as sorghum, corn, and modified cassava flour (Mocaf), according to Sumardiono et al. (2018) and Mishra et al., (2012).

In agreement with Budijanto et al. (2013) who employed non-rice resources in the process . According to Zhiqing et al.(2011) manufactured analog rice using broken rice (bulgur) . The raw materials used in the production process determine the protein level of analogous rice. According to Noviasari et al. (2013) the majority of analog rice contains more protein than regular rice, which may be because white rice proteinase components were employed in the manufacture of the product. Additionally, analog rice has higher fibre and improves digestion. As one of the most popular processes for producing analog rice is extrusion.

The Extrusion method is the main method to production of extrusion products and give it good eating parameters are used to modify key qualities such as color, shape, size, texture, and cooking properties. Analog rice can be used as a rice substitute that is high in protean, fiber and other healthy components, especially by persons looking to vary their diet Riaz (2000). The aim of this study, trying to produce of analog rice made from cheap carbohydrates resources, similar with white rice in shape and eating properties and high in nutritional values, the current work studied the nutritional value of analog rice and outlined its manufacturing process.

2. Materials and methods.

2.1. Materials.

The main ingredients for analog rice production were maize, white sweet potato (*Ipomoea batatas*), and Soy flour, white rice grain, was obtained from Field Crops Research Institute. The broken pasta was obtained from El-Sewesria for pasta products, the broken rice was obtained from El-Mostafa for rice milling Qaluobia province- Egypt. All chemicals were of reagent grade and were obtained from El-

Gomhoria Company for Chemicals.15 Sherif Street - Downtown – Cairo, Egypt.

2.2. Analog rice preparation.

Analog rice formulation and preparation.

Preparation of raw materials and mixing of blends were made in the Food Technology Research Institute –Agriculture Research Center – Egypt. Maize grains were milled by a humor mill, grounded to flour to pass through a B.S.S standard sieve No. 60 (250 *µm*), dry broken pasta fraction and dry broken rice fraction were milled by a humor mill and grounded to pass through a B.S.S standard sieve No. 60 (250 microns). Defatted soy flour was grounded to pass through a B.S.S standard sieve No. 60 (250 µm).

White Sweet potato was washed, cutting, soaked and steaming to produce (puree). Analog rice blends were made in (Rice and extrusion technology lab-.China) by machine Nutrition rice/analog rice process line (Shandong loyal industrial.CO) .China. Model (LD 70L Double Screw Extruder with Cooling System).

All flours and white sweet potato puree were mixed with each analog rice blend as in (Table 1) and hydrated to obtain water content of 25-30%. Then mixed with additives for 25 min to form the dough. The analog rice dough was extruded by an analog rice machine with vacuum under (2 bar pressures , 90 ºC) and used rice die, by fellow (mixing – Screw conveyor – Extruding –Vibrant cooling conveyor – air conveyor–vibrant drying machine – Air conveyor -Drying).Fig (1).

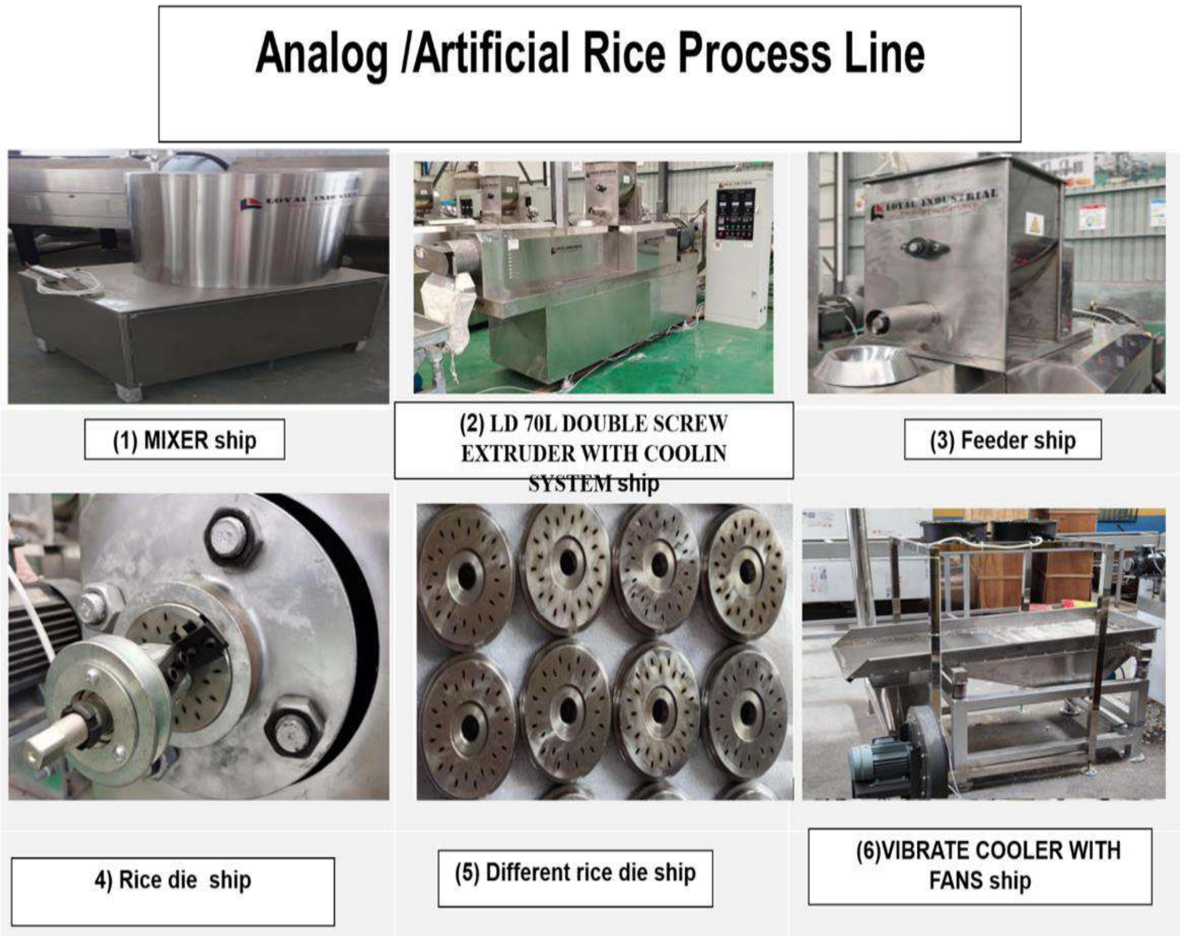
Analog rice has the same appearance as white rice. Longitudinal and transverse cutting is used in the hot extruder to avoid sticking, materials are forced to pass through a metal tube with 2.0 mm internal diameter. After 3.5 mm movement of the conveyor, the blade cuts the extruded dough at a 50°c angle.

Therefore, each piece is 4 mm long and 1.5 mm in diameter with a conical end (Leila et al. 2021) and then dried in a humidity chamber with humidity 70% for three drying steps ; 85°c for 30 minutes then 70 ° c for 20 minutes then 60 °c for 20 minutes by using the drier in an analog rice machine . Dried analog rice was left to rest for 1 h at 50°C temperatures, and then rice was left one hour in room temperature till rice temperature decrease to 25°c packed in polyethylene (PE) bags.

Table 1. The formula ingredients of analog rice blends.

	Control	B1	B2	B3	B4	B5	B6
White rice grain %	100	--	--	--	--	--	--
Maize flour % (MF)	--	40	40	30	40	40	30
Broken pasta fraction powder % (BPFP)	--	20	30	30	--	--	--
White Sweet potato puree% (WSPP)	--	--	--	--	20	30	30
Broken rice fraction powder % (BRFP)	--	40	30	30	40	30	30
Defatted soy flour% (DSF)	--	--	--	10	--	--	10
Xanthan gum %	--	0.1	0.1	0.1	0.1	0.1	0.1
Water %	were 25-30 to 100g flour						

Figure (1):



2.1. Physicochemical properties

1000-seeds weight, one thousand kernels of each analog rice blend was randomly counted in triplicate and separately weighed. The mean of triple replications was reported. Bulk density, White rice kernels and different analog rice blends were poured into a certain known volume from a fixed height and the mass of samples occupying the volume and weight were determined; the ratio was calculated as g/ml Narpinder et al (2005). Grain shape here is referred to as the length-width ratio, which is calculated using the equation where L/W is the length-width ratio of rice samples, L is average length of 10 seeds rice analog (mm), and W is the average width of 10 seeds rice analog (mm). Based on the length-width ratio, rice kernel was classified**.** The amylose content of the powdered samples was determined according to Ma-Hai and Deng (2017).

2.2 Proximate analysis

Chemical analysis was carried out. Moisture, protein, crude fat, ash, and total starch, which were determined according to the AACC (2010) .Approved Methods 44-16, 46-30, 30-10,, 08-01 and 76-31.01. Total protein (N X 5.7) and total carbohydrates by difference. Amylose % contents were determined according to (Ma-Hai and Deng 2017). All chemical tests were carried out in triplicate.

2.3. Cooking properties

Optimum cooking time: analog rice blend (2 g) samples were taken in a test tube from each blend and cooked in 20 ml distilled water in a boiling water bath. Cooking time was determined by removing a few kernels at interval different time during cooking and pressing them between two glass plates until no white core was left. Water uptake ratio: analog rice blends (2 g) for each cultivar were cooked in 20 ml distilled water for an optimum cooking time in a boiling water bath.

The mixture was drained, and any surface water was discarded by pressing the cooked rice mixtures between sheets of filter paper. Following an exact weight measurement of the cooked samples, the water uptake ratio was determined. Volume rising% ratio: the outcome was expressed as a volume ratio. Cumulative volume of 10 g cooked analog rice was divided by volume of 10 g uncooked raw rice blends.

For the best cooking time in a boiling water bath, analog rice blends (2 g in 20 ml distilled water) for each cultivar were cooked for the total solid loss. With numerous washing piles, the gruel was transferred to 50 ml beakers and diluted with distilled water. The aliquot that had leached solids was dried entirely by evaporation at 130°C in an air oven. The percentage of gruel solids was calculated after the solids were weighed, according to Narpinder et al. (2005) cooking characteristics taste.

2.4 Sensory evaluation

A total of ten panelists from the staff of Food Technology Research Institute, Agricultural Research Center, Egypt and 20 from different consumers(woman and men) in Qaluobia province , Egypt. They asked for performed the sensory evaluation of the analog rice blends and control from white rice. Analog rice samples were prepared for the sensory evaluation with the following steps: rice grains samples were rinsed twice, soaked for 10 mins to allow even distribution of moisture, and steamed for optimum cooking time before served. Using a 9-point hedonic scale (9 – extremely like to 1– extremely dislike), panelists were asked to rank for (color, aroma, taste, appearance, texture, stickiness and overall acceptability) ,according to Nugraheni, et al. (2020).

2.5. Textural properties.

The textural properties of cooked analog rice blends and control samples were determined using the procedure described by Singh, et al. (2003). The cylinder has been used to conduct a back extrusion test. Cooked analog rice blends (100 g) were cooled to 25 ºC and were placed inside a test cylinder and pressed with 150 g weight for 30 s before conducting the test. A cylinder plunger with a flat base, having a diameter of 38 mm, was used in conjunction with an Instron Universal Testing Machine (Model 4464, Instron, Buckinghamshire, England) for backward extrusion of cooked analog rice blends. A force-distance curve was obtained from the test and the following textural properties were determined: hardness(N) –the slope of the initial linear portion of the curve, cohesiveness(N) – the force required to initiate the shear and extrusion , firmness(N) – the maximum force registered during extrusion, chewiness(N mm) – area under the curve. Narpinder et al .(2005).

Statistical Analysis.

One-way analysis of variance (ANOVA) was performed using SPSS (2000). SPSS software version 6.0 (SPSS Institute Inc., Cary, NC, USA).was used to statistically examine the data. The threshold for statistical significance was $P \leq 0.05$.

3. Results and Discussion.

3.1. Chemical composition of raw material.

By studying the chemical analysis of raw materials in table (2) , it was found that the highest level of moisture was in WSPP with a percentage of 76.2 %, while the level was in MF, BPFP, BRFP , and DSF (12.8%, 11.35%, 10.25% and 12.4% respectively. Also it was showed that the highest percentage of protein, was in DSF, then BPFP, then MF , then BRFP, and the lowest in protein percentage was WSPP , 44.50%, 11.73%, 10.50%, 7.21% and 3.40 % respectively. The highest percentage of fat was found in DSF 3.65%, followed by MF with a percentage of 1.50%. The proportion of crude fiber was highest in DSF flour with a percentage of 5.75%, followed by WSPP, then MF, then BRFP and BPFP (3.12%, 1.64%, 0.86% and 0.58 %) respectively. The highest percentage of ash was in WSPP with a percentage of 3.00%, while it was lowest in each DSF, broken BRFP, MF and the least was BPFP. This results agreement with results reported by those ,Asael (2015);Alloush (2015),Shaista et al. (2017) and Gewaily et al . (2018).

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Table2. Chemical composition of raw marital (g/100 g). (% on dry basis).

Chemical composition (g/100 g).	Moisture	Protein	Fat	Crud fiber	Ash	Carbohydrates
WR	10.85±0.10	7.16±0.15	0.44±0.10	0.64±0.09	0.58±0.05	91.18±0.23
MF	12.84±0.14	10.50±0.12	1.50±0.09	1.64±0.07	1.1±0.05	85.26±0.27
BPFP	11.35±0.11	11.73±0.10	0.65±0.07	0.58±0.05	0.6±0.07	86.44±0.31
WSPP	76.26±0.15	3.40±0.11	0.77±0.10	3.12±0.08	3.2±0.09	89.51±0.20
DSF	12.42±0.07	44.50±0.16	3.65±0.11	5.75±0.09	2.5±0.08	43.6±0.29
BRFP	10.25±0.09	7.21±0.09	0.72±0.14	0.86±0.06	0.8±0.05	90.41±0.26

WR= white Rice grains MF=Maize flour. BPFP= Brocken pasta fraction powder WSPP= White sweet potato puree .DSF= Defatted Soy Flour. BRFP=Brocken rice fraction powder.

3.2. Proximate analysis of the formulations of analog rice on the dry base.

Chemical composition values of analog rice blends made by using various mixtures of (MF=Maize flour ,BPFP= Brocken pasta fraction powder, WSPP= White sweet potato puree, DSF= Defatted Soy Flour and BRFP=Brocken rice fraction powder , at hot extrusion. The moisture, protein, fat, ash, crude fiber, carbohydrate and starch percentage content studying in Table (3) and Figure (2). The chemical characteristics of analog rice blends showed that, the moisture (%) in analog rice blends and control was non-significant by difference among blends and control. Protein content in the analog rice blends was high, with a ratio of (9.1 to 13.3%) in the first three mixtures containing MF , BPFP and DSF with BRFP, while in the last three samples (B4, B5 and B6)containing MF , WSPP and DSF with BRFP it was 7.8% to 10.7%, but the lowest percentage of protein was in the control 7.3% this increase in the samples of analog rice compared to the control may be due to the high percentage of protein in the raw materials of maize flour ,broken pasta fraction powder and defatted soybean compared with control rice . Fat content showed an increase in the analog rice blends than the control, it reached 0.9% in B1 to1.3 % in B3, while the control was 0.8%, which may be due to the high

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content of fats on the raw materials to control specially samples which contain defatted soy flour and white sweet potato however the highest percentage of ash was (2.5%) found in sample B6 .This result could be due to the high percentage of white sweet potato puree powder , which are high in ash content. crude fiber content was the lowest percent in control and it increased from B1 to B6 (1.1%,1.3%, 1.9%, 1.5%,1.7% and 2.5%) respectively and the samples which included soybean and white potato were higher in their crude fiber content. As for starch, it was the highest percentage in the control (87%), while it decreased in the analog rice samples from 84.4 to 80% may be due to the increase of all other components such as ash, protein and fat. Iranna and Sahoo (2017) who reported that the moisture, ash, fat, protein, carbohydrate and crude fiber were increased with the substitution of broken rice flour with of broken rice pasta substituted defatted soy flour is presented .

Table 3. Proximate analysis of the formulations of analog rice (% on the dry base).

Parameters g/100g	Control	B1	B2	B3	B4	B5	B6
Moisture	$8.7^{a} \pm 0.21$	$9.6^{a} \pm 0.19$	$9.8^{a} \pm 0.22$	$9.9^{a} \pm 0.18$	$9.4^{a} \pm 0.14$	$9.4^{a} \pm 0.12$	$9.63^{a} \pm 0.19$
Protein	$7.3^{c} \pm 0.09$	$9.1^{b} \pm 0.11$	$10.4^{b} \pm 0.10$	$13.3^{a} \pm 0.13$	$7.8^{c} \pm 0.11$	$7.4^{c} \pm 0.15$	$10.7^{b} \pm 0.09$
Fat	$0.8^{c} \pm 0.05$	$0.9^{b} \pm 0.03$	$1.0^{a} \pm 0.06$	$1.3^{a} \pm 0.04$	$0.9^{b} \pm 0.08$	$0.8^{b} \pm 0.09$	$1.1^{a} \pm 0.07$
Ash	$1.0^{b} \pm 0.09$	$1.1^{b} \pm 0.07$	$1.3^{b} \pm 0.05$	$1.9 \pm ^{a} 0.08$	$1.5^{b} \pm 0.09$	$1.7^{a} \pm 0.06$	$2.5^{a} \pm 0.05$
Crude fiber	$0.6^{c} \pm 0.03$	$1.1^{b} \pm 0.07$	$1.5^{b} \pm 0.09$	$2.0^{a} \pm 0.08$	$1.8^{a} \pm 0.05$	$1.9^{a} \pm 0.07$	$2.2^{a} \pm 0.09$
Carbohydrate	$91.3^{a} \pm 0.24$	$87.8^{a} \pm 0.29$	$85.8^{b} \pm 0.25$	$83.5^{b} \pm 0.27$	$88.0^{a} \pm 0.29$	$88.0^{a} \pm 0.22$	$85.5^{b} \pm 0.24$
Starch %	$87.0^{a} \pm 0.23$	$83^{b} \pm 0.29$	$82.0^{b} \pm 0.25$	$80.0^{b} \pm 0.24$	$84.4^{a} \pm 0.27$	$84.3^{a} \pm 0.25$	$80.8^{b} \pm 0.22$

Control= 100 % while rice.

B1= 40 % Maize flour (MF)+ 20 %Broken pasta fraction powder (BPFP)+ 40 Broken rice fraction powder % (BRFP) .

B2= 40 % Maize flour (MF)+ 30 %Broken pasta fraction powder (BPFP)+ 30 Broken rice fraction powder % (BRFP).

B3= 30 % Maize flour (MF)+ 30 %Broken pasta fraction powder (BPFP)+ 30 Broken rice fraction powder % (BRFP)+ 10% Defatted soy flour% (DSF).

B4= 40 % Maize flour (MF)+ 20 % White Sweet potato puree% (WSPP)+ 40 Broken rice fraction powder % (BRFP).

B5= 40 % Maize flour (MF)+ 30 % White Sweet potato puree% (WSPP)+ 30 Broken rice fraction powder % (BRFP).

B6= 30 % Maize flour (MF)+ 30 % White Sweet potato puree% (WSPP)+ 30 Broken rice fraction powder % (BRFP)+ 10% Defatted soy flour% (DSF).

Values are expressed as mean ± SD Means within a raw showing the same letters are not significantly different ($P \geq 0.05$).

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Figure (2): Analog Rice Samples

3.3. Physiochemical Properties of uncooked analog rice blends.

The Physical properties of uncooked analog rice blends in Table (4) showed that thousand seeds weights ranged between (17 to 18 g) in different analog rice blends but in control, it was (16.4). This increase in the weight of a thousand grains may be due to high protein content with high Molecular weight of analog rice blends compared with (control) , which in turn led to an increase in the weight of the product this results with Gholizadeh-Vazvani ,et al .(2022) ,who found that the positive coloration between protein contain and thousand seeds weights in different bread wheat genotypes. L/B: Kernel length /Kernel breadth in analog rice blends recorded highest L/B ratio before cooking ranged from (1.54-1.70) and least was found in control (1.55) this may be due to the size tube in rice die in Analog Rice Process Line(extruder), Elongation and wide with no significant recorded between blends and control , As for the bulk density, it was in the analog rice mixtures from (0.76 to 0.82), while it was low in the control by 0.70, as a result of the high analog rice samples in the percentage of protein and fiber, in addition to the thermal extrusion process. Amylose content is one of the chemical properties that determine the physical properties of rice. Based on the analysis, analog rice has amylose content was high in blends the ranging from 21.2-24.2%., while it was lower in the control by 19%.

This may be due to the thermal extrusion process which converts amylopectin into amylose as a result of pressure and heat treatment in thermal extrusion and from the results obtained, the analog rice produced is included in rice which has a high amylose content, so that the rice produced when cooked will produce non sticky rice, easy to expand, clot when cold and have a shiny appearance. Public taste does depend entirely on amylose content as a reference for favorite rice (Khairunnisa, et al; 2017 and Pudjihastuti et al. 2019).

Table (4) Physiochemical properties of uncooked analog rice blends.

	TK weight (g)	L/B ratio	Bulk density (g/ml)	Amylose content (%)
Control	16.4 ^{b} ±0.11	1.55 ^{a} ±0.07	0.70 ^{a} ±0.03	19.0 ^{c} ±0.15
B1	17.5 ^{a} ±0.07	1.70 ^{a} ±0.09	0.80 ^{a} ±0.05	22.5 ^{a} ±0.17
B2	17.8^{a} ±0.15	1.62 ^{a} ±0.13	0.82 ^{a} ±0.07	23.3 ^{a} ±0.16
B3	18.0^{a} ±0.10	1.64 ^{a} ±0.08	0.84 ^{a} ±0.09	21.2 ^{b} ±0.18
B4	17.0^{b} ±0.09	1.58 ^{a} ±0.12	0.76 ^{a} ±0.06	23.0 ^{a} ±0.19
B5	17.3 ^{a} ±0.14	1.55 ^{a} ±0.17	0.80 ^{a} ±0.09	24.2 ^{a} ±0.13
B6	17.6 ^{a} ±0.13	1.54 ^{a} ±0.11	0.82 ^{a} ±0.09	22.6 ^{a} ±0.16

TK =Thousand kernel .L/B: Kernel length /Kernel breadth. Values are expressed as mean ± SD Means within a column showing the same letters are not significantly different ($P \geq 0.05$).

3.4. Cooking quality of analog rice samples.

The cooking characteristics of analog rice samples are shown in Table (5). Optimum cooking time results showed that the highest time was in control at 15.3 min but in all other analog rice samples it ranged between 10.8 and 11.8 min. Such decrease may be due to the effect of hot extrusion during processing the pressure, temperature, and time which are important factors in hot extrusion that affect protein denaturation and gelatinization of starch granules. Simple pass of dough at the high temperature in the extruder helps a suitable shape in analog rice blends, this results agreed with Riaz (2000). The water uptake ratio was decreased in control (2.3%) but it increased in other samples B1,B2,B3,B4,B5andB6 (2.6, 2.8, 2.5,2.5,2.6 and 2.3%) ,respectively .This increase may be due to Xanthan gum analog rice blends and the extrusion process which converts carbohydrate to amylose which absorbs more than amylopectin also may be due to the denaturation of protein which let it more acceptable for water absorption also the increase of fibers which absorbs more content of water. These results are in agreement with. Zhiyuan and Yanyan (2011), who reported that in extrusion, starch containing high amylopectin melts instead of gelatinization.

In comparison, starch with high amount of amylose gelatinizes well at a high temperature due to entrapment of water molecules between polymer chains, Also Harsimran ,et al (2017) , reported that , the using of xanthan gum in pasta formulations may be helps in increasing of water uptake and water absorption (%) in pasta samples , this may be due to the effect of xanthan gum bonding a large part of the boiling water in cooked pasta . Weight increasing (%) was the most less (%) value in control at (1.90%) but increased in all other samples of analog rice range from (1.95 to 2.25%). This increasing in blends may be effected by increasing in water uptake in analog rice blends by same reasons. The cooking loss is one of the important parameters for consumer and industry acceptance. Table 5 indicated that cooking loss, the total solid loss (TSS) percent was a decrease in control 5.1 and an increase in the analog rice samples from 5.8 to 8.1 % in in B1 –B6 because the extrusion process turns amylopectin to amylose also crude fiber in analog rice samples which is more soluble in boiling water. Iranna and Sahoo (2017) reported that the cooking loss was increased with fortified of broken rice flour by defatted soy flour in gluten free protein rich broken rice pasta, the addition of DSF consisted of soy protein, crude fiber, and other ingredients, could disrupt the starch matrix allowing more of the starch leaching out during the cooking process, Hossain et al. (2009) also declared that during cooking, rice kernels absorb water and increase in volume, this increase is not desirable, whereas, a lengthwise increase without an increase in girth is a desirable characteristic in high quality premium rice. Gelatinization temperatures showed were higher in control 77% than all analog rice samples from (67 to 70%) this reduction in gelatinization temperature may be due to a former heating process during extrusion but thecontrol has not been heat treated. Gelatinization temperature is another important quality predictor in determining the cooking quality of rice, low gelatinization temperatures rice needs less energy input during cooking than high gelatinization temperatures rice. Gelatinization temperatures in rice is mainly controlled by the starch functional properties are closely associate with amylose and amylopectin structure **.**This results agreed with Ali et al.(2015).

Table (5) cooking quality of analog rice samples.

	Optimum cooking time(min)	Water uptake ratio (%)	Weight increasing (%)	Volume increasing (%)	Total Solid (%)	Gelatinization temperatures ºC
control	15.3ª±0.20	2.3ᵇ±0.17	1.90 ᵇ ±0.11	2.0 ⁰ᵇ ±0.16	5.1ᵇ ±0.15	77 ª ±0.27
BI	11.5ᵇ±0.18	2.6 ª ±0.15	2.25 ª ±0.15	2.36 ª ±0.13	6.7 ᵇ ±0.13	68 ᵇ ±0.25
B2	11.6ᵇ±0.24	2.8 ª ±0.19	2.21 ª ±0.14	2.34 ª ±0.17	6.0 ᵇ ±0.12	68 ᵇ ±0.21
B3	11.8ᵇ±0.23	2.5 ª ±0.18	2.15 ª ±0.13	2.27 ª ±0.15	5.8 ᵇ±0.14	70 ᵇ ±0.23
B4	10.8ᵇ±0.17	2.5 ª ±0.21	2.04 ᵇ ±0.17	2.15 ª ±0.14	8.1ª ±0.17	67 ᵇ ±0.25
B5	11.0ᵇ±0.25	2.6 ª ±0.23	2.05 ᵇ ±0.16	2.17 ª ±0.15	7.7ª ±0.15	68 ᵇ ±0.24
B6	11.3ᵇ±0.20	2.3 ᵇ ±0.25	1.95 ᵇ ±0.12	2.16 ᵇ ±0.16	7.4ª ±0.16	68 ᵇ ±0.26

Values are expressed as mean ± SD Means within a column showing the same letters are not significantly different (P≥ 0.05).

3.5. Sensory evaluation of analog rice blends.

Hot extrusion can produce rice anlage with a shape and cooking quality very similar to those of white rice. It use various broken carbohydrates sources and is feasible for use in medium- to large-scale food manufacturing, Analog rice has the same appearance as white rice. Transverse and longitudinal cutting are used the extruder , also, hot extrusion technology allows flexibility in the selection of broken to produce desired sensory properties in final product , (Budijanto and Dewi 2015) and (Leila et al. 2021). Hot extrusion also led to starch gelatinization which improves the cooking quality and sensory properties of final product in all evaluations (Riaz, 2000). Taste, texture, aroma and overall acceptability are an important parameter that determines consumer acceptance. Panelists that have an overpowering aroma tend to be disliked for consumption. The Taste, texture, aroma and overall generated by analog rice was influenced by all factors, including residence moisture, extrusion temperature, pressure, time, and diffusivity of odor materials, Siswo et al. (2022).

Results in Table (6) showed organoleptic characteristics (color, aroma, taste, appearance, texture, stickiness and overall acceptability) were evaluated of analog blends and control from white rice. In conclusion control and B1,B2 analog blends made from maize flour , broken pasta flour, broken rice flour with xanthan gum were higher in all parameters color, aroma, taste, texture , sickness and overall acceptability, with no significant different in statistical analysis ,as it begin the decrease in B3, which contain broken rice, broken pasta flour and defatted soy flour with no significant different in color,

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aroma, texture ,sickness and significant different in taste and overall acceptability, organoleptic characteristics were more less in B4 ,B5 and B6 which contain white sweet potato with significant differences in all sensory properties expiation the appearance and stickiness were no significant differences recorded with control. Overall acceptability was 8.6 in control and (8.1-8.2) in B1and B2 blends with no significant differences recorded with control, while it decreased in B3,B4,B5 and B6 blends (7.8,7.4,7.6and 7.8) respectively, with significant differences recorded with control.

Table 6. Sensory evaluation of analog rice blends.

Blends	Color	Aroma	Taste	Appearance	Texture	Stickiness	Overall acceptability
Control	8.6^{a} ±0.07	8.4^{a} ±0.05	8.8^{a} ±0.09	8.6^{a} ±0.03	8.4^{a} ±0.07	8.0^{a} ±0.05	8.6^{a} ±0.10
BI	8.4^{a} ±0.04	8.0^{a} ±0.06	8.2^{a} ±0.12	8.5^{a} ±0.06	8.0^{a} ±0.09	7.4^{a} ±0.08	8.1^{a} ±0.10
B2	8.5^{a} ±0.07	8.0^{a} ±0.03	8.0^{a} ±0.10	8.4^{a} ±0.05	8.1^{a} ±0.06	7.5^{a} ±0.04	8.2^{a} ±0.05
B3	8.0^{a} ±0.04	7.6^{a} ±0.04	7.8^{b} ±0.07	8.3^{a} ±0.06	8.2^{a} ±0.08	7.7^{a} ±0.06	7.8^{b} ±0.08
B4	7.9^{a} ±0.05	7.4^{b} ±0.07	7.4^{b} ±0.05	8.3^{a} ±0.06	7.6^{b} ±0.09	7.2^{a} ±0.05	7.4^{b} ±0.04
B5	7.8^{b} ±0.06	7.2^{b} ±0.05	7.4^{b} ±0.08	8.3^{a} ±0.04	7.7^{b} ±0.05	7.3^{a} ±0.07	7.6^{b} ±0.05
B6	7.6^{b} ±0.03	7.0^{b} ±0.09	7.6^{b} ±0.04	8.2^{a} ±0.05	7.8^{b} ±0.08	7.6^{a} ±0.09	7.8^{b} ±0.03

Values are expressed as mean ± SD Means within a column showing the same letters are not significantly different (P≥ 0.05).

3.6. Texture characteristics of analog rice blends

High amylose contain rice will lead to the deterioration of softness, viscosity, luster, and palatability, but amylose contain rice does not absolutely determine the texture of cooked rice because the palatability of cooked rice with similar amylose contain rice may vary greatly. However, rapid viscosity analyzer being important for consumers and instrumental textural analysis is generally accepted as main criteria to analyze properties of cooked rice, Ali et al(.2015). Textural properties of novel analog rice produced from carbohydrates resources and defatted soy flour in Table (7). All the textural properties maximum force (N), hardness (N), cohesiveness (N), and chewiness (N), were significantly difference with control (p< 0.05) .The energy is needed to compress the samples strands between teeth corresponds to hardness and firmness. Firmness was higher than the control 242 (N) and less in the other 3 samples (B1, B2, B3) by 230, 236 and 239(N), respectively with significant different with control, while it was more lower in the last (3) blends with white potato samples, (B4, B5, B6) by 225, 228 and 231(N), respectively with significant difference with control . Perhaps such decrease between samples and the control is due to the thermal extrusion processes and high amylose contain in analog rice blends , which weaken the cohesion and led to the fragility of the samples. An increase in weakening was observed among the samples from B4 to B6 with white sweet potato puree and defatted soy flour, then B1 to B3 as a result of the high amylose content and fiber content in these samples. The chewiness was observed to be lower than the control while it rose between samples, due to its content of amylose content and fiber. Cohesiveness indicates the strength of internal bonds of the analog rice blends sample, cohesiveness decreased from 177 to 160 (N) ,which was just about not comparable with the control with 181 (N) cohesiveness. However, higher level found in B3 which made from broken pasta flour and defatted soy flour with no significant different with control while all other samples were recorded a significant difference . By the way, chewiness was same direction in analog rice samples compared with control from white rice. This results agree with Limroongreungrata and Huang (2007) who found the energy required which indicates to hardness, cohesiveness, and springiness in cooked pasta strand until it is ready for swallowing increased during pasta products made from sweet potato fortified with soy protein, it was observed that substitution of defatted soy flour decreased firmness, cohesiveness and springiness .

Table 7. Texture characteristics of analog rice blends.

Parameters g/100g	Firmness (N)	Cohesiveness (N)	Hardness(N)	Chewiness(N)
control	242 ^{a} ±0.29	181 ^{a} ±0.25	85 ^{a} ±0.17	47.8 ^{a} ±0.17
BI	230 ^{b} ±0.27	160 ^{c} ±0.23	73 ^{c} ±0.13	39.2 ^{b} ±0.18
B2	236 ^{b} ±0.23	172 ^{b} ±0.27	78 ^{b} ±0.11	42.6 ^{b} ±0.14
B3	239 ^{a} ±0.26	177 ^{a} ±0.25	80 ^{a} ±0.16	43.3 ^{a} ±0.16
B4	225 ^{c} ±0.29	151 ^{d} ±0.27	67 ^{d} ±0.15	31.6 ^{d} ±0.19
B5	228 ^{c} ±0.23	160 ^{c} ±0.24	69 ^{c} ±0.18	32.4 ^{d} ±0.15
B6	231 ^{b} ±0.25	169 ^{b} ±0.29	71 ^{c} ±0.14	37.5 ^{c} ±0.12

Values are expressed as mean ± SD Means within a column showing the same letters are not significantly different (P≥ 0.05).

Also, Sudha et al. (2010) reported that the instant vermicelli influenced defatted soy flour and whey protein concentrate was decreased in texture characteristics and dough rheological characteristics and cooking quality.

Conclusion

This research was carried out to produce analog or artificial rice that uses a combination of cheap carbohydrate ingredients (Maize, white sweet potato, broken rice powder , and broken pasta powder),fortified with defatted soybean flour . By studding of technological steps, chemical composition, technology quantity and sensory evaluation of analog rice formulations. The expected result of this research was the availability of a good quality analog rice product that contains a relatively complete variety of nutrients so that, in the future, it can replace the role of milled rice as a staple food.
By this studying, we got high-quality analog rice from non-milled rice based on the proportion of deferent broken of carbohydrates resources ,It also helps to add value and benefit from broking rice and pasta fractions into a necessary product and contributes to reducing the price of rice. Providing water used in rice cultivation and directing it to wheat cultivation. The analog rice need to more studies for the consumer acceptance and in order for analog rice to replace white rice as a staple food in Egypt.

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