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Effect of various processing treatments on total flavonoid content of different varieties of cowpea

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Abstract
Flavonoid is an important polyphenol contributing to antioxidant activity of food. Total Flavonoid Content (TFC) of four cultivars of cowpea (Gomati, EC 4216, BL-1, and BL-2) were determined in this study. TFC was analyzed using spectrophotometer in terms of mg quercetin equivalent per gram. The effect of selected thermal processing (boiling, roasting, microwave, autoclave and extrusion) and bioprocessing (germination and fermentation) on the total flavonoid content of two variety of cowpea (Gomati and EC 4216) were studied. All treatments conducted in this study caused a significant (p<0.05) reduction in the analyzed flavonoid content in all cultivars of cowpea except extrusion. Among all the studied unprocessed cowpea cultivars BL-1 showed maximum flavonoid content (1.18 mg QE/gram) followed by Gomati (1.05 mg QE/gram), EC-4216 (1.02 mg QE/gram) and BL-2 (0.843 mg QE/gram). In thermal treatments, autoclaving caused highest reduction (83%-55%) in TFC followed by boiling (48%-43%), microwave (35%-21%) and roasting (33%-25%), while extrusion process enhances the TFC by 10% -13%. While in bioprocessing, germination causes maximum reduction (75%-38%) in TFC which increased with time (24hr, 48 hr, 72 hr), while fermentation reduces the flavonoid content by 67% - 43% which also increased with time (16hr, 24hr, 36hr). The correlation between Lab value and TFC was established which showed TFC of all cowpea cultivars were negatively correlated with 'a' value (-0.9440) and 'b' value (-0.924).

Keywords: flavonoids, processing, cowpea cultivars

Introduction
Currently, the use of some natural anti-oxidants, particularly, the phenolic substances including flavonoids and phenolic acids in foods, as well as preventive and therapeutic medicine, is gaining much recognition because of their nutraceutical and health benefits (Fan *et al*., 2007) [11]. Extensive epidemiological studies have indicated an inverse relationship between dietary flavonoids intake and the risk of coronary heart diseases, and certain cancers (Hung *et al*., 2004, Pupponen-Pimia *et al*., 2001) [14, 24]. Cowpea *(Vigna unguiculata* L. Walp.) is the most important food legume crop in the world. The history of cowpea dates to ancient West African cereal farming, 5 to 6000 years ago, where it was closely associated with the cultivation of sorghum and pearl millet. Cowpea is drought-tolerant and warm-weather crop, with the ability to fix atmospheric nitrogen through its root nodules. It is the most versatile African crop; it feeds people and their livestock.

Cowpea is an important food legume indigenous to Africa and provides more than half the plant protein in human diets (Rachie 1985; Philips) [7]. It provides a significant amount of calories and is a good source of vitamins and minerals and provides a significant amount of dietary protein. In addition to dietary fiber, cowpeas contain many health-promoting components such as vitamins, minerals and phytochemicals, which include phenolic compounds (Cai *et al*., 2003) [8]. Phenolic compounds are well-known antioxidants and have been shown to have the ability to prevent degenerative diseases (heart diseases and cancer) in which reactive oxygen species are involved. The consumption of leguminous plant such as cowpeas has been linked to reduced risk of free radical mediated diseases such as diabetes, obesity and coronary heart diseases. However, the consumption of cowpeas, like that of other legumes, is limited by the presence of anti-nutritional factors which affect the digestibility and bioavailability of nutrients and thus cowpeas need to be processed to reduce or even remove these factors. Traditionally, legumes are processed in different forms before consumption and such processing enhances their nutritive value by reducing the content of anti-nutritional factors and improves the digestibility of carbohydrates and proteins (Bishnoi *et al*., 1994).

Flavonoids, as natural products in the plant kingdom, are divided into six major sub-classes including flavones, flavonols, flavanones, catechins, anthocyanidins and isoflavones, based on variation in the heterocyclic C-ring (Ross and Kasum, 2002). High contents of anthocyanins, proanthocyanidins and/or other types of tannins are usually found in dark-coloured flowers, seeds or fruits. They can alter seed quality by reducing digestibility, but also have positive health effects. Isoflavones (e.g. daidzein and gen-istein) and flavonols (e.g. kaempferol, myricetin andquercetin) as secondary metabolites have beneficial effects for human health due to their antioxidant, anti-oestrogenic and antiproliferative activities. This has been demonstrated by consumption of soybean products containing such flavonoids which can reduce the risk of certain forms of cancer, heart diseases and oxidation-linked diseases of old age. Research on flavonoids has been conducted in soybean but relevant information about the flavonoid contents in other legumes is lacking (Messina, 1999) [16]. Furthermore, the bio-syntheses of flavonols, isoflavones and anthocyanins occur in similar pathways. The colour of anthocyanins is influenced by the presence of co-pigments such as flavonols and flavones. High contents of anthocyanins have been detected in dark-coloured seeds. It is reasonable to suspect that seed-coat colour might have some effects on the content of flavonoids in legume seeds. Cowpeas are processed and consumed extensively in developing countries and the large amount of seed coat discarded as waste may be considered as potential source of phenolics compound for application as natural antioxidants in food. Processing treatments may cause complex physical and chemical reactions such as leaching of water-soluble phenolics, freeing phenolics from bonded forms, degradation of polyphenols as well as breakdown and transformation of phenolics. Although a number of studies on the flavonoid contents of plant sources have been reported from different countries, the compositional data and effect of processing on flavonoid content are still insufficient, which necessitates the need to investigate more and more materials for the search of credible and beneficial natural anti-oxidants.

On the basis of these considerations, the objectives of this study were to evaluate the effects of thermal treatments (Boiling, roasting, autoclaving and microwaving) and bio processings (germination and fermentation) on the antioxidant contents (Phenolics, flavonoids) of selected cowpea cultivars.

Methods and Material

This project investigation "Effect of various processing treatments on total flavonoid content of different varieties of cowpea" was conducted in the department of Center of Food Technology, University of Allahabad. Three Cowpea cultivars EC 4216, BL-1 and BL-2 in their dried state were procured from Division of Seed Technology, IJFRI Jhansi while Gomati variety was purchased from seed shop, Allahabad.

The four varieties of cowpea studied under this project were.

Fig 1: Cowpea Gomati

Fig 2: Cowpea EC 4216

Fig 3: Cowpea BL-2

Fig 4: Cowpea BL-1

Different processing treatments like boiling, roasting, microwave, autoclave, extrusion, germination and fermentation had been given to the selected varieties of cowpea.

Table 1: Processing treatments and time intervals

Processing Treatment	Time Interval	References
Thermal		
Boling	90 min	Hefnawy, 2011
Roasting	45 min	Makerietan, 2011
Microwave	15 min 30 min	Saleh *et al*., 2006

Autoclave	15 min 30 min	Aljaji and EI-adway, 2006
Extrusion	-	Single screw extruder
Bioprocessing		
Germination	24 hours 48 hours 72 hours	Ahmed *et al*., 2010 [2]
Fermentation	16 hours 24 hours 36 hours	Mohiedeen *et al*., 2010

Determination of total flavonoid content

Sample extraction

5gram of cowpea seed samples were extracted with 50ml chilled aqueous ethanol (Ethanol's water, 80:20, v/v/) for 2hr at room temperature. The samples were centrifuged at 3000gram for 20 min and the supernatant was removed. Extraction was repeated twice and supernatants were pooled and evaporated at 40 C. The final volume was made to 10ml with distilled water and stored at -40C until analysis. The extraction was carried out in triplicates.

Flavonoid determination

The total flavonoid content of cowpea seed extract was determined according to the method of Boateng *et al*. (2008) [6].

Reagents

5% Sodium Nitrite
10% Aluminium Chloride
1 mole Sodium Hydroxide

Procedure

Ethanolic extract (2ml) was mixed with 150 microlitre of 5% Sodium nitrite ($NaNo_2$). After 5 mins. 150 microlitre of 10% Aluminium Chloride ($AlCl_3$) was added. After 10 min interval 1ml of 1Mole Sodium hydroxide (NaOH) and 1.2 ml of distilled water were added in the mixture. The mixture was shaken vigorously and after 10min incubation absorbance was read at 510nm by spectrophotometer.

Standard: A calibration curve was prepared using a standard solution of quercetin (0.05 – 0.5 mg/ml).

Calculation: Samples were analyzed in 3 replications and results wer expressed as mg quercetin equivalents (QE per gram of sampe (dry basis) from the standard curve).

Determination of colour value (Lab value)

Lab value

Tristimulus color: Tristimulus color in terms of Hunter L, a, b values was measured using X-Rite spectrophotometer (USA) using D-65 illuminant and 10o observer. 'L' value represents lightness, 'a' value shows redness-greenness and 'b' value indicates blueness-yellowness of the samples.

Principle of operation: Itmeasures spectral data—the amount of light energy reflected from an object at several intervals along the visible spectrum. These measurements result in a complex data set of reflectance values which are visually interpreted in the form of a spectral curve. Because a spectrophotometer gathers such complete color information, this information can be translated into colorimetric or densitometry data with just a few calculations. In short, a spectrophotometer is the most accurate, useful, and flexible instrument available.

A *Lab* color space is a color-opponent space with dimension *L* for lightness and *a* and *b* for the color-opponent dimensions, based on nonlinearly compressed CIE XYZ color space coordinates.

CIE *L*a*b** (CIELAB) is the most complete color space specified by the International Commission on Illumination (*Commission Internationaled 'Eclairage*, hence its *CIE* initialism). It describes all the colors visible to the human eye and was created to serve as a device independent model to be used as a reference.

The three coordinates of CIELAB represent the lightness of the color (*L** = 0 yields black and *L** = 100 indicates diffuse white; specular white may be higher), its position between red/magenta and green (*a**, negative values indicate green while positive values indicate magenta) and its position between yellow and blue (*b**, negative values indicate blue and positive values indicate yellow) (McGuire,1992; Minolta, 1998). The asterisk (*) after *L*, *a* and *b* are part of the full name, since they represent L*, a* and b*, to distinguish them from Hunter's L, a and b, described below.

Since the *L*a*b** model is a three-dimensional model, it can only be represented properly in a three-dimensional space. Two-dimensional depictions are chromaticity diagrams: sections of the color solid with a fixed lightness.

It is crucial to realize that the visual representations of the full gamut of colors in this model are never accurate; they are there just to help in understanding the concept. Because the red/green and yellow/blue opponent channels are computed as differences of lightness transformations of (putative) cone responses, CIELAB is a chromatic value color space.

The derived color function or chromaticity C*ab (Chroma or Chromaticity) was calculated using the following formula

Chromaticity= $\{(a)^2 + (b)^2\}^{1/2}$ as given by Fugita *et al*., (2007)

Results and Discussion

In this chapter finding of the present study entitled "Effect of various processing treatments on total flavonoid content of different varieties of cowpea is presented under the following subheadings:

- Effect of thermal processings (Boiling, roasting, autoclave, microwave and extusion) on total flavonoid content of cowpea cultivars.
- Effect of bioproccessings (Germination and fermentation) on total flavonoid content of cowpea cultivars.

Statistical analysis of data was also performed on SPSS 7.5

1. Flavonoid content of four varieties of cowpea

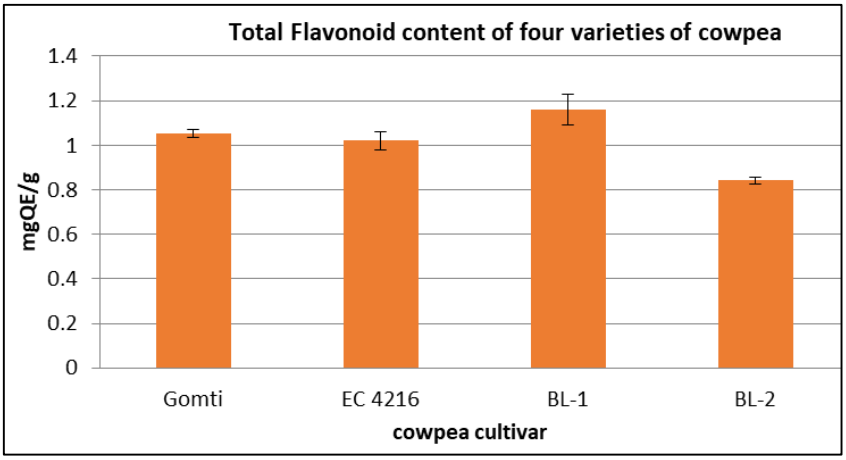
Flavonoids are considered to be primary antioxidants and they act as free radical acceptors and chain breakers in foods (Sridhar 2007). Flavonoids have generated interest because of their broad human health promoting and synergistic effects

with other antioxidants. The position and the degree of hydroxylation is of primary importance in determining the antioxidant activity of phenols. The antioxidant mechanism of flavonoids, may also result from the interaction between flavonoids and metal ions especially iron and copper (Shahidi *et al*., 1992) [28]. The present study showed Total Flavonoid Content (TFC) of four cultivars of cowpea (Gomati, EC 4216, BL-1 and BL-2). TFC was analyzed using spectrophotometer in terms of mg quercetin equivalent per gram. Among all analyzed cultivars Bl- 1 (1.18 mg QE/ g) showed maximum flavonoid content followed by Gomati (1.05 mgQE/g) and EC-4216 (1.02 mgQE/g) while BL-2 showed minimum flavonoid content (0.843 mgQE/g). It has been found in several studies that darker the colour of seed coat more is the flavonoid content. Sule Ola Salawu *et al*., (2014) reported, total flavonoid content (mgQE/g) in three varieties of cowpea. He observed Ife brown cowpea has the highest flavonoid content (0.95) followed by oloyin brown (0.59), with sokoto white having the lowest flavonoid content (0.36). Duenas *et al*., (2005) reported 1.145mg QE/g of TFC in whole grain of cowpea. Total flavonoids (raw beans) in the study by Boateng *et al*., (2007) ranged from 0.614 mg CE/g in pinto beans to 0.845 mg CE/g in kidney beans. Heimler *et al*., (2005), reported similar values for total flavonoids in dry beans. Oomah *et al*., 2005 reported values of 0.24 and 0.26 mgCE/g for flavonoid content in pinto beans and red kidney beans respectively. The high flavonoid levels in the beans may be due to their high anthocyanidin contents. Total flavonoid (0.29 mg QE/g) content in black soybeans was found to contain higher flavonoid than yellow soybeans (0.45 mg QE/ g) (Takahashi *et al*., 2005). Total flavonoid contents in legumes varied greatly.

Table 2: Flavonoid content of four varieties of cowpea

S. No.	Cowpea Cultivars	Mean ± SD mg QE/g
1	Gomati	1.053±0.02^{b}
2.	EC 4216	1.026±0.04^{b}
3.	BL-1	1.160±0.07^{c}
4.	BL-2	0.843±0.012^{a}

Results are expressed on dry weight basis
Values are expressed as mean values of three replications ± standard deviation
Means followed by same letter within a column do not differ significantly (p<0.05)



Graph 1: Flavonoid content of four varieties of cowpea

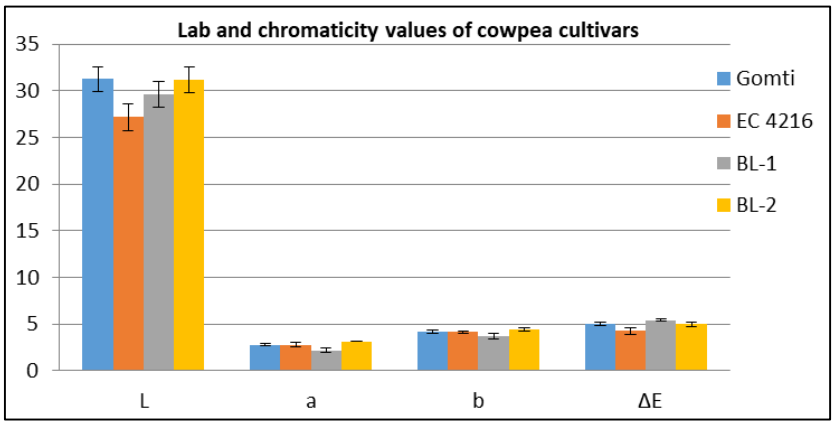
2. Color values of four varieties of cowpea

Several recent studies have reported that legumes with dark seed coat such as black soybean, red kidney bean, pinto bean and lentils possessed a high antioxidant activity due to the presence of high amount of phenolic compounds, mainly anthocyanin's and tannins. Cowpea seed color ranged from cream to dark brown. The L, a, b and chromaticity values of cowpea seed flours are presented. The color value L of a sample indicates its lightness. It has been reported that as L value of the sample decreases, the opaqueness of the sample increases. The International Journal of Natural Products Research 2013; a and b value indicate the intensity of red and yellow in the sample, respectively. Significant differences ($p \geq 0.05$) in L, a and b parameters of color were found between studied cowpea cultivars. Similar observations were found in other legumes also. L values (Lightness) was higher in BL-2 cultivars followed by Gomati, BL-1 and cowpea cultivars. EC-4216 cultivar being more pigmented and had lesser L value. Studies have shown that dry beans possessing darker colored seed coats have relatively higher total phenolics in comparison to those with lighter colored seed coats. The chromaticity value C*ab indicated that the BL-2 cultivar of cowpea is perceived as more intense than the other cultivar.

Table 3: Lab and chromaticity value of cowpea cultivars

S. No	Cowpea Cultivars	L	a	b	ΔE
1	Gomti	31.26±1.28^{b}	2.76±0.12^{b}	4.15±0.18^{b}	4.97±0.21^{b}
2	EC 4216	27.18±1.44^{a}	2.79±0.22^{b}	4.16±0.11^{b}	5.01±0.21^{b}
3	BL-1	29.64±1.36^{ab}	2.17±0.26^{a}	3.67±0.29^{a}	4.26±0.38^{a}
4	BL-2	31.22±1.36^{b}	3.15±0.43^{c}	4.41±0.15^{b}	5.42±0.15^{b}

Results are expressed on dry weight basis
Values are expressed as mean values of three replications ± standard deviation
L value denotes lightness of the seed samples
a value denotes redness of the seed samples
b value denotes yellowness of the seed samples
(C*ab) Chromaticity values denote color functions of the seeds samples
* Means followed by same superscript with in a column do not differ significantly ($p \leq 0.05$).



Graph 2: Lab and chromaticity value of cowpea cultivars

3. Correlation analysis between total flavonoid content and color values of cowpea cultivars

The correlation coefficients between TFC and color values of cowpea seed flours are shown in Table 4.3. Correlation analysis showed that TFC was negatively correlated with lightness (L) value (r^2=-0.318, p≥0.05) and positively correlated with a value (r^2= 0.944, p≥0.05). Similar observations were also found by other investigators in various seed legumes (Zielinski *et al*., 2008). Our result reveals that darkness and high color intensity in cowpea seeds were associated with more TFC than light colored seed. It is assumed that more darkness/redness (a value) indicate that these cultivars are highly pigmented and therefore could be possibly used as a marker for selection of flavonoid rich cultivars.

Table 4: Correlation between total flavonoid contents and color values of selected cowpea using Pearson correlation coefficient

	L	a	b	ΔE
TFC	-0.318	0.9440	-0.924	-0.93878

4. Effect of thermal processing on flavonoid content of cowpea

The effect of various thermal treatment on the flavonoid content of two varieties of cowpea were studied and reperesented in table 4.3. Thermal treatment leads to heat degradation of flavonoid content of cowpea. Udensi *et al*., 2007 also reported significant decrease in polyphenol content during various thermal treatments. Among all thermal treatments, autoclaving caused highest reduction ranging from 82% to 55% while roasting cause minimum reduction ranging from 25% to 33% in both cultivars of cowpea. While extrusion cause significant increase in flavonoid content by 10- 13%.

Effect of boling

Boiling for 90 min causes more reduction ranging from 43%-47% than microwave and roasting. According to Kumar, *et al*, (2006) the reduction in flavonid content during boiling is as result of the fact that flavonoid are polyphenols and all polyphenols are water soluble in nature. Therefore, reduction in flavonoid may be attributed to leaching out of phenols into the cooking medium under the influence of concentration gradient.

Effect of roasting

Roasting caused minimum reduction in flavonoid content ranging from 33 -25%. In previous studies, showed that boiling and roasting of dry beans resulted in 73and 17% reductions in polyphenols, respectively. The authors (Barroga *et al*., 1985) positively correlated the lowering of polyphenols in dry beans with a decrease in protein-precipitable phenols. According to Siddhuraju (2006) and Duenas *et al*. (2005), the stability of antioxidant products such as phenolics and flavonoids during heating maybe due to the formation of mailliard products which produces high antioxidant activity. Also noted that roasted cowpeas (black-eyed peas) contained similar nutritional and functional qualities as protein supplements. The authors concluded that roasted cowpeas could thus be used in cereal-based weaning foods.

Effect of Microwave cooking

Microwave cooking was carried out for 15 min and 30 min. Microwave cooking causesd reduction in flavonoid content which decreases with time that is reduction in microwave 15 min is more than microwave 30 min in both cowpea cultivars. It was observed that flavonoid content has reduced upto 20 to 34%. It cause less reduction than boiling and autoclavin. This decrease could be related to fact that these compounds are heat liable and degrade upon heat treatment. Similar results were obtained by Mahmood *et al*., (2000) i.e a significant reduction in flavonoid content was noticed after microwave cooking of different soaked seeds for 15 min but this loss appeared to be significantly ($p<0.05$) less than in seeds which cooked by autoclaving for 10 min.

Effect of autoclaving

Autoclaving caused higest reduction in TFC of both cowpea cultivars. However there was no significant difference observed between autoclave 15 min and 30 min in Gomati variety while in EC-4216, autoclave 15 min caused about 82% reduction and autoclave 30 min leads to 55.88% reduction of TFC. Avana *et al*., (2013) reported that autoclaving reduces the flavonoid content by 55-71% in cowpea Udensi *et al*., 2007 also reported autoclaving for 60 min resulted in 62.50% reduction of polyphenol content which is quite similar to reported values.

Effect of extrusion cooking

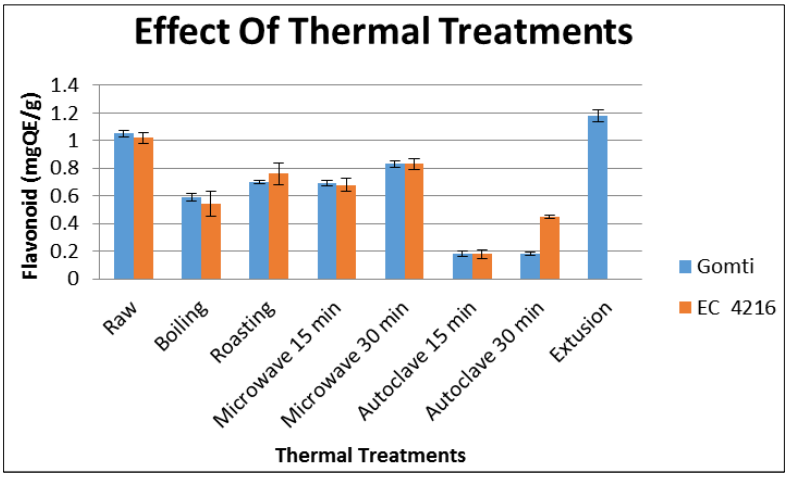
Extrusion cooking is a versatile process that combines several unit operations including mixing, shearing, conveying, heating, puffing and partial drying, depending on the extruder design and process conditions. The Extrusion cooking resulted in an increase (10-13%) of TFC in the Gomati cultivar. In a study by Antonio *et al*., 2013 also showed Extrusion cooking resulted in an increase (4.1-8.2%) of TFC

in the three desi chickpea cultivars. This increase could be related to the extrusion temperature (155ºC) and the release of bound flavonoids, which decreased during processing, or Maillard reaction products formed during extrusion. Maillard reaction involves condensation reactions between sugars and amino acids and it has been found to be linked to polyphenols via inhibition of polyphenol oxidase.

Table 5: Effect of thermal processing on flavonoid content of cowpea cultivars

Thermal Treatments	Processing time	Cowpea cultivars	
		Gomati	EC-4216
Raw	0 min	1.05±0.02^{e}	1.02±0.04^{e}
Boiling	90 min	0.59±0.03^{b}	0.54±0.09^{bc}
Roasting	45 min	0.70±0.01^{c}	0.76±0.08^{d}
Microwave	15min	0.69±0.02^{c}	0.68±0.05^{e}
	30 min	0.83±0.02^{d}	0.83±0.04^{e}
Autoclave	15min	0.18±0.02^{a}	0.18±0.03^{a}
	30 min	0.18±0.01^{a}	0.45±0.01^{e}
Extrusion		1.18±0.04^{f}	-

1. Results are given as the means ± standard deviation (SD) on dry weight basis.
2. Values in the same column followed by the same superscript letters are not significantly different at $P = 0.05$.
3. Values in parentheses indicate a decrease or increase, expressed as a percentage of raw cowpea seeds.



Graph 3: Effect of thermal processing on flavonoid content of cowpea cultivars

5. Effect of bioprocessing on flavonid content of cowpea

Table 4.4 represents effect of two bioprocessings that is germination and fermination on the flavonoid content of two cowpea cultivars. Bioprocessing causes significant reduction in flavonoid content in both cowpea cultivar. However, germination causes reduction in the range of 38% to 75% while fermentation reduced the flavonoid content by 38% to 65%.

Effect of germination

Germination caused reduction in flavonoid content upto 38-75% in 24, 48 and 72 hrs and reduction increased with time (table 4.4). Germination of EC-4216 caused more reduction than Gomati. Stated that during germination of cereals and legumes phenolic content is degraded by intrinsic phytase. Similar reduction was observed by Ramakrishna (2006) for germination which increases with time. This reduction might have originated from diffusion of phenolic content into water during soaking. Observed that germination of heated cowpea seeds at 12 hr, 24hrs 36 hr and 48 h caused reduction ranged from 8.52 -53.97%.

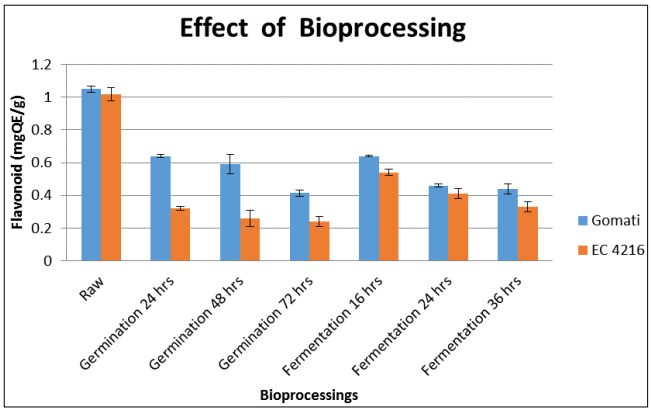
Effect of fermentation

Fermentation of cowpea cultivar for 16 hrs indicate reduction between 38% to 47% in flavonoid content and this reduction increases with time. Cowpea cultivar EC-4216 showed more reduction than Gomati cultivar. The fermentative microorganism phytase hydrolyze phytate into inositol. Reinhold, (1975) has suggested that the loss of flavonoid during fermentation might be due to activity of the enzyme phytase naturally present in the cereals, legumes and tubers. Mahmood *et al*., 2000 reported that period of increased fermentation leads to a significant decrease in polyphenol content.

Table 6: Effect of bioprocessing on flavonoid content of cowpea

Bioprocessing treatments	Processing Time	Cowpea cultivars	
		Gomati	EC 4216
Raw	0 min	1.05±0.02^{d}	1.02±0.04^{e}
Germination	24 hrs	0.64±0.01^{c}	0.32±0.01^{a}
	48 hrs	0.59±0.06^{b}	0.26±0.05^{a}
	72 hrs	0.41±0.02^{a}	0.24±0.03^{a}
Fermentation	16 hrs	0.64±0.005^{c}	0.54±0.02^{d}
	24 hrs	0.46±0.01^{a}	0.41±0.03^{c}
	36 hrs		

1. Results are given as the means ± standard deviation (SD) on dry weight basis.
2. Values in the same column followed by the same superscript letters are not significantly different at $P = 0.05$.
3. Values in parentheses indicate a decrease, expressed as a percentage of raw cowpea seeds.



Graph 4: Effect of bioprocessing

Summary and Conclusion

The present study entitled "Effect of various processing treatments on total flavonid content in different varieties of cowpea", was carried out in order to assess the total flavonoid content in four varieties of cowpea (Gomati, EC-4216, BL-1, BL-2) and to study the effect of various thermal an bio-process treatments. The study observed the effect of various thermal processes like boiling, roasting, microwave, extrusion as well as traditional processes like germination and fermentation on total flavonoid content of selected cultivars of cowpea. It was observed that flavonoids are the most important group of the phenolics family. There is increasing awareness and interest in the antioxidant behavior and potential health benefits associated with phenolics because these compounds have been related to the prevention of chronic diseases, such as cancer, cardiovascular problems and diabetes.

The study concludes that among all cowpea cultivars Bl-1 showed maximum flavonoid content followed by Gomati, EC-4216, and BL-2. Among all thermal processings autoclaving caused highest reduction in TFC of cowpea while roasting caused lowest reduction while extrusion process enhances the TFC by 10% - 13%. Thus optimized extrusion cooking process is a recommended technology for increasing TFC in cowpea cultivars, which could be used as functional foods.

All the traditional process treatment like fermentation and germination causes significant reduction in TFC. Germination (72hrs) showed maximum reduction in TFC followed by Germination (48 hrs & 24 hrs). Fermentation at 36hrs results in maximum reduction while 16 hrs fermentation causes minimum reduction in TFC selected cowpea cultivars. Germination caused more reduction in TFC than fermentation.

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