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# Production and evaluation of extruded products from decorticated maize (*Zea mays* L.) flour supplemented with decorticated selected legume flour

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**ABSTRACT**

Maize (*Zea mays* L.) is an important staple food in Africa where in Sudan it's a prospective crop. The nutritional value of this crop needs some fortification to compensate for some nutritional deficiencies. The results obtained from decorticated maize flour supplemented with different ratios of decorticated faba bean (*Vicia faba* L.) (dfb) and decorticated cow pea (*Vigna unguiculata*) (dcp) on extrusion products indicated an increase in protein content of 2.1 % ( from 13.86 to 15.96%) in dfb and (from 12.77 to 14.87%) in dcp. The results indicate that tannins and phytic acid content in extruded products were lower than in blend. Tannins content for extruded products range is 222 – 230.24 mg/100g in dfb products, and 227.68 – 233 mg/100g in dcp products compared to a range of 393.34 – 415.32 in dfb blends, and 355.74 – 379.71 mg/100g in dcp blends. Phytic acid content for extruded products range was 174.30 – 196.01 in dfb products, and 167.20 – 188.01 mg/100g in dcp products compared to 202.47 – 229.35 mg/100g in dfb blends and 198.47 – 212.88 mg/100g in dcp blends. This means that the extrusion cooking reduced antinutritional factors. Heedless, a significant ($P \leq 0.05$) increase in minerals content (Ca, K, P, Na, Fe and Mg) was noticed because of adding dfb and dcp to the products compared to control. Essential amino acids in test products were increased compared to the control ones. The protein quality in dfb and dcp products was improved and the lysine score increased from 15.40 to 38.42 and from 16.20 to 49.33 for in these products, respectively. Extruded samples supplemented with 5% dfb and dcp, separately, had significant ($P \leq 0.05$) increase in volume by 10 and 20 $cm^3$, respectively. Sensory evaluation of extruded products showed that supplementation with 5% dfb and dcp resulted in superior products in color, taste, crispness and general acceptability. However, extruded products of dfb reflected superior quality than those of dcp. Nevertheless, the study showed that the extruded products of dfb and dcp are better than the control. Eventually, these results recommend producing extruded products from decorticated maize flour supplemented with 5% dfb or dcp in order.

**Keywords**: Maize, faba bean, cowpea, protein & fortification.

**INTRODUCTION:** There are many ready-to-uses (RTU) prepared imported foods used in aid programs to overcome the dilemma for a nutritious and healthy food in the developing countries including Sudan. Though they are very expensive and may not meet the requirements for the intended consumers. Snack food consumption in Sudan has been increasing. That is, because of increase in urbanization and the number of working mothers. This shift can be exploited by the food industries to fabricate nutritious snack foods. Extrusion cooking, as an attractive process for continuous food production, has been extensively developed in recent years. Direct expanded food products that include snack foods, breakfast cereals and pet foods, are produced `by extrusion cooking using high temperature short time (Rokey, 1994). Extrusion cooking technology is extensively utilized in the ready to eat (RTE) breakfast cereals industry which is time–saving and convincible method (Eastman *et al.*, 2001). However, breakfast cereal flakes are made by extrusion and finally puffed. In addition the blends of cereals and legumes are produced by the same method since a long time ago (Jansen, 1970). Complete gelatinization of wheat flour occurred at 40% water content during cooking. However, water percentage less than that (40%) did not achieved the complete gelatinization (Guo *et al.*, 2018). A temperature of 150 – 230°C and moisture of 13 – 19% produced, almost, total gelatinization of maize flour during extrusion (Lazou *et al.*, 2007). The extrusion temperature and moisture are directly proportional with gelatinization. The mix of corn soy extrudates are far more nutritious than the products made from the sole cereal. In spite of the fact that the benefits of extrusion are not yet authenticated but the speculations getting rid of anti-nutritional factors, gelatinization of starch, increasing soluble dietary fiber and reducing the oxidation of lipids. On the other hand, the nutritional value of proteins faces a deterioration due to Maillard reactions between proteins and sugars and this varies due to the protein type and the processing methods of extrudates (Singh *et al.*, 2005). However, there are a lot of merits of food extrusion that include prolonging the shelf life, ideal method for producing variable available food and being economic and environmentally – friendly. Beside the mentioned benefits, this industry allows better nutritional products that increase the metabolic availability of proteins and starches and the retention of nutrients. However, the extrudates have higher safety, accessibility, and affordability in all environments (Egal and Oldewage-Theron, 2020). This study focused on the evaluation of the extrusion products of mixes of maize (*Z. mays*) and dfb and dcp and the pure dough of this cereal. The mixing and its evaluation as compared to the test cereal aims at upgrading the nutritious values of the extrusion products and supporting the health of the consumers, eventually.

**OBJECTIVES:** This study was carried out to investigate the effect of adding decorticated faba bean (*V. faba*) (dfb) and cow pea (*V. unguiculata*) (dcp) flours in the ratios of 5, 10 and 15% to decorticated maize flour to produce extruded products and evaluated their nutritional values..

**MATERIALS AND METHODS:** White maize, faba bean and cow pea, sugar, vanilla, salt and baking powder were obtained from local market (Khartoum North).After cleaning all the samples were milled using laboratory Mill Type 120, No. 69444 Helsinki-Stockholm-Sweden and were sieved through mesh (250 um) into fine powder. The blends were prepared by adding decorticated maize flour, vanilla, salt, baking powder and sugar (control sample), then decorticated faba bean, cow pea flours were added in the ratios of 5%, 10% and 15%. Samples were prepared by adding tab water till well wetted and then extruded by a machine model DLG 90 twin screws (temperature 160 – 180°C) (Fregoun Foods Factory). Each sample was processed in the extruder for approximately 20 minutes, then cut into regular shapes. Moisture, ash, crude protein, fat, carbohydrates and mineral composition were determined for (blends and hot plate products) according to Mounika *et al.* (2017) method. Tannin was determined by method Ranganna (1986) and phytic acid content by Wheeler and Ferrel (1971). *In vitro* protein digestibility of samples was carried out using enzymatic method of Mouliswar *et al.* (1993). Extrusion samples were assessed organoleptically by the ranking test according to the procedure described by Ihekoronye and Ngoddy (1985). Statistical analysis of data generated was done using statistical Package for Social Science (SPSS). Means were tested by analysis of variance (ANOVA), and then means were separated using Duncan's Multiple Range Test (DMRT) according to Steel (1997). The test samples used were 100% DM, 95% DM/5% Dfb, 90% DM/10% Dfb and 85% DM/15% Dfb. The same was done for Dcp i.e 95% DM/5% Dcp, 90% DM/10% Dcp and 85% DM/15%Dcp

**RESULTS AND DISCUSSION:** Table (1) showed the results of proximate composition of control (maize flour), that was blended with 5,10 and 15% decorticated faba bean and cow pea flours. Incorporation of dfb and dcp caused significant increase in protein content. This positive effect is attributed to the faba bean and cow pea which are rich in protein content. A range of 28.0 - 32.9% in faba bean was reported by Carnovale *et al.* (1988) and 24.13% in cow pea (Olalekan and Bosede, 2010). Table (2) confirmed the tannins, phytic acid and *in vitro* protein digestibility of decorticated maize, faba bean and cow pea and decorticated blends from dm with different ratios of dfb and dcp.

Table 1: Chemical analysis of unmachined Dm, Dfb and Dcp samples and extruded test products

| (DM/Dfb/Dcp)% | Moisture content (%) | Ash content (%) | Crude protein (%) | Fat content (%) | Crude fibre (%) | Carbohydrates (%) | Energy (kj/100g) |
|---|---|---|---|---|---|---|---|
| 100/0/0 | 6.52±002[b] | 1.25±0.01[c] | 11.03±0.15[e] | 3.98±0.02[a] | 0.81±0.01[b] | 76.41±0.21[a] | 385.58±0.18 |
| Extruded | 11.35± 0.06[a] | 1.26±0.03[c] | 12.41±0.11[bc] | 4.85±0.04[a] | 0.92±0.03[b] | 69.21±0.23[a] | 370.13±0.19[a] |
| 0/100/0 | 6.65±0.03[ab] | 2.60±0.05[a] | 29.60±0.15[a] | 3.96±0.04[a] | 1.93±0.03[a] | 55.26±0.23[h] | 375.08±0.23[f] |
| 95/5/0 | 6.64±0.3[ab] | 1.57±0.02[bc] | 13.43±0.13[cd] | 3.96±0.01[a] | 1.09±0.02[ab] | 73.31±0.20[c] | 382.60±0.19[c] |
| Extrude | 11.34±0.12[a] | 1.57±0.04[b] | 13.86±0.12[b] | 4.68±0.03[a] | 1.09±0.03[ab] | 67.64±0.25[c] | 367.40±0.80[b] |
| 90/10/0 | 6.53±0.03[b] | 1.83±0.03[b] | 14.64±0.11[c] | 3.97±0.03[a] | 1.25±0.03[ab] | 71.78±0.18[e] | 381.41±0.17[d] |
| Extruded | 11.34±0.12 | 1.83±0.02[ab] | 14.85±0.13[ab] | 4.73±0.01[a] | 1.25±0.06[ab] | 66.00±0.08[d] | 365.97±0.98[d] |
| 85/15/0 | 6.69±0.01[ab] | 1.92±0.04[b] | 15.89±0.15[c] | 3.97±0.02[a] | 1.74±0.04[a] | 69.79±0.16[f] | 378.45±0.22[e] |
| Extruded | 11.39±0.11[a] | 1.92±0.05[a] | 15.96±0.15[a] | 4.96±0.02[a] | 1.74±0.04[a] | 64.03±0.26[f] | 364.60±0.72[e] |
| 0/0/100 | 7.18±0.7[a] | 2.03±0.05[b] | 24.06±0.13[b] | 3.99±0.08[a] | 1.90±0.03[a] | 60.84±0.28[g] | 375.51±90[f] |
| 95/0/5 | 6.91±0.06[a] | 1.36±0.05[c] | 12.38±0.12[d] | 3.99±0.01[a] | 0.95±0.00[b] | 74.41±0.25[b] | 383.07±0.23[b] |
| Extruded | 11.42±0.16[a] | 1.33±0.01[bc] | 12.77±0.10[bc] | 4.35±0.02[a] | 1.21±0.01[ab] | 68.92±0.15[b] | 365.91±0.20[d] |
| 90/0/10 | 6.91±0.04[a] | 1.62±0.03[bc] | 13.56±0.14[cd] | 3.97±0.05[a] | 1.12±0.01[ab] | 72.82±0.16[d] | 381.25±0.18[d] |
| Extruded | 11.43±0.14[a] | 1.59±0.02[b] | 13.61±0.11[b] | 4.79±0.02[a] | 1.34±0.01[ab] | 67.24±0.56[c] | 366.51±0.11[c] |
| 85/0/15 | 6.91±0.08[a] | 1.57±0.01[bc] | 14.44±0.11[cd] | 3.98±0.04[a] | 1.76±0.05[a] | 71.34±0.12[e] | 378.94±0.14[e] |
| Extruded | 11.47±0.18[a] | 1.69±0.07[ab] | 14.87±0.14[ab] | 4.86±0.03[a] | 1.65±0.03[a] | 65.46±0.22[e] | 365.06±0.48[d] |
| $Lsd_{0.05}$ | 0.379* | 0.460* | 1.271** | 0.049[NS] | 0.762* | 0.769** | 0.824** |
| SE± | 0.134 | 0.153 | 0.425 | 0.016 | 0.247 | 0.256 | 0.275 |

Tannins content and phytic acid in dfb and dcp are higher than content in dm. The results of Phytic acid in this test blends are higher than that reported by Sreerama *et al.* (2012) result which was 140 mg/100gm in cow pea flour. The minerals content (mg/100g) of decorticated maize, faba bean and cow pea and decorticated blends from dm with different ratios of dfb and dcp was observed in table 3. From these results, it can be observed that minerals increased with increasing of dfb and dcp. Addition of dfb in the ratios 5, 10 and 15% caused significant increase in protein content 13.86, 14.85 and 15.96%, respectively (table 3). The corresponding results for dcp products were lower 12.77, 13.61 and 14.87 for 5, 10 and 15%, respectively. This is due to the protein content in raw dfb (29.60%) was higher than the protein content in raw dcp (24.06%). Energy value of extruded products of decorticated faba bean and decorticated cow pea are lower than results of the blends (table 1). Table (2) showed the tannins content, phytic acid and protein digestibility of extruded products from dm with different ratios of dfb and dcp of extruded products. In the control tanin was 217.73 mg/100g, and for 5,10 and 15% of dfb products were 222.00, 225.57 and 230.24 mg/100g, and 227.68,230.70 and 233.00 mg/100g for dcp products. These results of tannins are lower than results of the blends (table 2).

Table 2: Tannins, phytic acid and protein digestibility of unmachined Dm, Dfb and Dcp samples and extruded test products

| (DM/Dfb/Dcp)% | Tannins (mg/100g) | Phytic acid (mg/100g) | Protein digestibility (%) |
|---|---|---|---|
| 100/0/0 | 366.72±0.00[g] | 185.06±1.54[i] | 66.01±0.61[d] |
| Extruded | 217.73±2.60[f] | 152.97±0.69[f] | 62.16±0.55[e] |
| 0/100/0 | 445.12±0.00[a] | 221.32±4.00[b] | 78.76±1.08[a] |
| 95/5/0 | 393.34±0.00[e] | 202.47±2.36[f] | 64.70±0.98[f] |
| Extruded | 222.00±0.95[e] | 174.30±1.51[d] | 64.25±0.38[d] |
| 90/10/0 | 402.00±0.00[d] | 214.04±3.15[e] | 67.11±1.41[c] |
| Extruded | 225.57±1.18[d] | 188.33±0.68[b] | 66.64±0.46[b] |
| 85/15/0 | 415.32±0.00[b] | 229.35±1.52[a] | 66.15±3.03[d] |
| Extruded | 230.24±0.63[b] | 196.01±1.23[a] | 67.00±0.39[a] |
| 0/0/100 | 410.14±0.01[c] | 207.81±5.22[e] | 72.56±0.98[b] |
| 95/0/5 | 355.74±0.00[i] | 198.47±0.82[h] | 62.32±1.00[g] |
| Extruded | 227.68±0.57[c] | 167.20±1.41[e] | 62.98±0.45[e] |
| 90/0/10 | 364.73±0.00[h] | 201.89±1.41[g] | 63.95±0.42[h] |
| Extruded | 230.70±0.44[b] | 177.04±1.24[c] | 65.00±0.66[c] |
| 85/0/15 | 379.71±0.00[f] | 212.88±2.61[d] | 65.17±0.40[e] |
| Extruded | 233.00±0.51[a] | 188.01±0.99[b] | 66.80±0.57[b] |
| $Lsd_{0.05}$ | 1.938** | 1.007** | 0.874** |
| SE± | 0.646 | 0.336 | 0.291 |

Table 3: Mineral content of unmachined Dm, Dfb and Dcp samples and extruded test products

| (Dm/Dfb/Dcp)% | Ca | K | P | Na | Fe | Mg |
|---|---|---|---|---|---|---|
| 100/0/0 | 22.64±0.02[h] | 282.52±0.61[i] | 233.37±0.02[i] | 16.98±0.01[f] | 5.88±0.06[a] | 273.65±0.57[i] |
| Extruded | 23.66±1.93[g] | 282.70±0.59[c] | 235.96±3.54[g] | 17.00±0.08[d] | 5.89±0.08[a] | 273.35±3.90[g] |
| 0/100/0 | 83.44±0.20[a] | 420.41±58.85[b] | 315.35±2.05[c] | 27.35±0.06[a] | 6.44±0.13[a] | 585.68±4.02[a] |
| 95/5/0 | 56.66±0.03[d] | 292.05±0.57[h] | 240.07±0.58[h] | 18.61±0.02[e] | 5.93±0.02a | 482.41±0.60[d] |
| Extruded | 57.00±3.11[c] | 292.19±0.63[g] | 241.94±1.09[f] | 18.96±0.16[c] | 5.98±0.15[a] | 483.88±0.87[c] |
| 90/10/0 | 59.45±0.02[c] | 303.84±1.71[g] | 260.33±0.59[g] | 19.68±0.01[d] | 5.96±0.01[a] | 522.19±0.58[c] |
| Extruded | 59.69±2.35[b] | 304.06±1.11[f] | 262.85±0.58[e] | 19.91±0.25[b] | 6.04±0.12[a] | 523.48±0.66[b] |
| 85/15/0 | 61.40±0.56[b] | 325.09±1.19[f] | 279.28±1.18[f] | 20.78±0.01[c] | 5.99±0.01[a] | 555.38±0.56[b] |
| Extruded | 61.94±2.34[a] | 325.80±0.58[e] | 280.04±0.66[d] | 20.97±0.13[a] | 6.13±0.14[a] | 556.38±0.73[a] |
| 0/0/100 | 59.53±0.24[c] | 574.59±2.66[a] | 420.44±0.78[a] | 22.70±0.20[b] | 6.36±0.11[a] | 423.71±19.62[e] |
| 95/0/5 | 36.40±0.53[g] | 362.44±0.42[e] | 298.38±0.40[e] | 15.99±0.01[g] | 5.91±0.01[a] | 377.14±1.02[b] |
| Extruded | 36.84±1.97[f] | 362.98±0.63[d] | 299.98±0.53[c] | 16.60±0.16[e] | 5.96±0.10[a] | 378.14±0.58[f] |
| 90/0/10 | 37.79±0.19[f] | 383.93±0.10[d] | 308.45±0.40[d] | 16.07±0.05[f] | 5.93±0.01[a] | 392.22±0.20[g] |
| Extruded | 37.90±0.81[e] | 384.00±0.45[b] | 309.10±0.71[b] | 17.07±0.19[d] | 5.99±0.13[a] | 393.14±1.08[e] |
| 85/0/15 | 39.41±0.44[e] | 402.51±0.48[c] | 321.44±0.46[b] | 16.14±0.01[f] | 5.95±0.01[a] | 403.20±0.30[f] |
| Extruded | 39.804±1.01[d] | 403.61±0.36[a] | 322.41±1.02[a] | 17.48±0.22[d] | 6.05±0.15[a] | 404.24±1.25[d] |
| $Lsd_{0.05}$ | 0.629** | 1.325** | 1.497** | 0.638** | 0.571[NS] | 1.243** |
| SE± | 0.210 | 0.442 | 0.498 | 0.183 | 0.01826 | 0.414 |

Extrusion cooking caused a significant reduction in tannins content in the control compared to blends. Alonso *et al.* (2000) found a significant reduction in tannins and phytic acid in extrusion cooking products. The phytic acid content was 152.97 mg/100gm for extruded control product and from 174.30 – 196.01 mg/100g in decorticated faba bean products (dfb). Phytic acid content in decorticated cow pea products (dcp) was from 167.20 - 188.01 mg/100g. These results agree with Alonso *et al.* (2000), results. Extrusion cooking has enhanced *in vitro* protein digestibility, results presented in table (2). Table (3) showed the mineral content (mg/100g) of extruded products from dm with different ratios of dfb and dcp. Increasing levels of dfb and dcp in extruded products showed increase in mineral content than the blends. Table (4) shows the contents of amino acids (mg/100g) for extruded products in mg/100 g. All amino acids were increased in fortification with 5,10 and 15% decorticated faba bean and decorticated cow pea flour than the control, especially lysine. It was increased from 7.135 mg/100 g in control to 38.420 mg/100 g for 15% decorticated faba bean flour products: and from 16.195 to 54.175 mg/100 g for 5 and 15% decorticated cow pea flour. Therionine, leucine and isoleucine were increased in extruded products compared to control. Lysine-deficiency is considered as a major nutritional problem in maize protein, this problem will be solved either through direct addition of lysine or supplementation by legumes or using high lysine corn (Jansen, 1970). The effect of additional decorticated faba bean and cow pea flours on extruded product samples volume is shown in table (5). The addition of decorticated faba bean and cow pea up to 15% significantly (P≤0.05) decreased the volume of samples compared to the control. The volume increased when adding 10% decorticated faba bean and cow pea flours. Singh *et al.* (2005) claimed that the expansion ratio of extrudates decreased with increase in the level of pea grits in feed material. Results of sensory evaluation of extruded products containing decorticated faba bean flour and decorticated cow pea flour are presented in table (6).The results showed significant (P≤0.05) differences among the products containing decorticated faba bean flour and cow pea flour in color, flavor, taste and crispness, and non significant differences in color with 10% decorticated faba bean flour and decorticated cow pea flour. General acceptability showed significant differences between all samples and the best one was that supplemented by 5% decorticated cow pea flour products (figure 1).

Table 4: Amino acids in extruded test products

| Amino acid | 100% decorticated maize | Maize + decorticated faba bean% | | | Maize + decorticated cow pea% | | |
|---|---|---|---|---|---|---|---|
| | | 95+5 | 90+10 | 85+15 | 95+5 | 90+10 | 85+15 |
| Aspartic acid | 187.602 | 226.757 | 409.098 | 922.326 | 235.951 | 559.276 | 630.098 |
| Thereonine | 26.887 | 41.595 | 80.147 | 119.626 | 36.359 | 104.017 | 143.265 |
| Serine | 72.270 | 116.029 | 116.335 | 181.474 | 68.236 | 195.224 | 207.283 |
| Glutamic acid | 167.488 | 185.918 | 208.986 | 372.620 | 49.991 | 72.948 | 355.960 |
| Glycine | 29.086 | 30.011 | 31.235 | 38.333 | 42.993 | 44.286 | - |
| Alanine | 1919.336 | 1208.432 | 1236.012 | 2204.025 | 1190.113 | 1609.431 | 2051.679 |
| Cystine | 181.136 | 217.125 | - | 404.603 | 141.528 | 307.326 | 364.083 |
| Valine | 792.759 | 1054.713 | 1587.248 | 1857.571 | 1066.766 | 1139.266 | 1788.522 |
| Methionine | 13.933 | 19.670 | 27.329 | 36.785 | 14.375 | 36.073 | 95.367 |
| Isoleucine | 341.230 | 355.488 | 529.646 | 649.178 | 412.936 | 414.982 | 526.635 |
| Leucine | 798.444 | 819.255 | 1305.484 | 1648.323 | 814.572 | 1280.173 | 1338.150 |
| Tyrosine | 32.193 | 48.875 | 76.478 | 92.638 | 16.281 | 28.241 | 53.155 |
| Phendalanine | 122.101 | 136.112 | 265.564 | 268.266 | 152.866 | 299.652 | 320.035 |
| Histidine | 56.013 | 84.268 | 121.142 | 186.755 | 64.659 | 160.189 | 188.145 |
| Lysine | 7.135 | 15.402 | 35.414 | 38.420 | 16.195 | 30.702 | 54.175 |
| Ammonia | 1373.344 | 1513.042 | 1551.295 | 1883.780 | 1182.425 | 1781.913 | 1796.983 |
| Arginine | 134.387 | 207.896 | 522.348 | 598.256 | 216.842 | 264.096 | 590.653 |

Table 5: Volume of extruded test products

| (Dm/Dfb/Dcp)% | Volume ($cc^3$) |
|---|---|
| 100/0/0 | 210.00±10.25$^{d}$ |
| 95/5/0 | 230.00±5.37$^{a}$ |
| 90/10/0 | 220.007±11.16$^{b}$ |
| 85/15/0 | 190.00±5.98$^{e}$ |
| 95/0/5 | 220.67±2.25$^{b}$ |
| 90/0/10 | 215.67±3.72$^{c}$ |
| 85/0/15 | 185.00±4.04$^{f}$ |
| $Lsd_{0.05}$ | 4.306$^{**}$ |
| SE± | 1.235 |

Table 6: Quality attribute of extruded test products

| (Dm/Dfb/Dcp)% | Quality attributes | | | | |
|---|---|---|---|---|---|
| | Color | Flavor | Taste | Crispiness | General acceptability |
| | Scores | | | | |
| 100/0/0 | 7.50±0.15a | 6.60±0.13a | 6.65±0.11a | 6.00±0.14c | 6.35±0.06ab |
| 95/5/0 | 7.55±0.13a | 5.95±0.14c | 5.90±0.12b | 6.25±0.13ab | 6.55±0.11a |
| 90/10/0 | 5.05±0.10d | 4.65±0.12d | 5.05±0.13d | 5.95±0.11d | 6.25±0.16ab |
| 85/15/0 | 3.25±0.11f | 3.80±0.15e | 4.00±0.15e | 5.00±0.12e | 3.85±0.14d |
| 95/0/5 | 7.25±0.12ab | 6.00±0.11b | 6.40±0.10a | 6.60±0.07a | 6.10±0.10b |
| 90/0/10 | 6.00±0.09c | 5.70±0.12c | 5.55±0.16c | 6.05±0.15bc | 6.00±0.05b |
| 85/0/15 | 4.15±0.08e | 4.75±0.09d | 5.15±0.14a | 6.05±0.13bc | 4.95±0.09c |
| Lsd0.05 | 0.239* | 0.518* | 0.347* | 0.416* | 0.292* |
| SE± | 0.078 | 0.174 | 0.116 | 0.139 | 0.065 |

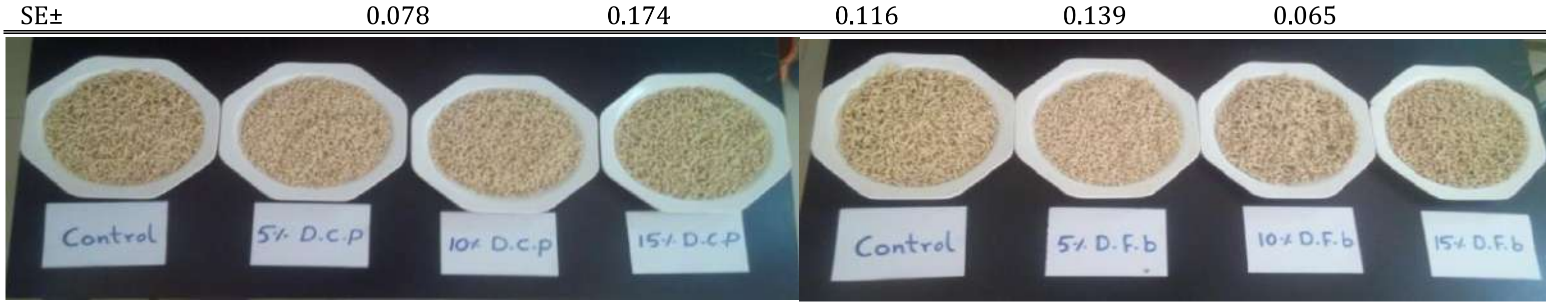


Figure 1: Extruded products from Dm/Dfb/Dcp

**CONCLUSION:** Supplementation of decorticated maize flour with decorticated faba bean flour and cow pea flour has improved the nutritional value of blend flours and extruded products. Values of limiting essential amino acids have been improved in extruded products supplemented with 5 – 15% decorticated faba bean and cow pea flours and maize flour with 5% decorticated faba bean and 5% cow pea flours gave extruded product with the highest volume (expansion ratio). The highest results in general acceptability results were found to be in 5% decorticated faba bean in extruded products, extruded products were better in all nutritional value and lower in antinutritional value than blends, extruded from maize and are suitable for celiac disease patient's.

**CONFLICT OF INTEREST:** The Authors declare that the study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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