Effect of co-pressing of niger (*Guizotia abyssinica* Cass.) and black cumin (*Nigella sativa*) seeds on yield, oxidative stability and sensory properties of cold pressed oil

Admasu Fanta

Bahir Dar University, Faculty of Chemical and Food Engineering
P. O. Box 76 Bahir Dar, Ethiopia
Email: fantaadmasu@gmail.com

ABSTRACT

Oxidation is an important problem in edible oil industry. This is relevant when the edible oil is composed of poly unsaturated fatty acids that are prone to oxidation. This study was performed to investigate the effectiveness of black cumin seed co-pressing on improving oxidative stability (OS) of niger seed oil (NSO) without adversely affecting its sensory quality. Four black cumin seed (BCS) with levels (0, 5, 10 & 15%) were co-pressed with niger seed (NS) at two screw speeds (SS) (28.9 and 46.6 rpm). Oil yield, Rancimat induction period (IP), and sensory attributes were measured. No significant interaction of SS and BCS level was observed to influence oil yield ($p>0.05$). However, SS has imparted a significant influence on oil yield ($p<0.05$). The oil yield obtained by 28.9 rpm SS was found to be higher at all levels of BCS. IP was significantly affected by the interaction of SS and BCS level ($\alpha<0.05$). Progressive increase of BCS level was more effective in improving IP at the 28.9 rpm SS than at 46.6 rpm. Most sensory attributes of BCS co-pressed NSO samples significantly deteriorated as BCS level was increased beyond 5% ($\alpha<0.05$). Application of BCS co-pressed NSO in *Shiro Wot* preparation (cooked sample) however was best accepted by panelists at 10% BCS level in all sensory attributes. The present study suggested that BCS co-pressing at 5 and 10% levels improves the stability and sensory property of NSO for raw and cooked edible food application respectively.

Keywords: Black Cumin Seed, Co-pressing, Screw Speed, Oxidative Stability, Niger Seed Oil
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INTRODUCTION

Despite its unfamiliarity in the world oilseed trade as well as its being minor oil crop in India and other African countries, niger is one of the most important edible oil crops in Ethiopia providing 50 to 60 % of the indigenous edible oils (Dutta *et al.*, 1994, Riley and Belayneh, 1989). Though it is considered by the international scientific community as a new non-conventional supply of seed oils due to its high linoleic acid content and high nutritional value (Remedan and Moersel, 2002), NS is an oil seed that humans have cultivated for approximately 5000 years (Ramadan *et al.*, 2009).

The use of niger as a source of edible oil, after production at household level through pounding it by wooden mortar and pestle of lightly roasted seed together with added boiling water and transferring the pounded mash into an earthen pot which is rotated manually in order to let the oil migrate to the top and separated by decanting the oil known by the name of *Kiba Noug*, has been practiced since time immemorial. *Kiba Noug* preparation is still continued to be practiced at households of rural setting. Francis and Campbell (2003) described that the oil extracted from the seed of niger crop is the preferred food oil in Ethiopia. This long established use of fresh niger seed oil (NSO) in the Ethiopian cuisine could not be as advanced as it is demanded by consumers. This may be partly because of low stability nature of NSO against oxidation resulting in rapid development of rancid off odor upon relatively short storage period. The higher proportion of polyunsaturated fatty acids, its relative low amount of unsaponifiable matter, its low total phenolics and polar lipids , have been reported to be among the possible reasons for NSO's slow oxidative stability (Ramadan and Mörsel, 2004).

Oxidized lipids not only result in objectionable flavors and odors, loss of color and nutrient value, but also generate potentially toxic compounds which may be detrimental to the health of consumers (Luzia *et al.*, 1997; Wsowicz *et al.*, 2004). One of the most effective ways of retarding lipid oxidation and hence increasing shelf life of oils and oil products is to incorporate antioxidants which may be defined as substances that when present at low concentration compared with those of oxidizable substrates significantly delay or prevent the oxidation of that substrate. In doing so, antioxidants slow down the rate at which oxidation occurs. Wsowicz *et al.* (2004) indicated that much interest has developed recently in naturally occurring antioxidants. The appeal in application of natural antioxidants as food additives is also raised because of their potential health benefits. Shaker (2006) and Ramadan (2013) reported the importance of natural antioxidants for human health in decreasing risks of heart disease, their anti-carcinogenic properties and that they are safer than their synthetic counterparts. The well-known synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) were reported by Jayaprakasha *et al.* (2001) to have a restricted usage in foods because they are suspected as being carcinogenic.

Reports have pointed out that blending of edible oils has imparted improved healthiness and functionality to the blend. According to Toliwal *et al.* (2005) oils can be blended to derive the protective advantage due to the presence of specific ingredients that offer protection against oxidation to improve frying recyclability. Researches indicated that BCS is among some oilseeds that possess remarkable antioxidant property making it a suitable candidate to be a component in blending with other less stable edible oils to achieve improved oxidative stability among other nutritional advantages.

In their oxidative stability investigation, Ramadan and Mörsel (2004), suggested BCS oil to be more stable than NSO. The higher oxidative stability of BCS was attributed to its high content of the essential oil thymoquinone and related compounds such as thymol and dithymoquinone (Tekeoglu *et al.*, 2007), which possess antioxidant activities such as quenching of reactive oxygen species (Kruk *et al.*, 2000). Lutterodt *et al.* (2010) also indicated that cold pressed BCS oil contains significant antioxidant property and concluded that it may enhance the oxidative stability of food products in addition to provision of health benefit to consumers. Ramadan and Wahdan (2012) and Ramadan (2013) showed blending BCS oil enhanced markedly the oxidative stability of sunflower and corn oils. Similarly, co-pressing of BCS and NS may enhance oxidative stability of the final oil either without noticeable change or with an extent towards improved sensory property. In the present study, the effect of co-pressing of NS with BCS on yield, oxidative stability and sensory property of the oil was investigated.

MATERIALS AND METHODS

Materials

Niger (*Guizotia abyssinica* Cass.) and black cumin (*Nigella sativa*) seeds were purchased from a local market (Bahir Dar, Ethiopia). The seeds were cleaned to be free of impurities before mixing them for pressing.

Methods

Experimental design

The experiment was a 2 x 4 x 3 factorial design with two screw speeds (28.9 and 46.6 rpm) and four BCS levels (0, 5, 10 and 15% w/w), and each factor-level combination was replicated three times. Batches of one kilo gram blends of BCS and NS were used for pressing. The seed blends were mixed thoroughly and packed in screw capped glass bottle and kept in cool and dry place until pressing. The moisture contents of BCS and NS were 5.54 and 5.18%, respectively.

Pressing of oil

The oil seed blends were subjected to pressing using a bench top oil expeller (IBG MONFORTS Oekotec Company CA59G country). The machine was operated at the speeds of 28.9 and 46.6 rpm. The oil obtained after each pressing was collected and centrifuged at an rpm of 3500 for 20 minutes. The yield of the oil was calculated using the formula (Deli *et al.*, 2011):

$$Oil\ yield\ (\%) = \frac{\text{Mo}}{\text{Ms}}\ x\ 100$$

Where: Mo is weight of the extracted oil and

Ms is weight of the oil seed used

The oil obtained was contained in amber colored and capped glass bottle and was kept in a refrigerator until further tests.

Sample preparation for sensory analysis

Raw oil

The raw oil samples were prepared according to the recommended practice for panel sensory evaluation of edible vegetable oils by (AOCS-Cg2-83). Oil samples (20 mL) were kept in 50-mL closed beakers in an oven at 50 ± 1 ^{O}C for 30 minutes before subjected to sensory analysis.

Cooked oil

The oil samples have been used to prepare *Shiro Wot* following common procedures. Two hundred grams of chopped onions are toasted at low heat until golden brown. Fifty grams of the oil sample is then added to fry the onion for about five minutes. Twenty five grams of Ethiopian spiced pepper and a small amount of water were added and the mixture was cooked for 15 minutes. One hundred and ninety grams of the *Shiro* powder was then added bit by bit and with vigorous stirring to avoid lump formation. The stew was left on mild heat for additional 15 minutes and 10 grams of iodized salt has been stirred in it before it is removed from the heat. A table spoon of the stew was spread on a 10 cm^2 *Injera* (Ethiopian traditional fermented flat bread made of *tef* flour), folded and pined together by a toothpick before it was served for panelists. The samples were coded with a three digit random number.

Determination of oxidative stability

The oxidative stability of the oil samples was determined by the induction period (IP) on Rancimat 743 apparatus (Metrohm, Herisau, model Switzerland) at 110°C and an air flow rate of 18 l/h (ISO6886:2006). Three gram samples were carefully weighed into each of the eight reaction vessels and analyzed simultaneously. Exhaust vapors were collected in deionized water where conductivity was measured until a sudden increase. The end of the induction period (IP), expressed in hours, was determined by the formation of volatile acids measured by a sudden increase of conductivity during a forced oxidation of the oil samples.

Sensory analysis

Sensory analysis of the oil samples was done mainly to judge the influence of black cumin flavor and color on the acceptability of the NSO samples obtained after co-pressing at different BCS levels. The sensory analysis was conducted at two different conditions of the oil samples, raw and cooked. The cooked sample sensory analysis was done to examine the residual black cumin sensory effect after the oil was used to prepare pea flour stew (*Shiro Wot*) which is one of the most frequently consumed Ethiopian traditional dishes. It was carried out assuming that the strength of BCS pungency and bitterness, which becomes progressively intense as BCS level increases, would fade to be mellow and impart acceptable spiciness to the food due to volatilization upon heating during preparation. The strength of the characteristic black cumin sensory property on NSO (raw) and as used in *Shiro Wot* preparation (cooked) was evaluated using a method outlined by Matthäus and Brühl (2003) with some modifications. A five point hedonic scale was used where '1' represented the expression of "dislike strongly" and '5' represented that of "like strongly". The attributes examined were 'smell', 'taste', 'aftertaste', 'color' and 'overall acceptability'. The sensory analysis of both raw and cooked samples was conducted by a five-membered panel of experienced and trained assessors who were women aged between 32 and 43 years of age and normally make decision on edible oil selection, and cook *Shiro Wot* for own household on regular basis.

Data analysis

Data was analyzed using ANOVA through the general linear model (GLM) procedure of the SPSS 20. Least significant difference was used to separate means at $p < 0.05$.

RESULTS AND DISCUSSION

Oil yield

The mean oil yield obtained from co-pressing of NS and BCS blend at 28.9 and 46.6 rpm SS is shown in Figure 1. Only SS has significant influence on oil yield ($p<0.05$). The oil yield obtained by pressing at the lower SS (28.9 rpm) was found to be higher at all levels of BCS. The reduction of oil yield, as af-

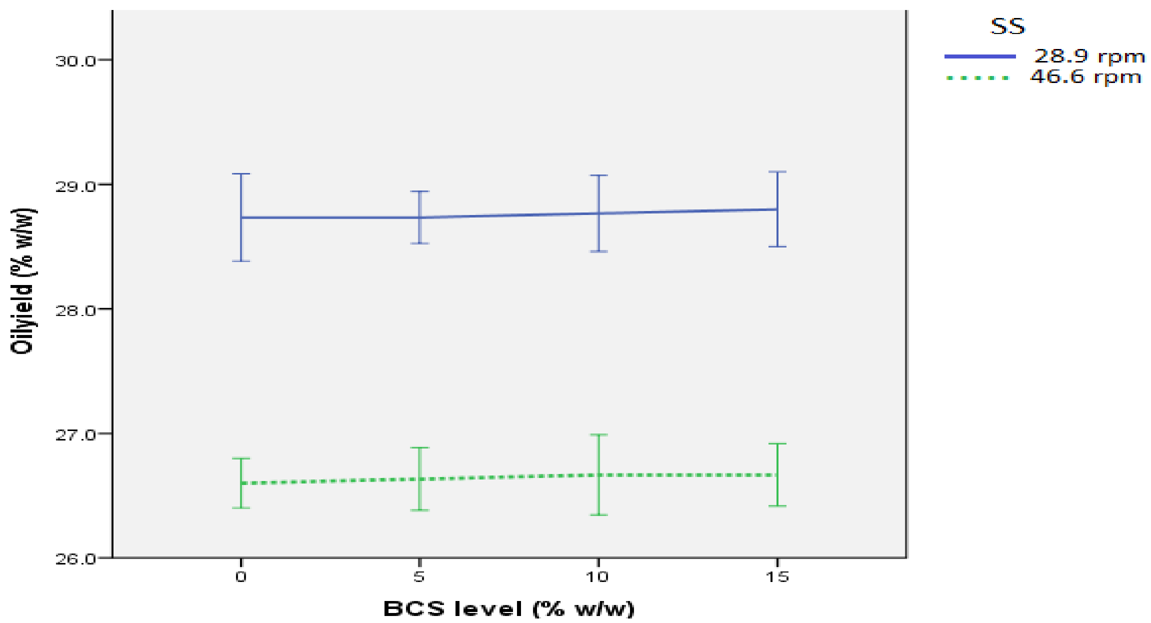

Figure 1. Effect of SS and BCS level on oil yield. All values are means of three measurements and error bars are ±1standard deviation.

fected by the increased SS, is in agreement with previous works. Evangelista (2009) reported that slow screw speed would probably extend the pressing process which may result in increased heating that in turn might result in ease of flow and hence higher oil yield. The decrease in oil yield at higher screw speed may be explained by the fact that higher screw speed increases throughput while leaving less time for the oil to flow out from the meal resulting in reduced extraction rate. Previous research publications also reported that a decrease of rotational speed of screw shaft causes an increase in pressure and a decrease in the efficiency or extraction rate of the screw press (Jacobsen and Backer, 1986, Vadke *et al.*, 1988).

Oxidative stability of the oil

Both SS and BCS level have brought about significant effect on induction period (IP). Increasing BCS level improved the IP. The lower SS (28.9 rpm) has improved the IP better than that of the higher (46.6 rpm). The control sample (0% BCS) didn't bring about significant change in IP irrespective of SS setting. IP was significantly affected by the interaction of SS and BCS level ($\alpha<0.05$) suggesting that increasing BCS level was more effective in improving IP at 28.9 rpm SS compared to at that of 46.6 (Figure 2). The highest IP was recorded at 15% BCS level and 28.9 rpm SS (8.3 hrs.) which was79.7% more than the IP of the control. The least improvement of IP was observed at 5% BCS and 46.6 rpm SS (5.3 hrs.) which still was up by 16.2% compared to the control. The observed progressive improvement of OS of NSO as BCS level increased, which was more pronounced at 28.9 rpm SS, is believed to be associated with the consequent increased concentration of those BCS bioactive compounds responsible to act against the oxidation of NSO. Ramadan and Wahdan (2012) reported that addition of BCS oil to corn oil resulted in a marked decline of peroxide value, which is used as an oxidative index during early stage of lipid oxidation. In addition, increased BCS oil proportion was reported to have further decreased peroxide value of the corn oil signifying its enhanced OS. This increased OS as the level of BCS increased is in line with Singh *et al.* (2014) who reported that ferrous ion chelating effect of BCS oil and its oleoresins, and its scavenging on DPPH radical were directly proportional to concentration. Poiana (2012) also noted the remarkable inhibitory effect of grape seed extract on primary lipid oxidation of sunflower oil upon heating under simulated frying conditions. The grape seed extract has shown progressive enhancement of the inhibitory effect upon increasing of its concentration.

The noticeable further OS improving effect of BCS level at 28.9 rpm SS than that of 46.6 may be associated with the increased extraction of BCS antioxidant components owing to the increased extraction rate at the reduced SS. Even though published research articles on conducting experiment to see the influence of screw speed on oxidative stability of oils were not found, , the increased yield upon pressing at the lower SS and the enhanced IP upon progressive BCS increase may explain the fact that more and more BCS antioxidant compounds were extracted into the NSO. This phenomenon may explain the significant interaction between BCS level and SS. Tasan *et al.* (2011) published a seemingly contrary report that sunflower crude oil extracted by full pressing, which corresponds to low rpm SS, was found out to be inferior in OS and other quality attributes compared to its corresponding pre-pressed sunflower oil expelled at higher SS. However, the result of the present study indicates the need to optimize SS for higher extraction rate of BCS co-pressed NSO while retaining antioxidant properties.

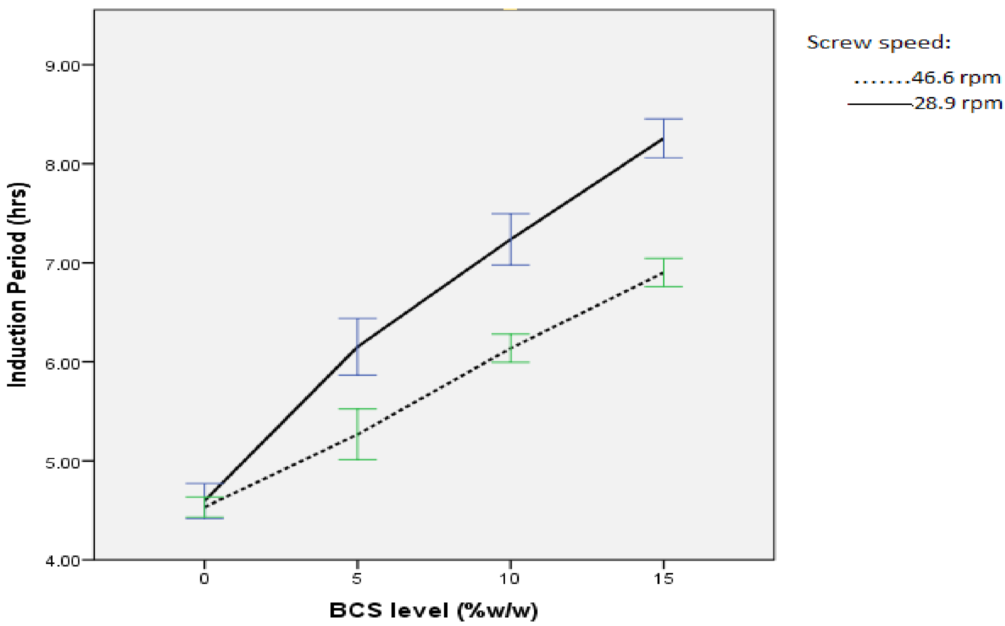

Figure 2. Influence of SS and BCS levels on Induction Period (IP) of NSO. All values are means of three measurements and error bars are ±1 standard deviation.

Effect of BCS level and SS on NSO sensory characteristics

The more and more enhanced IP advantage obtained as the level of BCS increased was not always a phenomenon without adverse effects on the sensory property. The strong pungency and bitterness of BCS on the oil or foods made of it, was assumed to dwindle by the heat of cooking. For this reason, the sensory effect of BCS was studied in two independent conditions as raw and cooked sample.

Only BCS level has brought about significant change on the sensory attributes studied ($\alpha<0.05$). The result indicated that BCS co-pressing with NS has enhanced most sensory attributes at 5 % BCS level of the raw NSO samples (Table1). The highest acceptance of the NSO sample co pressed with 5% BCS may be attributable to the mild extent of pungency and bitterness which could be enough to be used in raw cold pressed oils as acceptable.

Using the oil samples in cooking *Shiro Wot* has significantly improved most of the sensory attributes studied ($\alpha<0.05$). As indicated on Figure 3 all the sensory attributes of *Shiro Wot* were best accepted at 10% BCS level and deteriorated when the BCS increased to 15%. Though it was seen that 15 % BCS has improved after cooking in all attributes compared to its raw counterpart, the extent of improvement was minimum and its acceptance was below average.

The shift in sensory acceptance from 5% (raw) to 10% (cooked) may be explained by the fact that the pungency and bitterness could have been reduced by the heating action that removes volatile compounds. The occurrence of 0.5-1.6 % volatile oil in BCS was reported by Ramadan (2007). Singh *et al.* (2014) and Burits and Bucar (2000) identified the volatile thymoquinone, p-cymene, α-thujene, thymohydroquinone, longifolene, and carvacrol as major compounds of BCS volatile oil which were pointed out by (Kiralan, 2012) to significantly dwindle upon microwave and conventional roasting.

There was significant difference between raw and cooked samples ($p<0.05$) for all sensory attributes and level of BCS, except for color which was not

Table 1. Effect of BCS level and SS on Sensory characteristics of raw and cooked samples*

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%BCS	Smell		Taste		Color		Aftertaste		Overall acceptability	
	28.9 rpm	46.6 rpm	28.9 rpm	46.6 rpm	28.9 rpm	46.6 rpm	28.9 rpm	46.6 rpm	28.9 rpm	46.6 rpm
Condition I: Raw NSO										
0	$3.2^{a}\pm 0.8$	$3.4^{a}\pm 0.6$	$2.8^{a}\pm 0.5$	$2.6^{a}\pm 0.9$	$5.0^{a}\pm 0.0$	$5.0^{a}\pm 0.0$	$3.0^{a}\pm 0.7$	$3.2^{a}\pm 0.5$	$3.4^{a}\pm 0.5$	$3.6^{a}\pm 0.5$
5	$4.4^{b}\pm 0.6$	$4.2^{b}\pm 0.5$	$4.8^{b}\pm 0.5$	$5.0^{b}\pm 0.0$	$5.0^{a}\pm 0.0$	$5.0^{a}\pm 0.0$	$4.8^{b}\pm 0.5$	$4.6^{b}\pm 0.6$	$5.0^{b}\pm 0.0$	$5.0^{b}\pm 0.0$
10	$4.8^{b}\pm 0.5$	$4.8^{b}\pm 0.5$	$2.8^{a}\pm 0.5$	$2.6^{a}\pm 0.6$	$4.6^{b}\pm 0.6$	$4.2^{b}\pm 0.5$	$2.2^{c}\pm 0.8$	$2.2^{c}\pm 0.5$	$2.2^{c}\pm 0.4$	$2.4^{c}\pm 0.5$
15	$4.6^{b}\pm 0.6$	$4.8^{b}\pm 0.5$	$1.8^{c}\pm 0.5$	$1.6^{c}\pm 0.6$	$3.2^{c}\pm 0.8$	$3.4^{c}\pm 0.6$	$1.4^{d}\pm 0.6$	$1.6^{d}\pm 0.6$	$1.2^{d}\pm 0.4$	$1.0^{d}\pm 0.0$
Condition II: NSO cooked in *Shiro Wot*										
0	$3.2^{a}\pm 0.8$	$3.4^{a}\pm 0.5$	$3.2^{a}\pm 0.8$	$3.4^{a}\pm 0.5$	n/a	n/a	$3.0^{a}\pm 0.7$	$3.2^{a}\pm 0.8$	$3.2^{a}\pm 0.8$	$3.2^{a}\pm 0.4$
5	$3.2^{a}\pm 0.4$	$3.4^{a}\pm 0.5$	$3.4^{a}\pm 0.5$	$3.4^{a}\pm 0.5$	n/a	n/a	$3.2^{a}\pm 0.4$	$3.0^{a}\pm 0.6$	$3.4^{a}\pm 0.5$	$3.2^{a}\pm 0.8$
10	$5.0^{b}\pm 0.0$	$5.0^{b}\pm 0.0$	$5.0^{b}\pm 0.0$	$5.0^{b}\pm 0.0$	n/a	n/a	$5.0^{b}\pm 0.0$	$5.0^{b}\pm 0.0$	$5.0^{b}\pm 0.0$	$4.8^{b}\pm 0.5$
15	$5.0^{b}\pm 0.0$	$5.0^{b}\pm 0.5$	$4.2^{c}\pm 0.8$	$4.0^{c}\pm 0.7$	n/a	n/a	$2.4^{c}\pm 0.5$	$2.2^{c}\pm 0.8$	$2.2^{c}\pm 0.8$	$2.2^{c}\pm 0.4$

*Values given are means of the scores given by 5 trained panelist's ± standard deviation. Means in the same column within each condition and in the same row under same sensory attribute with different superscript letters are significantly different ($\alpha < 0.05$).

investigated in cooked samples as it was not applicable owing to the little influence of NSO on the color of the *Shiro Wot* prepared by incorporation of many different ingredients in addition to the evolvement of color as a result of heat. The attribute smell was significantly different only at 5% BCS level indicating lower acceptance for the cooked sample in comparison to that of its raw counterpart. As the level of BCS was increased, it appeared that cooking didn't affect the smell of the sample. The raw sample was significantly different from the cooked one in taste and aftertaste at all levels of BCS except for the control (0% BCS). Raw sample exhibited superior acceptability at 5% BCS level while the cooked one was highly favored at 10 %. As indicated above, the loss of strength of the characteristic black cumin flavor of the cooked sample of the present study may be associated with the loss of volatile oil components exposed to heating for a total of 35 minutes during the *Shiro Wot* preparation.

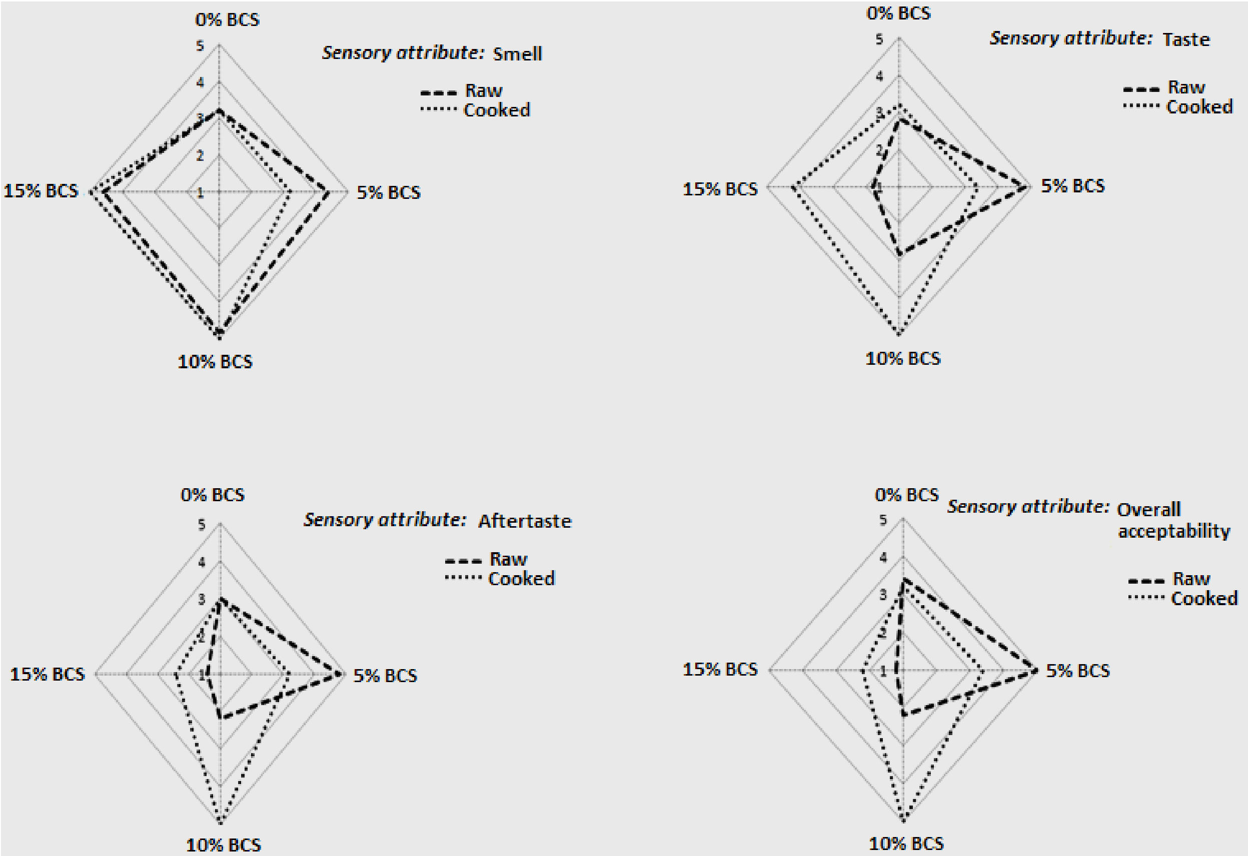

Figure 3. Change of sensory properties of raw versus cooked NSO samples at different co-pressed BCS levels.

CONCLUSION

Cold pressed NS oil co-pressed with BCS has better oxidative stability and organoleptic characteristics than its corresponding oil without BCS co-pressing. The best black cumin seed level recommended to be co-pressed with NS depends upon its end-use application as raw or cooked. Cold pressed NSO co-pressed with 5% BCS would especially be best suited for food preparation practiced without the need to apply heat. The level of BCS could be increased up to 10% for NSO that would be used in cooking.

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