Physicochemical and Functional Properties of Flours Prepared from Common Beans and Green Mung Beans

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The proximate composition, amino acid profiles, and functional properties of flours prepared from common bean varieties and green mung beans were studied. There were significant differences in proximate composition of the various flours. The amino acid contents of common bean flours were comparatively lower than those of green mung bean flours. The sample flours contained 1.02–1.40% potassium, 0.40–0.91% phosphorus, 0.49–0.65% calcium, and 0.013–0.039% sodium. The wettability value was significantly higher with flour prepared from white common bean variety than with the other sample varieties. Common bean flours showed significantly better water and oil absorption capacity than green mung bean flour. Nitrogen solubility was pH dependent, with a minimum at pH 4.0 and a maximum at pH 12.0. The flour prepared from green mung beans had the highest bulk density and emulsion capacity. Compared to the other samples, the emulsion prepared from white common bean flour was more stable and did not separate into aqueous phase within 2 h after the preparation.

Keywords: *Common beans; green mung beans; flours; composition; functional properties*

INTRODUCTION

Common bean (*Phaseolus vulgaris*) is a tropical food legume in Central Africa and other tropical areas. It is usually interplanted with cereals as mixed crops. Due to the high price of meat and fish, much importance is now placed on beans as a source of proteins.

A review of literature reveals limited information on the physicochemical and functional properties of common beans. Hang et al. (1970) reported that nitrogen solubility of mung bean, pea bean, and kidney bean was pH dependent. Mean proximate composition of California small white bean was 9.65% moisture, 25.90% crude protein, 0.25% crude fat, 0.20% reducing sugars, and 57.80% starch (Sathe et al., 1981). Phirke et al. (1982) found that soaking dry beans for 12 h reduced cooking time by about 60% and that dehulling seeds decreased polyphenol content by 60–70% and increased protein content by 10%. Common bean types grown and consumed in Kenya were high in phosphorus, magnesium, and calcium but low in iron (Ochetin et al., 1985). Compared to adzuki beans (*Vigna angularis*), common beans contained more ash, free lipid, and insoluble and soluble dietary fiber. Dry seeds of common beans required longer cooking time than those of adzuki beans (Hsieh et al., 1992).

In the present study, physicochemical and functional properties of flours prepared from three varieties of common beans and green mung beans (*Phaseolus aureus*) were investigated.

MATERIALS AND METHODS

Flour Preparation. Three varieties (red, black, and white) of common bean seeds were purchased from a local market (Ngaoundere, Cameroun). Green mung bean seeds were purchased from a supermarket (Nancy, France). To facilitate hand dehulling, all seeds were soaked in water overnight and the seed coats hand peeled from the cotyledons. The dehulled beans were oven-dried at 40 °C for 6 days and subsequently milled in a Fitzpatrick mill, Model JT (Fitzpatrick Co., Elmhurst, IL) to pass through a 100 mesh screen.

Chemical Composition. Proximate composition of the various flours was determined according to AOAC standard procedures (AOAC, 1990). Crude protein was expressed as % N × 6.25. Samples for mineral analysis were prepared according to AOAC (1990) procedures, and the minerals (except phosphorus) were assayed spectroscopically using an atomic absorption spectrophotometer (Model 1100, Perkin-Elmer, Norwalk, CT). Phophorus was determined following the colorimetric molybdenum (Mo)-blue method (AOAC, 1990). Amino acid compositions of samples (except tryptophan) were determined according to the method of Moore (1963) and Moore and Stein (1963), using an LC3000 Biotronik Eppendorf amino acid analyzer equipped with a Meck D2000 integrater. Single assays on single sample hydrolysate were made. Tryptophan was not determined. Amino acid concentrations were calculated on the basis of grams of amino acid per 16 g of nitrogen.

Physical and Functional Properties. *Nitrogen Solubility.* The method described by Narayana and Narasinga Rao (1982) was used to determine the protein solubility. Nitrogen solubility (percent) was calculated as (water soluble nitrogen × 100)/total nitrogen in the sample.

pH. The pH was measured by making a 10% (w/v) flour suspension of each sample in distilled water. Each sample was then mixed thoroughly in a Waring microblender, and the pH was recorded with a Tacussel electronic pH meter (Model PHN-850, Villeur-Banne, France).

Bulk Density. Bulk density was determined according to the method described by Narayana and Narasinga Rao (1984). Bulk density was calculated as weight of sample per unit volume of sample.

Wettability, Emulsion Capacity, Oil and Water Absorption, and Foam Stability. Wettability, emulsion capacity, oil and water absorption, foam stability determinations were carried out following the methods described by Okezi and Bello (1988).

Emulsion capacity is expressed as the amount of oil emulsified and held per gram of flour. Water or oil absorption is expressed as grams of water or oil absorbed per gram of flour. Volumetric changes in the foam, oil, and aqueous layer were recorded after 0.5, 2, 4, and 6 h. Foam volume changes in the cylinder were recorded at intervals of 2, 10, 30, 60, and 90 min.

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Table 1. Proximate Composition of Flours Prepared from Common Bean Varieties and Green Mung Beans[a]

composition	RCB[b]	BCB[b]	WCB[b]	GMB[b]
moisture (%)	5.1 ± 0.3[a]	4.7 ± 0.2[b]	5.2 ± 0.4[a]	4.1 ± 0.2[b]
fat (%)	1.0 ± 0.2[c]	2.2 ± 0.1[a]	1.9 ± 0.1[b]	0.9 ± 0.2[c]
protein (%)	23.2 ± 0.9[b]	21.2 ± 0.8[c]	22.8 ± 0.5[b]	24.9 ± 0.9[a]
ash (‰)	3.9 ± 0.1[a]	2.1 ± 0.2[c]	3.8 ± 0.2[a]	2.8 ± 0.1[b]
carbohydrate by calculation	66.8 ± 1.2[bc]	69.7 ± 1.2[a]	66.1 ± 1.4[c]	67.1 ± 1.3[b]

[a] Values are means of triplicate determinations. Means in the same row with different superscripts are significantly different ($p < 0.05$). [b] RCB, red common bean; BCB, black common bean; WCB, white common bean; GMB, green mung bean.

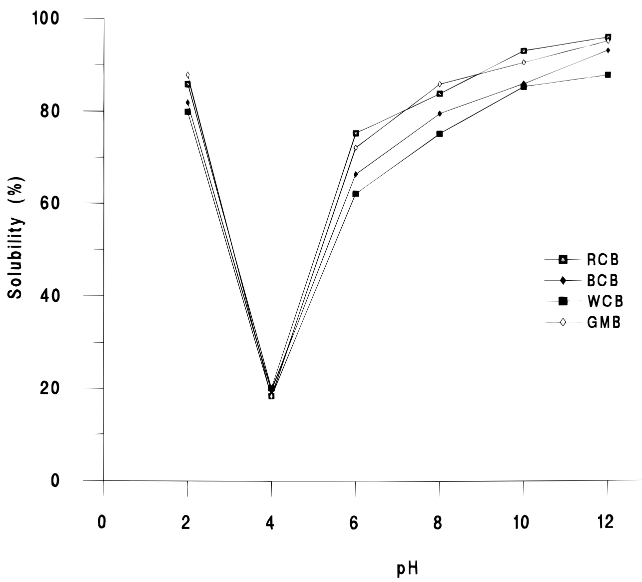

Figure 1. Effect of pH on nitrogen solubility of flour prepared from common bean varieties and green mung beans. See Table 1 for key.

Statistical Analysis. The experiments were performed in triplicate and the means ± standard deviation of three values were reported. Data were subjected to analysis of variance, and Duncan's multiple range test (Steel and Torrie, 1980) was used to determine the significant differences among means.

RESULTS AND DISCUSSION

The proximate composition of flours prepared from common bean varieties and green mung bean (Table 1) showed significant differences ($p < 0.05$) among types of beans. Black common bean variety had the highest fat content (2.1%), highest carbohydrate content (69.7%), and lowest protein content (21.2%). The protein contents of the flours varied from 21.2 to 24.9%, indicating that common bean flours or green mung bean flour could be a valuable protein supplement in food products, such as an extender in meat products.

Nitrogen solubility was pH dependent, and the main difference was in solubility of nitrogen at pH 2 and 6 (Figure 1). The minimum nitrogen solubility at pH 4.0 ranged from 18 to 20% for the four flours. Winged bean flour had a minimum nitrogen solubility of 23% at pH 4.5 (Narayana and Narasinga Rao, 1982); cowpea powder had a minimum nitrogen solubility of 19.36% at pH 4.0 (Okaka and Potter, 1979). Maximum nitrogen solubilities of 88, 93, 95, and 96% were recorded for white and black common beans, green bean, and red common bean, respectively.

The amino acid profiles (Table 2) of flours prepared from red, black, and white common beans were similar. However, black common beans contained about 2 times more tyrosine, lysine, and proline than red and black common beans, respectively. The green mung bean flour showed a superiority in amino acid content over common bean flours.

Table 2. Amino Acid Profiles of Flours Prepared from Common Bean Varieties and Green Mung Beans

	g of amino acid/16 g of N in			
amino acid	RCB	BCB	WCB	GMB
essentials				
isoleucine	2.69	3.36	2.19	4.63
leucine	5.13	5.65	3.78	8.68
lysine	2.04	5.32	2.71	4.11
methionine	0.62	0.90	0.55	1.06
cysteic acid	1.04	1.20	1.15	1.45
phenylalanine	3.10	3.99	2.60	6.15
tyrosine	1.98	3.02	1.56	3.43
threonine	2.91	3.10	2.12	3.13
valine	3.13	3.42	2.46	5.54
nonessentials				
alanine	2.37	3.03	2.19	4.45
arginine	3.41	3.29	3.95	5.92
aspartic acid	7.31	8.40	6.00	15.06
glutamic acid	9.05	9.24	7.75	19.94
glycine	2.94	3.21	2.23	3.51
histidine	2.13	3.26	2.21	3.51
proline	3.29	7.26	2.29	5.62
serine	3.71	4.74	2.67	5.84

Table 3 indicates the mineral composition of various bean flours. The flour contained high levels of potassium (1.02−1.40%), phosphorus (0.40−0.91%), and calcium (0.49−0.65%). Sodium, zinc, copper, and manganese were present at low levels of 0.013−0.039%, 26−39 ppm, 15−22 ppm, and 13−22 ppm, respectively. Common bean types grown in Kenya were high in phosphorus, magnesium, and calcium but low in iron (Ochetim et al., 1985).

Values of pH, bulk density, wettability, emulsion capacity, and water and oil absorption are presented in Table 4. The pH values of the flours in water suspension are important since some functional properties such as solubility and emulsion properties are highly affected by pH changes (McWatters and Cherry, 1977). There was a significant difference ($p < 0.05$) in the pH of the different flours, with the flour of black common bean having the lowest pH. The flour prepared from green mung bean had the highest bulk density and emulsion capacity. There were no significant differences in bulk density among flours made from common bean varieties. The high bulk density of the flour prepared from the green mung beans is important with regard to its packaging, while its high emulsion capacity makes it a potential useful ingredient in preparing meat analogs. The time required to reach complete wetness was 2-fold longer for flour of white bean than for red common bean flour. Okezi and Bello (1988) reported a wettability value of 7.67 min for winged bean flour.

Water and oil absorption capacities of flours prepared from common bean varieties were significantly higher than those of green mung bean. Water and oil absorption capacities of the raw cowpea flours were 2.4 and 2.9 g/g, respectively (Abbey and Ibeh, 1988). Our results compared favorably with the findings of these investigators and suggest that flours prepared from common beans could be used as ingredients in the preparation of comminuted products such as sausages. Wolf (1970) showed that these properties enabled bakers to add more water to doughs so as to improve handling characteristics and maintain freshness in the bread.

The flour of white common bean was superior to the other flours in emulsion stability (Table 5). The emul-

Table 3. Mineral Composition of Flours Prepared from Common Bean Varieties and Green Mung Beans[a]

	%					ppm			
	P	K	Mg	Na	Ca	Fe	Zn	Cu	Mn
RCB	0.54 ± 0.05[b]	1.40 ± 0.10[a]	0.29 ± 0.06[a]	0.039 ± 0.009[a]	0.50 ± 0.06[b]	84 ± 10[b]	39 ± 5[a]	22 ± 3[a]	20 ± 3[a]
BCB	0.40 ± 0.05[c]	1.02 ± 0.07[b]	0.16 ± 0.03[b]	0.027 ± 0.006[b]	0.49 ± 0.05[b]	102 ± 12[a]	26 ± 2[a]	22 ± 4[a]	22 ± 4[a]
WCB	0.91 ± 0.03[a]	1.05 ± 0.06[b]	0.23 ± 0.05[a]	0.013 ± 0.004[c]	0.59 ± 0.07[a]	94 ± 9[ab]	38 ± 4[a]	21 ± 2[a]	19 ± 3[a]
GMB	0.59 ± 0.04[b]	1.10 ± 0.08[b]	0.21 ± 0.02[a]	0.018 ± 0.005[c]	0.65 ± 0.05[a]	64 ± 8[c]	28 ± 4[a]	15 ± 3[b]	13 ± 2[b]

[a] Values are means of triplicate determinations. Means in the same column with different superscripts are significantly different ($p < 0.05$).

Table 4. Physicofunctional Properties of Flours Prepared from Common Bean Varieties and Green Mung Beans[a]

	RCB	BCB	WCB	GMB
pH	6.2 ± 0.1[a]	5.9 ± 0.1[b]	6.2 ± 0.1[a]	6.2 ± 0.1[a]
bulk density (w/v)	0.5 ± 0.1[b]	0.5 ± 0.1[b]	0.5 ± 0.1[b]	0.6 ± 0.1[a]
wettability (min)	21.3 ± 1.2[c]	24.7 ± 1.3[b]	44.3 ± 1.3[a]	25.3 ± 1.1[b]
emulsion capacity (mL of oil/g of flour)	19.8 ± 1.2[b]	14.5 ± 1.3[c]	15.5 ± 1.2[c]	21.7 ± 1.3[a]
oil absorption (g of oil/g of flour)	2.2 ± 0.2[a]	2.1 ± 0.1[a]	2.1 ± 0.1[a]	1.9 ± 0.1[b]
water absorption (g of water/g of flour)	3.0 ± 0.4[a]	2.9 ± 0.4[a]	2.9 ± 0.1[a]	2.1 ± 0.2[b]

[a] Values are means of triplicate determinations. Means in the same row with different superscripts are significantly different ($p < 0.05$).

Table 5. Emulsion Stability of Flours Prepared from Common Bean Varieties and Green Mung Beans[a]

		emulsion stability (mL)			
parameter	time (h)	RCB	BCB	WCB	GMB
foam	0.5	2.5 ± 0.2[b]	2.7 ± 0.3[b]	2.7 ± 0.3[b]	3.4 ± 0.3[a]
	2.0	2.5 ± 0.2[b]	2.7 ± 0.2[b]	2.7 ± 0.2[b]	3.4 ± 0.4[a]
	4.0	2.3 ± 0.1[b]	2.1 ± 0.2[b]	2.2 ± 0.1[b]	2.6 ± 0.2[a]
	6.0	2.0 ± 0.1[ab]	1.8 ± 0.2[b]	2.0 ± 0.1[ab]	2.1 ± 0.3[a]
oil	0.5	23.4 ± 0.4[a]	22.5 ± 0.4[b]	22.3 ± 0.3[a]	20.5 ± 0.2[c]
	2.0	21.3 ± 0.3[b]	18.3 ± 0.2[c]	22.3 ± 0.3[a]	17.3 ± 0.3[c]
	4.0	19.5 ± 0.3[b]	17.5 ± 0.3[c]	22.0 ± 0.4[a]	16.2 ± 0.3[c]
	6.0	18.9 ± 0.4[b]	16.8 ± 0.4[c]	21.4 ± 0.2[a]	15.3 ± 0.4[d]
aqueous	0.5	0.0 ± 0.0[b]	0.0 ± 0.0[b]	0.0 ± 0.0[b]	1.9 ± 0.2[a]
	2.0	2.1 ± 0.1[c]	4.2 ± 0.1[b]	0.0 ± 0.0[d]	5.1 ± 0.2[a]
	4.0	3.9 ± 0.2[c]	5.0 ± 0.1[b]	0.3 ± 0.1[d]	6.2 ± 0.2[a]
	6.0	4.5 ± 0.2[c]	5.7 ± 0.2[b]	0.9 ± 0.2[d]	7.1 ± 0.3[a]

[a] Values are means of triplicate determinations. Means in the same row with different superscripts are significantly different ($p < 0.05$).

Table 6. Foam Stability of Flours Prepared from Common Bean Varieties and Green Mung Beans[a]

time	foam stability (mL)			
(min)	RCB	BCB	WCB	GMB
2	17.3 ± 0.9	17.6 ± 0.5	18.3 ± 0.5	18.1 ± 0.8
10	16.0 ± 0.6[b]	16.0 ± 0.7[b]	17.6 ± 0.7[a]	17.5 ± 0.6[a]
30	15.0 ± 0.6[bc]	14.5 ± 0.8[c]	16.6 ± 0.9[a]	15.8 ± 0.4[b]
60	14.6 ± 0.8[a]	11.5 ± 0.9[c]	13.4 ± 0.9[b]	12.0 ± 0.8[c]
90	13.5 ± 0.7[a]	8.7 ± 0.9[c]	10.3 ± 0.8[b]	9.3 ± 0.9[c]

[a] Values are means of triplicate determinations. Means in the same row with different superscripts are significantly different ($p < 0.05$).

sion prepared from white common bean did not separate into aqueous phase within 2 h after preparation. The emulsions prepared from red and black common beans did not separate after 30 min. Okezi and Bello (1988) observed that emulsions prepared from winged bean flour were stable after 30 min and those prepared from winged bean isolate and soy isolate did not separate into aqueous phase within 6 h after preparation. Sathe et al. (1982) suggested that the high emulsion stability of winged bean proteins was due to the globular nature of the major proteins of winged bean.

Results of foaming stability of flours are presented in Table 6. The foams from red common bean flour were more stable after 60 and 90 min than those of the other types of beans. Okaka and Potter (1979) suggested that the superiority of soy flour to cowpea powder in foaming property was due to the high protein content of soy flour. In the present study, the green mung bean flour with the highest protein content of 24.9% was the least stable in foaming stability. This suggests that not only the amount of native protein in the product but probably also the nature of the protein involved influences the foaming stability of the flour. This requires further investigation.

The results of this investigation showed that samples are rich in protein, potassium, phosphorus, and calcium and have good functional properties. Flours from these legumes could therefore be used as a protein supplement in human diets. However, further studies are necessary to evaluate the effect of flours prepared from these seeds on the quality of extended meat batters or other food systems.

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