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# Effect of Red Kidney Bean (*Phaseolus vulgaris* L.) Flour on Bread Quality

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## Abstract

**Legumes are important sources of food proteins and provide well-balanced essential amino acid profiles when consumed with cereals and other foods. Apart from their nutritional properties, legume proteins also possess functional properties that play an important role in food formulation and processing. The objective of this work was to study the effects of red kidney bean (*Phaseolus vulgaris* L.) flour (RKF) substitution at 5%, 10%, and 25% levels on nutritional, sensory, and textural characteristics of yeast leavened bread. Optimized level of substitution of RKF in refined wheat flour in the recipe was fixed at 15% based on preliminary studies. The bread with 15% RKF exhibited acceptable organoleptic characteristics and textural attributes. The addition of RKF showed higher nutritional and mineral composition in regard to plain white bread (control). The results further indicate a requirement for optimization of processing conditions to maximize bread quality attributes for better commercial acceptance.**

## Keywords

**Red Kidney Bean, Bread, Sensory Characteristics, Textural Properties**

## 1. Introduction

Bakery foods are the chief cereal products available to consumers and bread has been the principal food around the world [1]. Hence an increased consumer demand is experienced for nutritious, bread has led to considerable efforts to develop breads that provide health benefits with good organoleptic properties.

Kidney beans are good sources of important nutrients with 22.7% protein, 3.5% mineral matter, 1% fat, 5.1% crude fiber, and 57.7% total carbohydrates [2]. Red kidney beans have low sodium content and saturated fatty

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acids but are rich in unsaturated fatty acids (linoleic acid) [3]. They are also a good source of soluble and insoluble dietary fiber and display health benefits, which include reduced risk of heart disease and colon cancer [4]. However, red kidney beans' nutraceutical value is yet to gain popularity in the prevention of chronic diseases [5]. The effect of adding flours from different legume cultivars on some physical and nutritional properties of wheat based products has been studied earlier [6]. The functional properties of legume proteins such as chick pea flour (*Cicer arietinum* L.), pea protein isolate (*Pisum sativum* L.), and carob germ flour (*Ceratonia siliqua* L.) have been used in the preparation and development of bakery products, soups, extruded products and ready-to-eat snacks [7]-[9]. Thus, with this background information, this research project has been undertaken with following main objectives to optimize the feasibility of incorporation of RKF to the plain white bread, to, evaluate the nutritive value and overall acceptance of the developed bread and to investigate the textural and color parameters of the developed bread.

## 2. Materials and Methods

Refined wheat flour, red kidney beans (dried), salt, sugar, active dry yeast, oil were brought at the local market and special concern was given to adhere to the same brand names throughout the work.

### 2.1. Preparation of Blends

To prepare red kidney bean flour (RKF), the seeds were washed, cleaned and dried in hot air oven at 50˚C for 12 hours. The dried seeds were then finely ground, sieved and stored at 4˚C in air tight containers. The prepared flour, *i.e.*, RKF was then combined with refined wheat flour at 5%, 15%, and 25% levels and the quality of prepared bread was studied.

### 2.2. Yeast Leavened Bread Making Characteristics

Breads with different formulations were prepared by straight dough method of bread preparation [10]. The ingredients were added based on a % flour weight. After baking at 175˚C, the bread loaves were kept for cooling for 2 hours on a cooling rack. The cooled bread loaf was then weighed to obtain total loaf weight and was then taken up for volume calculation by rapeseed displacement method [11] before slicing. The specific volume was calculated by dividing loaf volume by loaf weight.

### 2.3. Proximate Composition Analysis

The RKF substituted bread was analyzed for moisture (method 44 - 16), protein (method 46 - 10), ash (method 08 - 01) and fat (method 30 - 10) using the American Association of Cereal Chemists [10] methods. Dietary fiber (method 991.43) was determined according to AOAC (1999) method [12]. All estimations were done in triplicate.

### 2.4. Color and Texture Studies

The color parameters of breads were measured using a Hunter Lab color flex model A60-1012-312 (Hunter Associates laboratory, Reston, VA). The equipment was standardized each time with white and black standards. Samples were scanned to determine lightness (L*), red-green (a*) and yellow-blue (b*) color components.

The Texture Profile Analysis test consists of compressing a 1 cm thickness bread slice two times in a reciprocating motion that imitates the action of the jaw. The texture of each slice of bread was analyzed using P/75mm compression platen in Texture Analyzer (Stable Micro Systems, Surrey, UK). All estimations were done in triplicate.

### 2.5. Optimization of Substitution Level of RKF in Bread

For deciding the best amount of substitution of refined wheat flour with RKF, sensory evaluation of the products was conducted based on overall external appearance, color, texture, flavor, taste and overall acceptability. Bread samples on a white plate labeled with one alphabet codes were presented to the observers, six panelists, were asked to evaluate the above attributes of the samples and to rate each attributes on a scale from 1 (dislike extremely) to 9 (like extremely) using a 9 point hedonic scale [13].

## 3. Results and Discussion

### 3.1. Influence of Incorporated RKF on the Physical and Sensory Properties of the Breads

There was a drop in the physical characteristics values with the increase in level of RKF substitution. This may be explained by the reduction of gluten content in the blends which hinders the formation of the perfect bread porous structure. The presence of coarser particles alleviates the weight of loaf but decreases the volume of the loaf. Hence, the specific volume also shows decreasing values. In bakery products, an ideal relation between dough weight and loaf volume yields the most desirable texture and grain [14] [15]. That is, specific loaf volume should not be touching extremes as it affects the crumb structure. Too small specific volume is associated with a very compact and closed grain structure, while too large loaf volume is associated with a very open grain and porous structure [16]. Moreover, Filipčev *et al.*, 2010 found that the type of ingredient added to bread did not significantly affect the specific volume but the supplementation level did [17]. It appears, therefore, that the decrease in bread volume resulting from RKF addition is most likely due to the mixed effects of gluten dilution and mechanical disruption of the gluten network structure by the RKF particles.

With increase in RKF incorporation from 0% to 25% legume taste increased for which there is a decrease in the taste results, there was a drop in chewiness and residue formation in the mouth was gained proving the decreasing score for mouthfeel (**Table 1**). These data also indicated that the texture decreases as we increase the level of substitution of RKF in bread, which possessed slightly darker color from that of control bread which may be due to the presence of red kidney bean seed coat in the flour prepared. According to the overall acceptability score 15% of RKF inclusion in bread could be accepted and further increase in RKF level would not give better consumer acceptance. The flavor of the bread was hampered which can be accounted to the strong characteristic flavor of legumes. A restricted use of dry bean flour has been shown to be acceptable in corn tortillas [18]. "Beany" flavor is one of the factors that terminate consumption of dry beans. Incorporation to a level as equal to 15% was determined to have acceptable score and could be thought of providing maximum nutrition with better organoleptic attributes scoring. Hence the level of incorporation of RKF in bread making was optimized at 15% level as compared to remaining two levels (5% & 25%) and it may be assumed that more than this level would provide better nutrition though the consumer acceptance scoring would be hindered.

### 3.2. Influence of Incorporated RKF on the Nutritional Composition of the Breads

The data (**Table 2**) shows that the RKF blends bread are more nutritious than the refined wheat flour bread. The proximate composition was shown to vary with increase in the level of inclusion of RKF in preparation of bread. An increase in moisture level was observed which accounts to the increased water activity of the RKF. A considerable increase in protein content as well as carbohydrates was also reported which could be accounted due to the presence of legume protein (red kidney bean flour protein content 19.13 ± 1.25) and carbohydrate present in red kidney bean flour. The addition of bean flour to wheat flour was expected to increase the protein content of the bread, since legumes generally contain more proteins than cereals [19]. From the data it was observed that the dietary fiber increased with increasing levels of incorporation of RKF. Dodevska *et al.*, 2013 showed that the best food items for increasing total fibre, cellulose and resistant starch intake are cooked peas and kidney beans [20].

**Table 1.** Showing the sensory evaluation* & physical parameters** results for optimization of the red kidney bean flour incorporation level in bread making.

| Sl.no. | Details | Appearance | Texture | Color | Flavor | Taste | Mouth Feel | Overall Acceptability | Weight g | Vol.[a] $cm^3$ | Sp.vol.[b] ($cm^3$/g) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5% | 7.72 | 7.93 | 7.35 | 7.28 | 7.80 | 7.55 | 7.78 | 240.00 | 570 | 2.38 |
| 2 | 15% | 7.25 | 7.50 | 7.00 | 7.33 | 7.17 | 7.53 | 7.57 | 255.36 | 435 | 1.70 |
| 3 | 25% | 5.42 | 5.17 | 5.58 | 5.67 | 5.42 | 5.00 | 5.33 | 245.12 | 400 | 1.63 |
| 4 | Control | 7.90 | 7.94 | 7.56 | 7.24 | 8.00 | 8.50 | 8.00 | 171.43 | 420 | 2.45 |

*The sensory results are mean values of 6 panelists' responses; **The physical parameter results are the mean values of three replicates; [a]Volume; [b]Specific Volume.

**Table 2.** Proximate analysis results of the red kidney bean flour, control, 5%, 15%, 25% breads.

| Sl.no. | Proximate Composition | Red Kidney Bean Flour[a] (Raw) | Bread | | | |
|---|---|---|---|---|---|---|
| | | | Control | 5% | 15% | 25% |
| 1 | Ash (g/100g) | 3.50 ± 0.00 | 0.64 ± 0.019 | 1.30 ± 0.21 | 1.40 ± 0.00 | 1.60 ± 0.00 |
| 2 | Moisture (%) | 7.26 ± 0.57 | 29.16 ± 0.64 | 31.70 ± 0.10 | 33.8 ± 0.09 | 33.30 ± 0.01 |
| 3 | Fat (%) | 1.26 ± 0.18 | 2.20 ± 0.17 | 2.30 ± 0.03 | 2.80 ± 0.50 | 3.36 ± 0.17 |
| 4 | Protein (g/100g) | 19.13 ± 1.25 | 8.06 ± 0.10 | 15.42 ± 0.08 | 16.3 ± 0.10 | 18.08 ± 0.18 |
| 5 | Carbohydrate (g/100g) | 58.33 ± 0.09 | 51.0 ± 0.8 | 56.33 ± 0.17 | 64.33 ± 0.24 | 66.67 ± 0.05 |
| 6 | Dietary Fiber (%) | 1.33 ± 1.41 | 2.13 ± 0.00 | 2.25 ± 0.00 | 2.28 ± 0.02 | 2.33 ± 0.14 |

[*]All the readings were repeated 3 times and the data are in their mean values ± standard deviation; [a]The proximate composition of prepared raw red kidney bean flour.

## 3.3. Influence of Incorporated RKF on the Textural Properties of the Breads

Hardness is generally used as a sign of bread quality and its alteration is frequently followed by the loss of resilience during storage [21]. Hardness of bread is indicated by the maximum force needed to compress the bread and usually represented by the first peak in the TPA graph (not shown). The variation in the hardness results is due to the variation in the substitution of the different level of RKF. Higher the force shows that harder is the bread. As per results (**Table 3**) 25% RKF bread is harder than other substituted level bread and this may be the reason to account for low score of sensory test for 25% RKF bread. The increase in hardness might be due to the result of loss of moisture [22]. The starch retrogradation and moisture distribution during staling might be another reason considered for the hardness increase [23].

Springiness represents the elasticity by determining the extent of recovery between the first and second compression and is a dimensionless ratio. The springiness of bread depends on the amount of the refined wheat flour because the soft spongy texture displayed in the leavened breads made out of refined wheat flour is due to presence of insoluble glutenins & surface active protein (globulin) [24]. In the current study (**Table 3**) the springiness was found to be constant at 0.9900 showing that RKF powder incorporation showed no or negligible effect on springiness of the bread.

Lower resilience value determines that bread can recuperate quickly from deformation hence proving the firmness of the product. The data (**Table 3**) revealed that 15% RKF bread is more firm with a resilience value lower as compared to other incorporation level, but when compared to control shows decrease in firmness.

Generally if the gumminess will be higher, the product is sticky. The gumminess may be attributed to the gelatinization degree of wheat gluten structure in the cooked samples. Minimum gumminess can be considered for optimization of the product as bread is adhesive in nature. In the present study, since the dough consisted of granular particles with constant cooking time, the gumminess must be due to the ratio of wheat flour to RKF powder and the quality of the RKF powder. Minimum gumminess was obtained for control bread followed by 5% RKF bread. Minimum gumminess was obtained for RKF bread which may be accounted by the effect of water absorption capacity, variations in flour particles size, and chemical compositions [25].

## 3.4. Influence of Incorporated RKF on the Color Values of the Breads

The colour of bread is associated with physico-chemical characteristics of the raw dough and chemical reactions that take place during baking which are dependent on operating conditions, such as Maillard reactions and caramelization which cause browning of baked products during baking [26]. The color of the bread showed difference depending on the replacement of refined wheat flour with 5%, 15%, and 25% red kidney bean flour. The L*, a*, b* values are shown in **Table 4**. The L* value which correspond to lightness decreased gradually with increase in incorporation level of red kidney bean flour. The positive values of b* indicates yellowness in the bread, which may be due to the use of refined wheat flour portion but the b* value gradually decreased for red kidney bean flour bread which can be described as because of the red hue of the red kidney bean seed coat. The chroma values are closer to the b* values for all the samples. Singh *et al.*, 2012 reported in their study that the

**Table 3.** The results of texture profile analysis.

| Sl.no. | Sample | Hardness | Springiness | Resilience | Gumminess | Chewiness | Cohesiveness |
|---|---|---|---|---|---|---|---|
| 1 | Control | 5211.9 | 0.99 | 0.23 | 3276.15 | 3674.37 | 0.58 |
| 2 | 5% | 6801.8 | 0.99 | 0.4 | 5282.3 | 5282.3 | 0.8 |
| 3 | 15% | 8681.0 | 0.99 | 0.34 | 7142.2 | 7070.7 | 0.82 |
| 4 | 25% | 10051.5 | 0.99 | 0.37 | 7837.3 | 7829.4 | 0.77 |

*All the readings were repeated 3 times and the data are in their mean values.

**Table 4.** Results of color estimation by color flex for the developed products.

| Sl.no | Details | L* | a* | b* | dE | Chroma |
|---|---|---|---|---|---|---|
| 1 | Control | 75.24 | 0.72 | 19.60 | - | 20.36 |
| 2 | 5% | 62.42 | 4.67 | 19.96 | 13.4 | 24.60 |
| 3 | 15% | 62.67 | 4.56 | 19.01 | 13.2 | 23.60 |
| 4 | 25% | 63.13 | 4.54 | 19.15 | 12.7 | 23.70 |

All the readings were repeated 3 times and the data are in their mean values.

color of bread crumb was dark due to the presence of finger-millet in composite flour with barnyard-millet, finger-millet, proso-millet and wheat flours [27]. Hence it can be concluded from the results that red kidney bean flour contributes much to color values of the product.

## 4. Conclusion

Addition of increasing amount of RKF to the refined wheat flour decreased the texture and firmness of the bread as well as overall acceptability score. The level of 15% inclusion for RKF was optimized and the developed product exhibited better in terms of sensory score and texture. The RKF flour incorporation contributed much to the color values by producing darker breads. The developed breads had improved nutritional characteristics, hence this study shows the possibility of utilization of legumes to increase the nutritional quality of bread.

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