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A sustainable, extruded legume-based protein source: antioxidant, anti-nutrient, and structural profile

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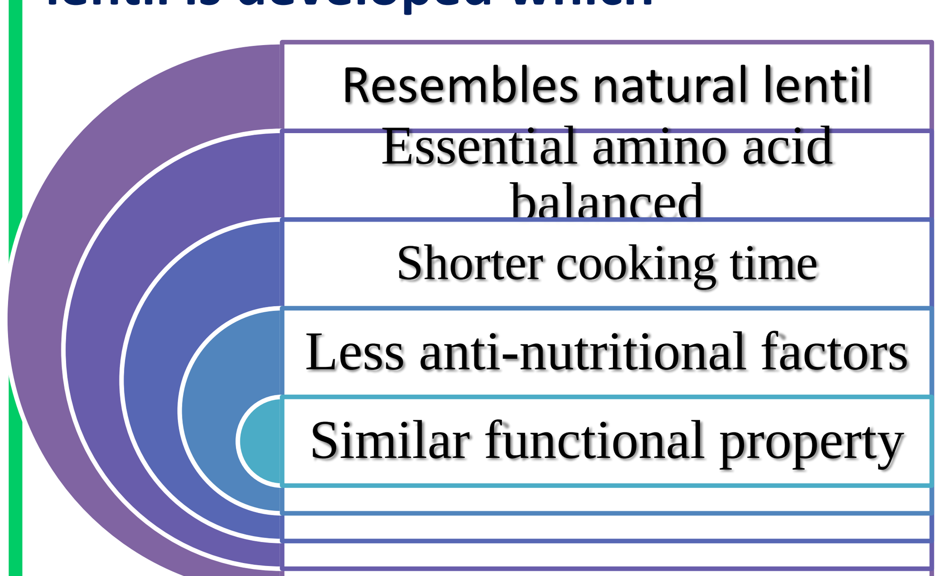
Introduction

The challenges of the expanding global population have necessitated the exploration of plant-based protein sources to minimize animal product consumption. However, legumes have comparatively low amounts of sulphur-containing essential amino acids and higher levels of anti-nutrients; they are also difficult to cook and have low digestibility. Protein quality in a single lentil does not reach the same level as animal products due to unbalanced essential amino acid (EAA) composition. To address this problem, an EAA balanced lentil is developed which

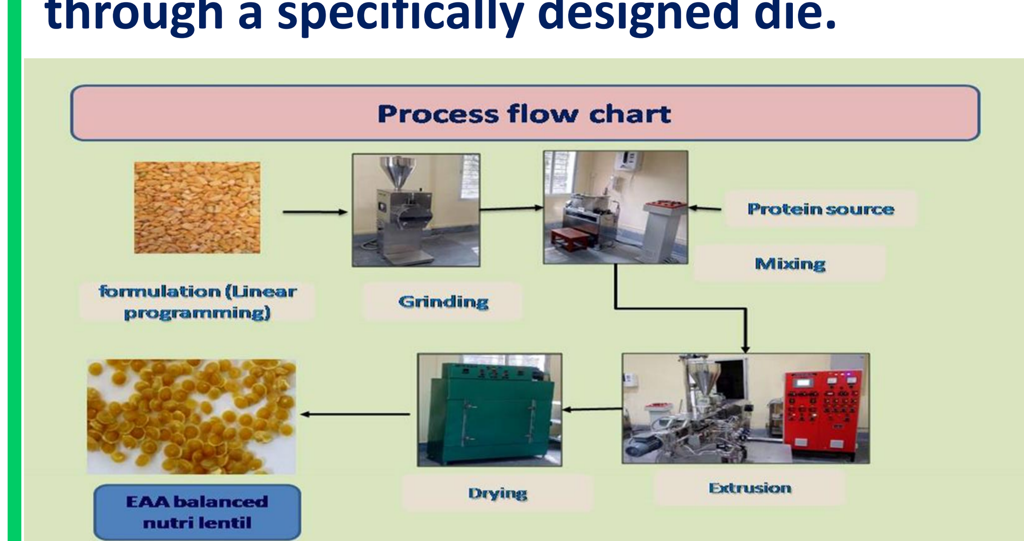


Aim

The present investigation studies the antioxidant, anti-nutrient, and structural profile of a A sustainable, extruded legume-based protein source known as Nutri lentil

Methods

Four combinations containing chickpeas/lentils/mung beans/protein isolate at different ratios (A—42:20:34:4, B—35:30:31:4; C—45:27:25:3; D—37:25: 35:3) were formulated using MATLAB's linear programming. The mixture was extruded using a twin screw extruder at die temperature (100 to 115 °C) with a screw speed of 100-200 rpm at a constant feed rate of 12 rpm and a feed moisture of 22%. The extrudate was passed through a specifically designed die.



Results & Discussion

Fig. 1. (1A)The effect of extrusion processing on the total phenolic content (TPC) and (1B) antioxidant capacity; DPPH assay, (1C) ABTS assay and (1D) FRAP assay of raw formulations

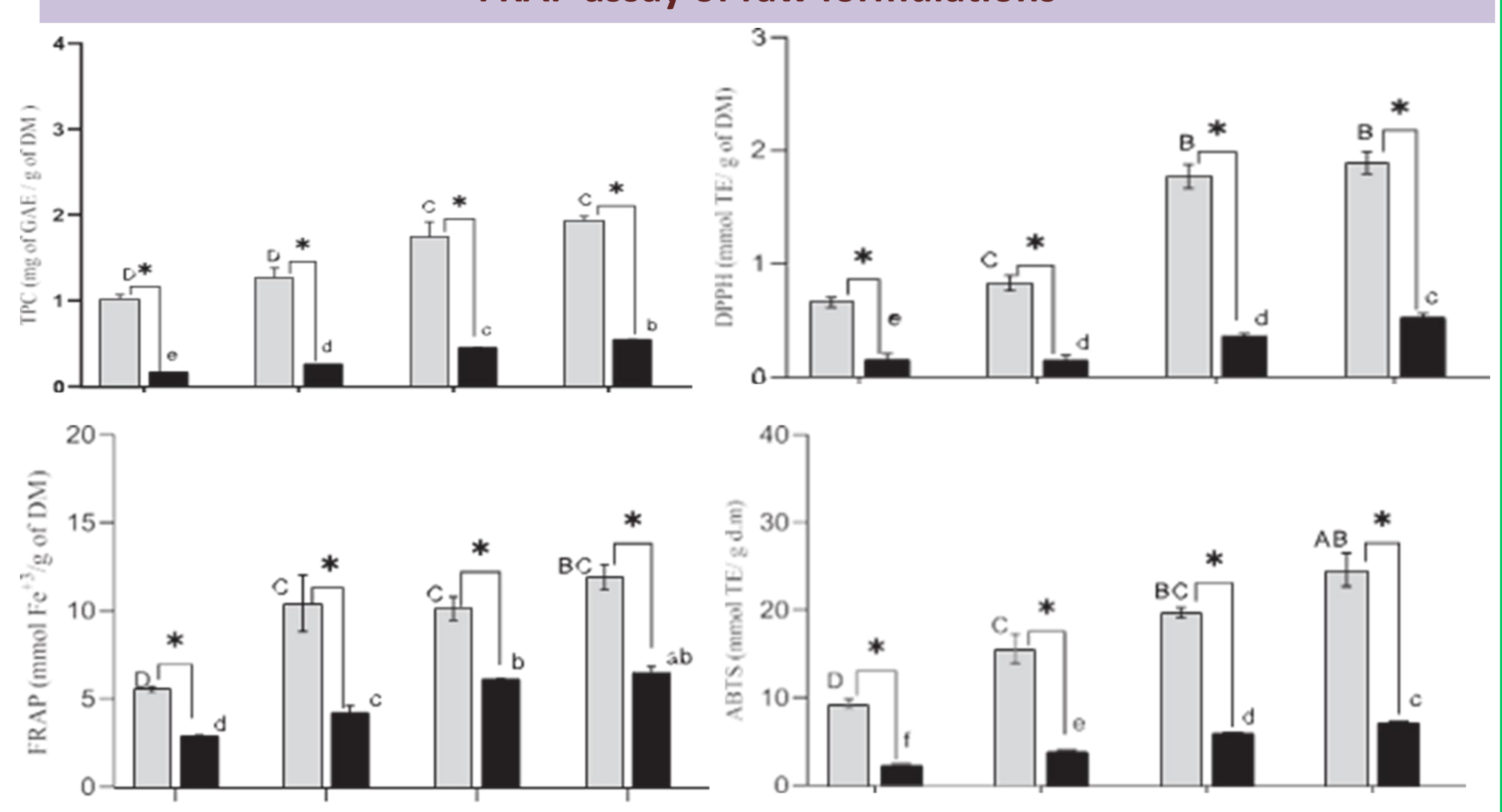


Fig 2. Phytic acid, tannin, trypsin inhibitor, total polyphenols content made from lentil using different extrusion temperature and feed moisture

Extrusion temperature (C)	Composition	Phytic acid (g/100 g dry matter)	Tannin (mg eq. cat/100 g dry matter)	Trypsin inhibitor (IU/mg dry mater)	Total polyphenols (mg GAE/g)
100	A	0.047 ± 0.02 (85.01%)	0.065 ± 0.04 (93.08%)	0.049 ± 0.02 (98.26%)	5.1 ± 0.8 (27.14%)
	B	0.072 ± 0.01 (77.27%)	0.062 ± 0.01 (93.40%)	0.046 ± 0.05 (98.37%)	4.8 ± 0.13 (31.43%)
	C	0.062 ± 0.01 (88.45%)	0.059 ± 0.02 (93.72%)	0.044 ± 0.04 (98.44%)	4.6 ± 0.12 (34.28%)
	D	0.60 ± 0.01 (82.45%)	0.059 ± 0.02 (93.72%)	0.044 ± 0.04 (98.44%)	4.6 ± 0.12 (34.28%)
150	A	0.030 ± 0.03 (81.38)	0.040 ± 0.01 (95.74%)	0.030 ± 0.02 (98.94%)	3.7 ± 0.6 (47.14%)
	B	0.027 ± 0.01 (82.64%)	0.038 ± 0.03 (95.96%)	0.026 ± 0.01 (99.07%)	3.5 ± 0.16 (50%)
	C	0.046 ± 0.01 (77.73%)	0.035 ± 0.01 (96.28%)	0.020 ± 0.02 (99.29%)	3.2 ± 0.11 (54.28%)
	D	0.029 ± 0.01 (80.64%)	0.036 ± 0.03 (91.96%)	0.021 ± 0.01 (99.07%)	3.5 ± 0.16 (50%)
200	A	0.011 ± 0.02 (89.04%)	0.020 ± 0.01 (97.87%)	0.017 ± 0.01 (99.39%)	2.9 ± 0.1 (58.57%)
	B	0.010 ± 0.001 (91.13%)	0.018 ± 0.02 (98.08%)	0.014 ± 0.03 (99.50%)	2.5 ± 0.09 (64.29%)
	C	0.008 ± 0.01 (90.30%)	0.011 ± 0.02 (98.83%)	0.013 ± 0.01 (99.54%)	2.4 ± 0.4 (65.71%)
	D	0.072 ± 0.01 (77.27%)	0.062 ± 0.01 (93.40%)	0.046 ± 0.05 (98.37%)	4.8 ± 0.13 (31.43%)
Lentil seed (Control)		1.1436 ± 0.10	0.94 ± 0.09	2.823 ± 0.12	7.0 ± 0.7

Fig. 3 SEM images) of (a) Natural lentil (b) Nutri lentil tray dried (c) Nutri lentil vacuum dried

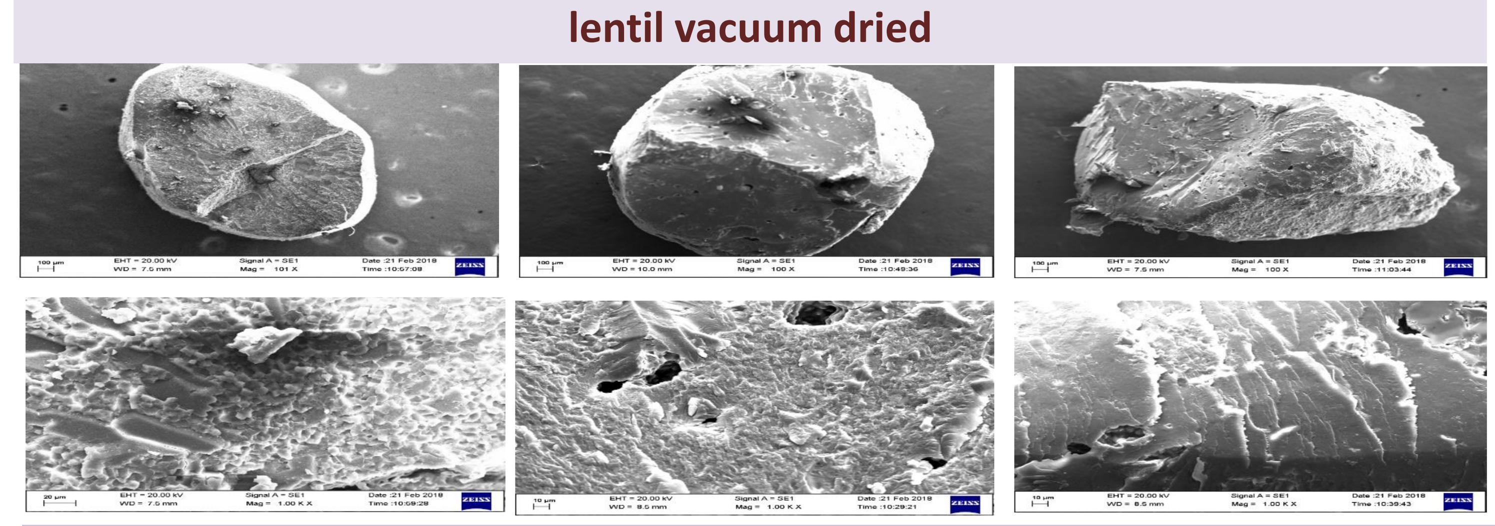
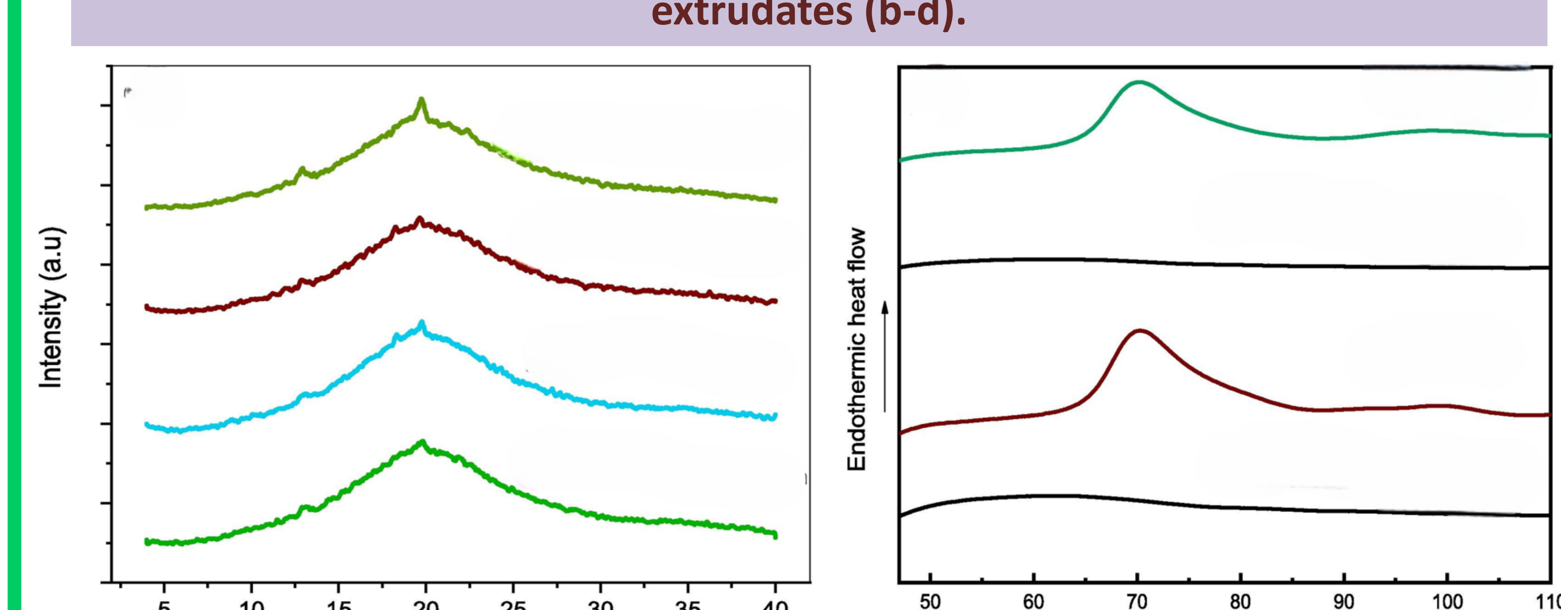


Fig. 3. Differential scanning calorimetry thermograms and X-ray diffractograms of faba bean flour, faba bean blends (FB) (a-c) and selected extrudates (b-d).



Conclusions

- The present studies show the ability of extrusion processing on reducing antinutritional factor such as phytic acid, tannin, trypsin inhibitor. The extrusion procedure lowered antinutritional factors by 77.2 to 93.6%.
- Extrusion resulted in a significant ($P < 0.05$) decrease in TPC and DPPH, ABTS and FRAP radical scavenging activities of all the samples compared to their corresponding raw formulations
- The use of low temperatures (<110 ◦C) and relatively low moisture (<14%) can retain higher contents of phenolics and improve the antioxidant activity.
- The interior structure revealed the formation of extensive air cells. An open cell structure and a thinner cell wall at lower temperatures showed high expansion. This might be attributed to the quicker cooking time of lentils (9 to 15 minutes).
- XRD revealed extrusion cooking transformed the disordered protein structure and crystalline starch structure to an amorphous one, indicating a continuous gelatinized starch phase.
- However, extruded samples exhibited two peaks at around 13◦ and 19.7◦ 2θ, indicating the presence of V-type pattern developed during extrusion cooking. This V-type peak was due to the formation of amylose–lipid complexes.
- Formulation C, with a higher amount of chickpeas, showed greater expansion and retained maximum antioxidants

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