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Development of Iron Fortified Chocolate Flavoured Rice Flakes

Gokul Shinde[1] and Manoharan Durgadevi[2*]

[1]Indian Institute of Food Processing Technology, Tamil Nadu, India
[2]Department of Food Product Development, Indian Institute of Food Processing Technology, Tamil Nadu, India

Abstract

Flaked or beaten rice is a very popular traditional product in India and other rice consuming countries. This product consumed as snack after roasting/frying and spiced or after soaking in water and seasoning with spices and vegetables. In order to re-introduce rice flakes, value addition in terms of flavor and taste will aid in consuming rice flakes as a major cereal breakfast. Iron deficiency and anemia are important problems affecting billions of people throughout the world. These are more prevalent in underdeveloped countries, during rapid growth periods and when nutritional requirements and/or losses are higher.

This research work has investigated the effect of flavour addition on the quality of rice flakes with iron fortification. The results from the physical properties of flaked rice and raw rice indicated that there was an increase in water holding capacity, sedimentation volume as compared to raw rice based on the gelatization of starch.

Another attempt was made to add chocolate flavour to rice flakes as result of coating. Chocolate sauce was coated to rice flakes using enrober. During the coating process rice flakes were fortified with fortificant Ferrous fumarate in three concentrations. Chocolate-coated rice flakes were having high iron compound than another variation. As the flakes were coated with cocoa powder, the Catechin content was also eniriched in the flakes. The storage stability study of coated rice flakes was conducted for one month at ambient temperature. The values obtained for Free Fatty Acid (FFA) and Peroxide Value (PV) were in acceptable range. After storage, sensory evaluation indicates that there was no change in flavour, taste, and overall acceptability on quality of product.

Keywords: Flaked rice; Fortification; Catechin

Introduction

Rice (*Oryza sativa* L.) is the basic food for two-thirds of the world population and are the most important cereal crop cultivated in the world [1]. 'Rice flakes' or 'flattened rice' or 'beaten rice', is a popular processed rice product used as a breakfast cereal, a substitute for cereal in weaning foods and a snack food. About one-fifth of the rice produced is converted into flakes [2].

Paddy production in the world is 660 million tonnes, out of which India produces around 144.6 million tonnes [3]. About 14.46 million tonnes (10% of production) are being utilized for the production of rice products like popped, expanded and flaked rice [4]. Flaked or beaten rice is a very popular traditional product in India and other rice consuming countries. This product is consumed as a snack after toasting/frying and spicing or after soaking in water and seasoning with spices and vegetables [5].

Rice flakes or poha is an important breakfast in semi-urban and rural areas and middle class families of urban India. Spicy or sweet preparations made from it are not only easy to make but they can be made at a short notice as well. Therefore it is extensively used all over the country round the year.

According to the World Health Organization, iron deficiency anemia is one of the most common nutrient deficiencies in the world. India has a high prevalence of iron deficiency which can be improved by iron fortification [6]. Iron deficiency anemia can be caused by low dietary intake of iron, poor iron absorption or excessive blood loss. Symptoms of anemia include, delayed cognitive development in infants and young children and decreased performance at work or school; constantly feeling weak and tired; irritability. Anemia during pregnancy also increases the chances of foetal deaths, abnormalities, pre-term and underweight babies. It is estimated that twenty percent of maternal deaths are directly caused by anemia and causes of another fifty percent of maternal deaths are associated with anemia in the world [7,8].

Rice flakes represent a perfect food vehicle for fortification. Chocolate coating will result in value addition of rice flakes as well as fortification will helpful to combat iron deficiency. Our study is the first to explore the feasibility of Fe fortification in rice flakes as a rapid and cost-effective solution to Fe-deficiency anemia in economically disadvantaged populations with rice as the major staple food and poor access to animal protein. The objective of this study was development of iron fortified chocolate flavoured rice flakes. Iron fortification of food is considered to be the most cost-effective [9], long term and convenient approach to provide additional absorbable iron to populations. Attempt was done to add chocolate flavour to rice flakes as result of coating.

Materials and Methods

A high amylose paddy cultivar, Co 1009, which is currently being used by the cottage industry in India for producing flaked rice was selected for the current study. Paddy was procured from rice flake manufacturing industry located at Kumbakonam, Tamil Nadu. Rice flakes were prepared in heavy duty roller flaker at Indian Institute of Food Processing Technology (IIFPT), Thanjavur. Rice flakes were prepared by the process described by Mujoo et al. [4]. Ferrous Fumarate for iron fortification was purchased from Medreich Limited, 49 (B), Bommasandra industrial area, Bangalore. Samples were prepared as shown in Table 1.

***Corresponding author:** Manoharan Durgadevi, Assistant Professor, Department of Food Product Development, Indian Institute of Food Processing Technology, Tamil Nadu, India, E-mail: durga@iifpt.edu.in

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The process of preparation of rice flakes is depicted in flow diagram Figure 1.

Raw Paddy was cleaned to remove impurities and soaked in hot water for about 7-8 hours at room temperature to increase its moisture content. Then paddy was drained of water and tempered for 4-5 hrs for even distribution of moisture content. After that paddy was roasted at high temperature of about 180-190˚C for a short period of time (20-25 Sec.) in fine sand and passed through heavy duty roller flaker operated at 900 rpm. The obtained rice Flakes were passed through sieves to separate husk, bran and broken flakes and to obtain flakes of fairly even size.

Chocolate sauce was prepared using cocoa powder, sugar, shortening, skimmed milk powder as given in Table 2. In another formulation, jaggery was used instead of sugar. All the raw materials required for making chocolate sauce were purchased from the local market of Thanjavur.

Ferrous fumarate was used in three concentrations for fortification of rice flakes i.e. 80, 120,160 mg /100 gm of rice flakes. Chocolate sauce was coated using enrober. After coating, samples were dried in a tray dryer for 1 hour at 40˚ C. Paddy and rice flake samples were analyzed for physical and chemical properties. Proximate analysis of all samples was done according method given in AOAC, 1997 [10]. During storage study of fortified flavoured rice flakes, rice flakes were analyzed for free fatty acid, peroxide value, colour change and microbial quality.

Samples Code	Sample
T_1	80 mg Ferrous fumarate Rice Flakes without coating
T_2	120 mg Ferrous fumarate + Rice Flakes without coating
T_3	160 mg Ferrous fumarate + Rice Flakes without coating
T_2	80 mg Ferrous fumarate + Rice flakes Coated with Choco sauce
T_3	120 mg Ferrous fumarate + Rice flakes Coated with Choco sauce
T_4	160 mg Ferrous fumarate Rice flakes Coated with Choco sauce
T_5	Control (Without Ferrous fumarate)
T_6	Rice flakes Coated with Jaggery sauce+80 mg Ferrous fumarate
T_7	Rice flakes Coated with Jaggery sauce+120 mg Ferrous fumarate
T_8	Rice flakes Coated with Jaggery sauce+160 Ferrous fumarate
T_9	Rice flakes Coated with Jaggery sauce+80 mg Ferrous fumarate
T_{10}	Rice flakes Coated with Jaggery sauce+120 mg Ferrous fumarate
T_{11}	Rice flakes Coated with Jaggery sauce+160 mg Ferrous fumarate

Table 1: Fortified and unfortified samples.

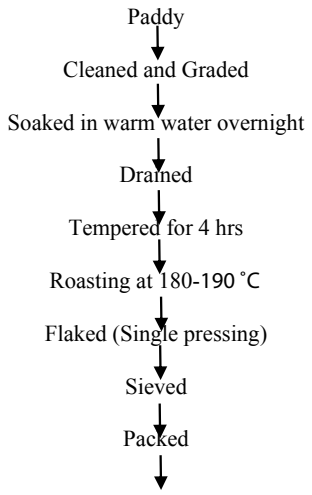

Figure 1: Process Flowchart for flaking.

Result and Discussion

Physical properties of rice and rice flakes

Bulk density of expanded rice products was calculated. Sedimentation test for pre-gelatinized products was carried out as per Bhattacharya and Ali [11]. The initial moisture content of raw rice used was 12%. The physical characteristics of flaked rice are given in Table 3.

Water absorption capacity, sedimentation volume, pasting properties of flaked rice was examined compared to raw rice. There was an increase in hydration capacity that is water absorption capacity, sedimentation volume as a result of gelatinization of starch. Flaking caused the damage of starch by application of mechanical force.

Pasting characteristics of rice and rice flakes

Pasting characteristics of rice and rice flakes observed in the Rapid Visco Analyzer. The RVA is a rotational viscometer that incorporates variable heating, cooling and shear capabilities. Figure 2 shows pasting curves of raw rice and rice flakes. The pasting properties of flour samples, including peak viscosity, trough, breakdown, final viscosities, setback time, are reported in Table 4.

Peak viscosity indicates the water holding capacity of the starch or mixture. There was higher peak viscosity (57.83 cP) for flaked raw rice flour as compared to rice flakes flour (54.83 cP). From the results obtained in this study, it can be concluded that there is an influence of flaking in pasting properties. It may be due to compression of grain and changes in starch.

Proximate composition of raw rice and flaked rice

Proximate composition of raw rice and flaked rice and flaked rice is given in Table 5. Paddy of moisture content of 12% (w.b) was used for flaking. Moisture content (w.b) of paddy was 22.4%, 14.4%, and 11.5% after soaking, roasting and flaking respectively. The starch of rice flour was partially hydrolyzed during processing. So there was increase in reducing sugar. Ash content of raw rice and flaked rice was 0.89% and 0.81% respectively. Increase in ash content may be due to use of iron roller flaker.

Composition I		
Sr no.	**Ingredients**	**Quantity(gm)**
1	Sugar	250
2	Water	300
3	Cocoa powder	50
4	Shortening	50
5	Skimmed milk powder	30

Table 2: Chocolate sauce with sugar.

Sr. No	Physical Properties	Flaked rice
1	Thousand flakes (g)	37.2 ± 0.28
2	Thickness of flakes (mm)	0.71 ± 0.01
3	Size of flakes (mm)	6.12 ± 0.05
4	Water Absorption capacity (ml)	4.52 ± 0.03
5	Sedimentation volume (ml)	16.1 ± 0.09
6	Bulk Density (g)	1.82 ± 0.01
7	Expansion Ratio	3.04 ± 0.01
8	Water activity (a_w)	0.09 ± 0.02
Values expressed as mean ± SD		

Table 3: Physical characteristics of rice flakes.

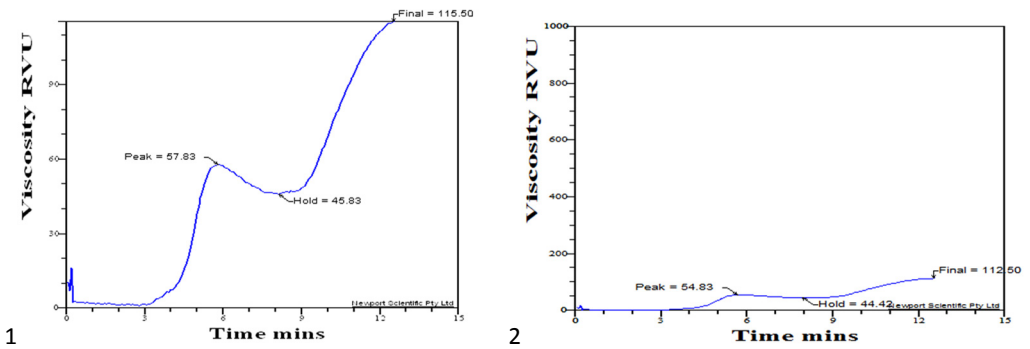

Figure 2: RVA graph raw rice flour (1) and rice flakes flour (2).

Sample Name	Wt.of flour (g)	Wt.of water (g)	Total weight (g)	Peak 1	trough 1	Breakdown	Final Viscosity (cP)	Set-back	peak Time (min.)
Raw Rice flour	2.560	25.940	28.5	4.83	44.42	10.42	115.5	57.83	5.67
Rice flakes	2.562	25.938	28.5	7.83	45.83	12.00	112.5	54.83	5.82

Table 4: Pasting characteristics of rice and rice flakes flour.

S. No	Components (%)	Raw rice	Rice flakes (T_1)
1	Moisture (w.b)	12.41 ± 0.10	11.14 ± 0.21
2	Protein	7.82 ± 0.05	7.61 ± 0.11
3	Fat	2.28 ± 0.01	2.26 ± 0.12
4	Ash	0.89 ± 0.04	0.71 ± 0.11
5	Crude fiber	6.85 ± 0.01	6.67 ± 0.02
6	Carbohydrate	75.21 ± 0.43	74.12 ± 0.52
7	Reducing sugar	1.09 ± 0.01	2.01 ± 0.08
8	Starch	73.64 ± 0.38	74.24 ± 0.87
Values expressed as mean ± SD.			

Table 5: Proximate composition of raw rice and flaked rice.

Sr. No	Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (g/100g)	Carbohydrate (g/100g)
1	T_1	11.41 ± 0.14	0.73 ± 0.01	2.11 ± 0.02	6.71 ± 0.13	6.45 ± 0.42
2	T_2	12.26 ± 0.19	0.81 ± 0.01	7.23 ± 0.01	6.14 ± 0.34	77.23 ± 0.14
3	T_3	12.65 ± 0.12	0.84 ± 0.02	7.15 ± 0.04	6.52 ± 0.02	77.12 ± 0.19
4	T_4	12.31 ± 0.18	0.91 ± 0.01	7.14 ± 0.12	6.49 ± 0.21	77.15 ± 0.34
5	Control S	12.11 ± 0.29	0.82 ± 0.01	7.11 ± 0.25	6.69 ± 0.05	77.54 ± 0.67
6	T_5	12.52 ± 0.24	0.89 ± 0.01	7.12 ± 0.11	6.76 ± 0.15	77.98 ± 0.61
7	T_6	12.12 ± 0.23	0.95 ± 0.01	7.03 ± 0.15	6.66 ± 0.16	76.66 ± 0.73
8	T_7	12.23 ± 0.23	1.27 ± 0.01	7.09 ± 0.03	6.82 ± 0.05	77.39 ± 0.66
9	Control J	12.24 ± 0.25	0.85 ± 0.01	7.11 ± 0.05	6.77 ± 0.25	77.17 ± 0.48
10	T_8	12.14 ± 0.21	0.93 ± 0.02	7.19 ± 0.12	6.75 ± 0.09	77.16 ± 0.44
11	T_9	12.21 ± 0.24	1.04 ± 0.01	7.19 ± 0.16	6.76 ± 0.14	76.13 ± 0.46
12	T_{10}	12.34.2 ± 0.26	1.36 ± 0.01	7.12 ± 0.05	6.78 ± 0.03	77.82 ± 0.45
Values expressed as mean ± SD Control S = Samples coated with chocolate sauce with Sugar. Control J= Samples coated with chocolate sauce with Jaggery.						

Table 6: Proximate analysis of fortified flavoured rice flakes.

Effect of chocolate coating on rice flakes

From the Table 6, results obtained for proximate analysis showed that there was an increase in ash content as the concentration of ferrous fumarate was increased. Protein, fat and carbohydrate content for all the samples were almost same.

Effect of fortification on the iron content of fortified flavoured rice flakes

There was an increase in iron content in fortified rice as the concentration of ferrous fumarate was increased showed in Table 7. The Iron content in jaggery-choco coated rice flakes was more as compared to sugar choco coated rice flakes.

Fe Treatment	Fe Concetration (mg/100 gm)
T_1	0.630
T_2	2.091
T_3	2.117
T_4	2.374
T_5	2.076
T_6	2.237
T_7	2.402
T_8	2.191
T_9	2.219
T_{10}	2.795
Control (S)	1.900
Control (J)	1.983

Table 7: Iron content of fortified flavoured rice flakes.

Fe Treatment	Colour L Value
T_1	60.21 ± 0.23
T_2	26.55 ± 0.29
T_3	26.46 ± 0.13
T_4	27.23 ± 0.39
T_5	27.40 ± 0.40
T_6	26.78 ± 0.25
T^7	26.18 ± 0.24
T_8	25.33 ± 0.13
T_9	26.18 ± 0.62
T_{10}	27.11 ± 0.92
Control (S)	27.15 ± 0.47
Control (J)	26.74 ± 0.82

Table 8: Effect of flavor addition on color of rice flakes.

Effect of flavour addition on colour of rice flakes

It is important that fortificant should not change the colour of the product that may lead to unacceptability of product. It observed that there was no significant colour change in rice flakes Table 8.

Catechin content

Catechin content was estimated in HPLC. The Catechin content of fortified flavoured rice flakes is given in Table 9. Catechin content was increased in flavoured fortified rice flakes due to addition of cocoa powder.

Sensory analysis of fortified flavoured rice flakes.

The sensory score given in Table 10 shows that colour was good for rice flakes coated with jaggery sauce compare to rice flakes coated with sugar chocolate sauce. Colour was increased in jaggery coated rice flakes as the concentration of ferrous fumarate was increased. Overall acceptability was more for jaggery coated rice flakes as compare to sugar chocolate coated rice flakes. Flavor and taste were also good for jaggery choco coated rice flakes compared to sugar choco coated rice flakes. Sensory score was higher for jaggery chocolate coated rice flakes samples T_5, T_6, T_7 than sugar chocolate coated rice flakes (T_8, T_9, T_{10}). Taste of jaggery coated rice flakes was better than sugar coated rice flakes. Iron content was more in T_{10} sample, but the sensory score was low. So we have selected jaggery coated rice flakes as best sample.

Shelf life study of Iron fortified rice flakes

During shelf life study, chocolate coated rice flakes analyzed for free fatty acid content and peroxide value, colour change.

Fe Treatment	Catechin Content (µg)
T_1	Nil
T_2	12.719
T_3	12.717
T_4	12.737
T_5	12.767
T_6	12.637
T^7	12.702
T_8	12.791
T_9	12.719
T_{10}	12.495
Control (S)	12.700
Control (J)	12.783

Table 9: Catechin content of samples.

Treatments	Colour	Flavour	Texture	Taste	Overall Acceptability
Control T_1	6.0 ± 0.2	7.2 ± 0.2	6.8 ± 0.4	7.5 ± 0.8	6.8 ± 0.2
T_2	8.0 ± 0.2	6.2 ± 0.6	7.4 ± 0.3	7.7 ± 0.2	7.8 ± 0.4
T_3	7.0 ± 0.4	7.6 ± 0.7	8.4 ± 0.6	8.4 ± 0.2	7.6 ± 0.3
T_4	6.9 ± 0.9	8.7 ± 0.1	6.7 ± 0.2	8.2 ± 0.4	7.8 ± 0.4
T_5	7.9 ± 0.3	8.1 ± 0.6	7.4 ± 0.8	7.5 ± 0.1	7.6 ± 0.2
T_6	7.4 ± 0.4	7.6 ± 0.4	7.3 ± 0.1	7.6 ± 0.5	7.7 ± 0.1
T_7	6.9 ± 0.1	7.7 ± 0.2	6.7 ± 0.7	7.7 ± 0.2	7.4 ± 0.3
T_8	8.3 ± 0.7	8.2 ± 0.3	8.5 ± 0.5	8.2 ± 0.3	8.3 ± 0.4
T_9	8.2 ± 0.2	9.1 ± 0.5	7.8 ± 0.4	9.0 ± 0.8	8.5 ± 0.1
T_{10}	7.9 ± 0.1	8.4 ± 0.5	7.8 ± 0.3	8.9 ± 0.4	8.2 ± 0.2
Control S	7.2 ± 0.6	6.8 ± 0.6	7.5 ± 0.7	6.3 ± 0.2	7.3 ± 0.1
Control J	7.8 ± 0.2	7.9 ± 0.4	8.4 ± 0.4	7.6 ± 0.8	7.9 ± 0.5

Table 10: Sensory scores obtained for flavoured fortified rice flakes.

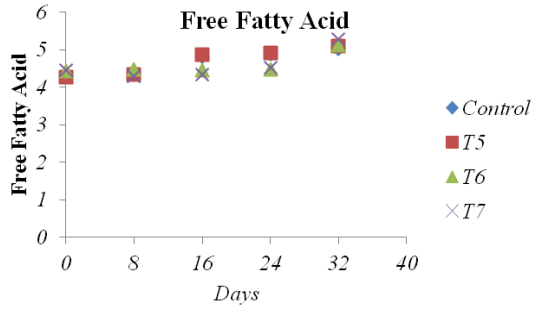

Figure 3: Free Fatty Acid content of sugar chocolate coated rice flakes during storage.

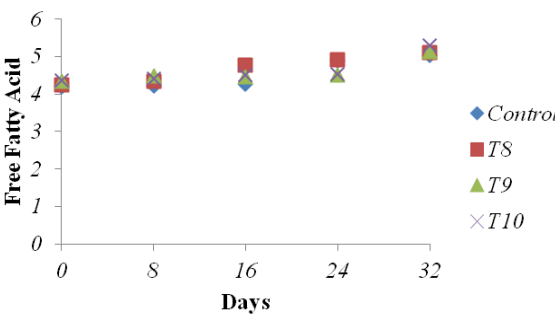

Figure 4: Free Fatty Acid content of jaggery chocolate coated rice flakes during.

Free fatty acid content: Free fatty acid value of jaggery and sugar chocolate coated rice flakes during storage is given in Figures 3 and 4.

An increase in FFA value is observed in all the rice flake samples during storage. The increase was considerably higher in samples, which were fortified with 160 mg of Ferrous fumarate. The result showed that the FFA values of samples was in acceptable range at the end of storage period, as per FSSAI standards.

Peroxide value: The peroxide value in all unfortified and fortified rice flakes was less than 10 mEq per kilogram of fat, the normal cutoff value for the rejection of products [12]. Peroxide values of sugar coated rice fake and jaggery chocolate coated rice fake during storage study is given in Figures 5 and 6 respectively.

Microbial quality of fortified flavoured rice flakes after storage

During one month of storage at room temperature, the iron fortificant did not adversely affect the peroxide value, color, or sensory quality of the chocolate-coated rice flakes as compared with unfortified rice flakes.

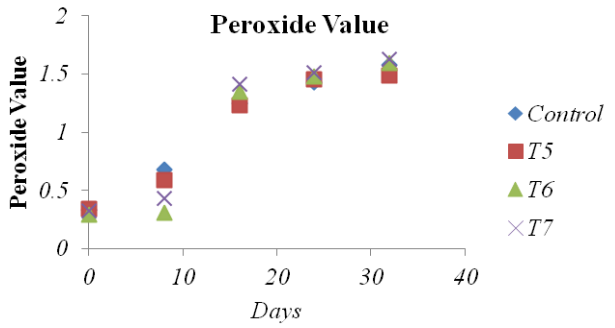

Figure 5: Peroxide value of sugar coated rice fakes during storage.

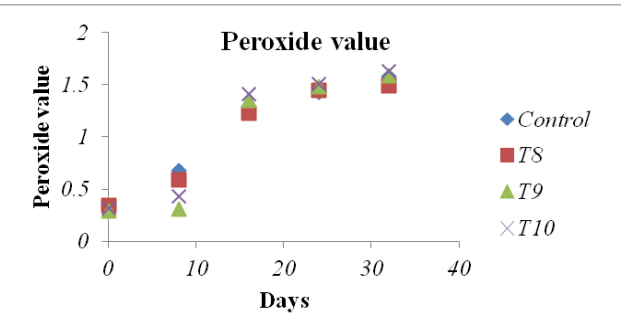

Figure 6: Peroxide value of jiggery chocolate coated rice fakes during storage.

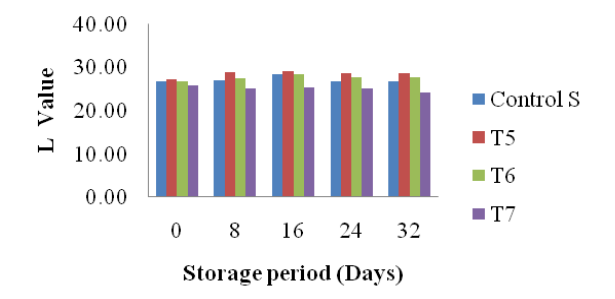

Figure 7: Effect of fortification on L value of color on sugar chocolate-coated rice flakes.

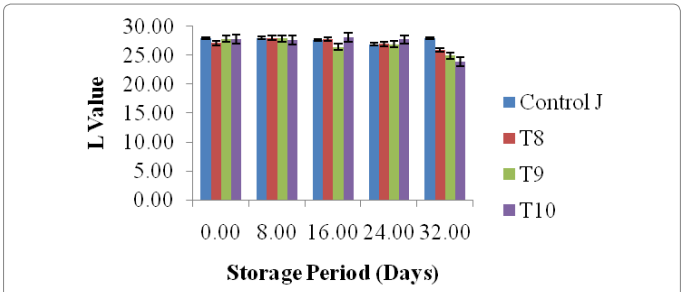

Figure 8: Effect of fortification on L value of color on jaggery chocolate-coated rice flakes.

Effect of fortification on the colour of fortified flavoured rice flakes

Figures 7 and 8 showed the changes in colour of fortified rice flakes. Due presence of natural antioxidant catechin present in cocoa powder, there were minimal changes in colour value during storage. It is known that oxidation of iron happen in the presence of oxygen with increased in storage time and eventually downgraded the quality of food.

Conclusion

An iron content result indicates that treatments were significantly different. Chocolate-coated rice flakes were having high nutritional value. Catechins were present in high amount in coated flakes with chocolate. Catechins are natural phenols and antioxidants. Health benefits of Catechin is that eliminates the free radicals preventing cancer development by blocking the growth of substance that causes cancer. It connects with cholesterols, absorbs and block it and it is effective for high blood pressure.

The results regarding free fatty acid (FFA) and peroxide value of rice flakes coated with chocolate sauce with sugar and jaggery during storage study suggest that there is slightly increased in FFA and PV. As par FSSAI standards the FFA and PV values of food products, containing fat and oils, should not exceed 1.5% and 10 meqO_2/kg respectively. The values obtained for FFA and PV were in acceptable range during five weeks of storage. Color was slightly decreased as compared to unfortified chocolate flavoured flakes. After storage period, the result of sensory score indicates that there was no change in flavour, aroma, and overall acceptability. During one month of storage of chocolate-coated rice flakes at room temperature, the iron fortificants did not adversely affect the peroxide value, color, or sensory quality of the chocolate-coated rice flakes as compared with unfortified rice flakes. Due to presence of antioxidant catechin there was minimal changes in colour, FFA and PV.

There is ample scope for further improvement in this work. Fortification of rice flakes can be useful in combating iron deficiency. Fortification study can be done in other staple crops to to combat micronutrient deficiency. In a future bioavailability study of fortified rice flakes can be done [13].

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