EFFECT OF DIFFERENT EXTRACTION METHODS ON THE QUALITY OF COCONUT OIL

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Abstract

The effect of different extraction methods on the quality of coconut oil was carried out in this research. Coconut oil was extracted from coconut meat by mechanical, solvent extraction and freezing (chilling and thawing) methods respectively. The oil was each analyzed for physicochemical properties following standard methods. Results revealed that the acid value, iodine value, peroxide value and saponification value were respectively 0.25mgKOH/g – 2.04mgKOH/g, 2.60 – 7.54mgKOH/g, 7.28 – 9.24mgKOH/g and 63.31 – 217.22mgKOH/g. The pH and thiobabituric acid values ranged from 4.7 – 5.27 and 1.89 – 2.35mgTBA/kg each. The results were significantly ($p < 0.05$) affected by the various extraction methods. Results also showed that the oil samples were low in vitamin E(1.4% – 1.5%) and vitamin C(3.32% – 3.72%) as well as zinc(1.33 – 1.77mg/l), sodium(1.94mg/l – 2.34mg/l) and potassium(4.22mg/l – 14.18mg/l). The findings of this research showed that the various extraction methods could be used to produce oil of good quality for both domestic and industrial applications.

Key Words: Coconut oil, Freezing, Mechanical, Solvent Extraction

Introduction

Extraction of oils from oilseeds is a major influential step for their commercialization. The extraction process has a direct effect on the quality and quantity of oils obtained. Coconut oil is extracted from fresh and mature kernel of the coconut by natural and mechanical means with or without the use of heat and without undertaking chemical treatment and refining procedure. Various methods like solvent extraction method, dry method and wet methods are available for extraction of coconut oil from coconut kernel (Marina, 2009). Solvent extraction is the use of solvents for oil recovery from food material. The solvent extraction method is a conventional extraction method commonly applied to oilseeds with low oil content (< 20%), like soybean. This method is considered as one of the most efficient methods in vegetable oil extraction, with less residual oil left in the cake or meal

(Taydee*t al*., 2011). The choice of solvent is based mainly on the maximum leaching characteristics of the desired solute substrate (Dutta*et al*., 2015). Solvents commonly used are hexane, diethyl ether, petroleum ether and ethanol. Other considerations are high solvent-solute ratio, relative volatility of solvent to oil, oil viscosity and polarity, as well as cost and market availability (Muzenda*et al*., 2012; Takadas and Doker, 2017). The solvent extraction method offers a number of advantages.

Freezing method consists of a combination of a few separation based on difference in freezing points of thecomponents in coconut milk to extract coconut oil. Advantages of this method includes no heatingabove 40 °C is introduced to the coconut oil thus theantioxidant properties of coconut oil are not reduced byheat. The expeller pressing is a mechanical method that extracts oil from nuts and seeds by using high pressure after conditioning of the food (Foods, 2020). This method generally captures approximately 65% of the oil from the fruit (Cheri, 2014).

Deterioration of oil quality remains a huge problem on storage and or use for other purposes. This deterioration hampers the domestic and industrial application of the oil. Processing methods have been found to exert some effects (positive or negative) on food products and coconut oil is not an exemption. The impact of the different coconut oil extraction methods on quality parameters is yet to be fully examined and made known to the processors, especially in rural areas. The most effective method of extraction in terms of the physical and chemical qualities of the oil ought to be ascertained and made known to the producers and users as well.

Coconut oil has been realized currently to be beneficial for consumption and medicinal. These have raised the demand for the oil over other vegetable oils. Moreover, quality is of paramount importance since the product is being ingested and most production is mainly on small-scale operations. There is the need to research into the local and commercial scale coconut oil processing to identify the processing methods, quality and shelf life of the oil for future development, use and upgrading in the industry. So the main objective of this study is to investigate the effect of extraction techniques (mechanical, solvent extraction and freezing method) on the quality of coconut oil.

Materials and Methods

Solvent extraction (SE), mechanical extraction (ME) and chilling and thawing methods were respectively used to extract the coconut oil. The oil quality analysis was carried out according to AOAC (2015).The data obtained from the analysis was analyzed using analysis of variance (ANOVA) according to the method of Iwe (2002) to determine the variance ratio. Sample means were compared to determine treatment effects. Tukey test was adopted in the calculation of least significance difference (LSD) and separation of means.

Solvent extraction of coconut oil

The coconut oil was extracted from 500g of the crushed coconut meat using 150cm^{3}of n-hexane solvent by means of soxhlet apparatus maintained at a constant temperature of 70°C for five to six hours to activate and release the oil molecule from the crushed coconut meat. Five hundred grams (500g) of the coconut meat was soaked in n- hexane in a wide jar, covered air tightly and stored for 24 hours to allow oil extraction. The oil was separated from the n- hexane by evaporation. At the end of the extraction process, the sample residue was removed from the thimble while the solvent used was recovered by means of rotary evaporator leaving the oil behind.

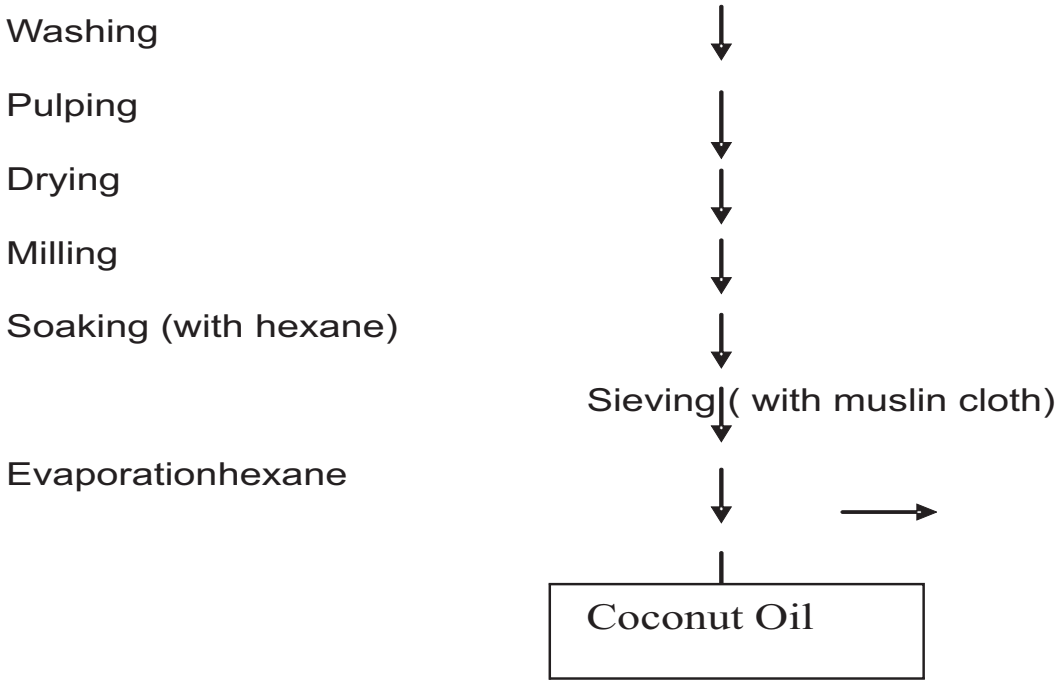

Fig 1: Extraction of coconut oil using solvent method

Mechanical extraction oil coconut oil

Five hundred grams (500g) of the dried coconut meat was crushed into smaller fragment using pestle and mortar. The crushed kernel was then heated in an oven set at 104°C for about one hour before feeding it into the screw press through the feed hopper and the oil extracted using automatic spiral oil press (ZX-10 model)

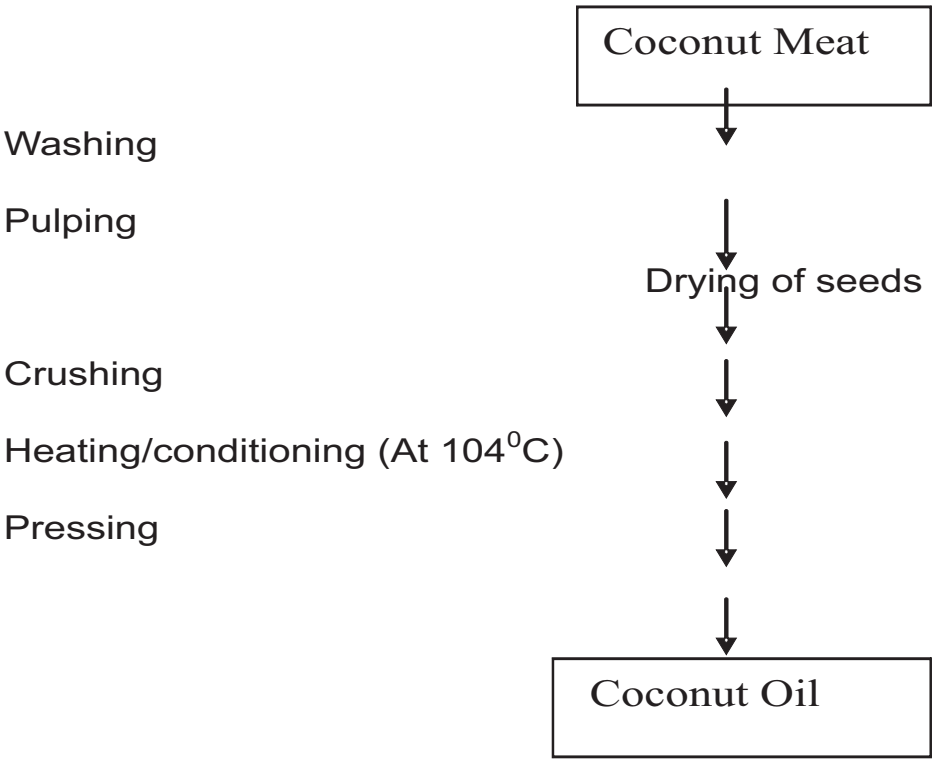

Fig 2: Extraction of coconut oil using mechanical method

Chilling and thawing (Freezing method)

Grated coconut meat (500 g) was mixed with water (1:1), hand kneaded for 5 min and filtered to extract coconut milk. Coconut milk was stirred for 10 min and the upper layer of cream was removed for chilling. Chilling was done at 0°C for 6 hours and then the chilled cream was thawed slowly at room temperature to extract the oil (Raghavendra and Raghavarao, 2011). Centrifugation (Eppendorf centrifuge model 5810-R Hamburg, Germany) was applied (4000 rpm) for 30 minutes at room temperature to obtain coconut cream. Coconut cream was further centrifuged at 4000 rpm for another 30 min to extract the oil. The oil was weighed, flushed with nitrogen and stored in dark at 5°C prior to analysis.

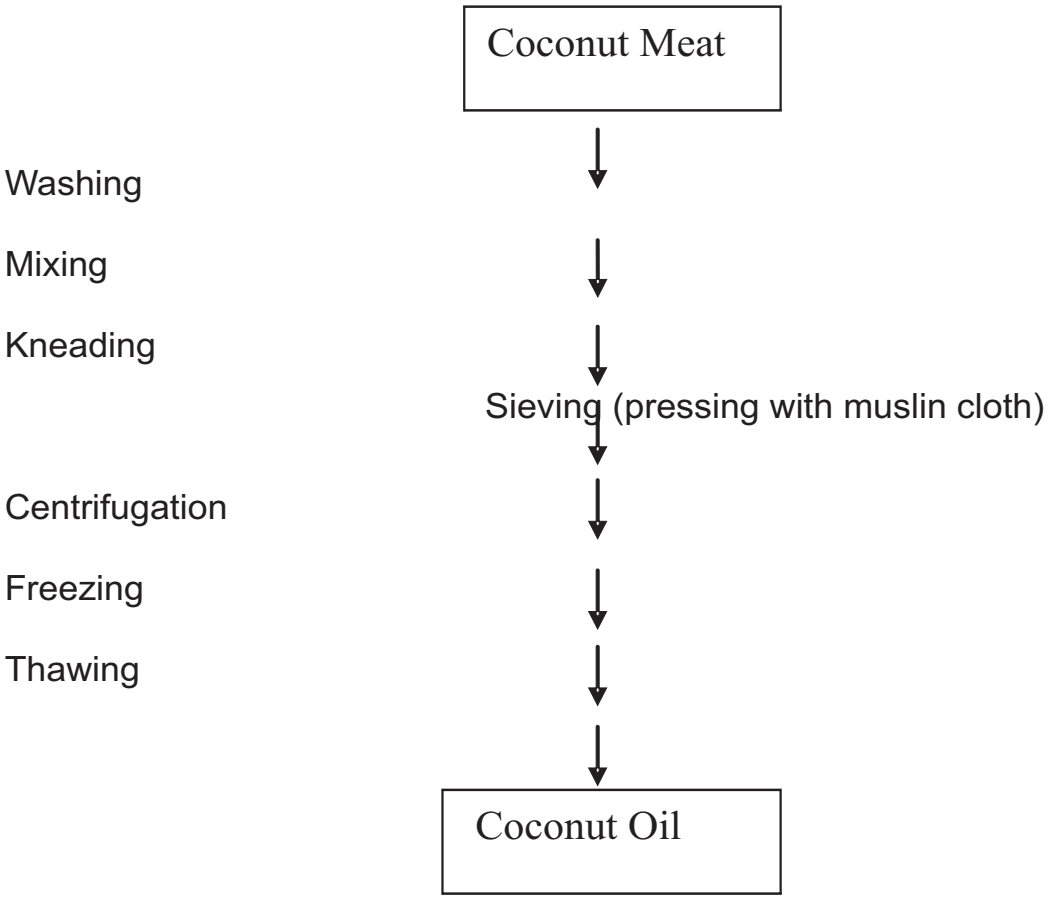

Fig 3: Extraction of coconut oil using solvent method

Results and Discussion

Physicochemical Properties of the Coconut Oil Samples

The moisture content of the coconut oil samples varied from 0.18% to 0.24%(Table 1). The result showed that oil sample extracted by solvent extraction method had the least moisture content (0.18%) followed by oil obtained by mechanical method which has 0.22% moisture while the highest moisture was observed from the sample from freezing method. It is best to keep the moisture content very low to avoid oxidation and rancidity. High moisture content increases hydrolytic rancidity of fats and oils which deteriorates the oil quality (Raghavendra and Raghavarao, 2011). Also 0.18% is below 0.2% recommended for oil stability against rancidity according to Nurah*et al.* (2017).The specific gravity of the coconut oil samples was in the range of 0.88 to 0.63. The values of the specific gravity of the coconut oil samples include 0.63 for the mechanically pressed sample, 0.88 for the solvent extracted sample and 0.71 for the oil obtained from freezing method. The specific gravity of the coconut oil samples (0.63, 0.88 and 0.71) indicate that the oil samples are denser than water and they are low

compared to the range of 0.90 - 0.93 reported for other oils from some common plants in Nigeria (Amira*et al.,* 2014).

The result also showed that the oil obtained from freezing method recorded the highest acid value (2.04mgKOH/g) followed by the mechanically extracted sample with value (1.79mgKOH/g) while the solvent extracted sample had the lowest value (2.39mgKOH/g). This indicates that the method of producing the coconut (solvent extraction method) reduces its acid value more compared to both the pressing and freezing methods. According to Akubugwo*et al.* (2008) acid value is used as an indicator for edibility of oil and suitability for use in the paint industry. The acid values (1.79mgKOH/g, 0.25mgKOH/g and 2.04mgKOH/g) of the coconut oil samples of this work fell within allowable limits for crude coconut oil as given by the Caricom Regional Organization for standard quality (Idu*et al*., 2018).The range of the iodine value of the coconut oil samples is from 2.60mgKOH/g to 7.54mgKOH/g. Significant ($p<0.05$) difference were recorded in all the coconut oil samples analyzed. The result indicates that the sample produced by Oil from solvent extraction method recorded the highest iodine value (7.54mgKOH/g) followed by the mechanically extracted and oil obtained from freezing methods with values 3.20mgKOH/g and 2.60mgKOH/g respectively. Iodine value (IV) is a measure of the degree of unsaturation in oils.The saponification values of the coconut oil samples include 83.80mgKOH/g, 217.22mgKOH/g and 61.31mgKOH/g for samples mechanically extracted, oil from solvent extraction method and frozen respectively. The implication is that the solvent extracted coconut oil sample will serve better in soap making compared to the mechanically extracted and oil obtained from freezing methods. The saponification values in this work (61.31mgKOH/g to 217.22mgKOH/g) are low compared to 282.61mgKOH/g - 284.00mgKOH/g recorded in the findings of Idu*et al.* (2018) on the hot pressed and cold pressed coconut oil.

Table 1: Physicochemical properties of the coconut oil samples

PARAMETER	SAMPLES			
A	BC	LSD		
M. C (%)	0.22[a]	0.18[b]	0.24[a]0.02	
SG0.63[c]±0.02	0.88[a]±0.01	0.71[b]±0.03	0.04	
AV (mgKOH/g)	1.79[b]±0.08	0.25[c]±0.04	2.04[a]±0.05	0.19
IV (mgKOH/g)	3.20[b]±0.02	7.54[a]±0.07	2.60[c]±0.05	0.17
SV (mgKOH/g)	83.80[b]±0.09	217.22[a]±0.12	61.31[c]±0.03	0.30
pH	5.27[a]±0.03	4.71[b]±0.03	4.70[b]±0.02	0.08
PV (mgKOH/g)	8.03[b]±0.09	7.28[c]±0.07	9.24[a]±0.01	0.01
Phenol(mgKOH/g)	0.34[a]±0.04	0.20[b]±0.01	0.39[a]±0.02	0.06
TBA(mgTBA/kg)	1.89[c]±0.08	2.07[b]±0.04	2.35[a]±0.05	0.11

Values are means of triplicate analysis and standard deviation. Means with different superscript along the columns are significantly ($P < 0.05$) different.

M.C = moisture content, SG**=** Specific gravity, AV= Acid value, IV= Iodine value, SV= Saponification value, PV= Peroxide value, TBA= Thiobabituric acid, A = Oil from mechanical method, B = Oil from solvent extraction method, C = Oil from freezing method

The pH value of the coconut oil samples (Table 1) ranges from 4.70 to 5.27.The mechanically extracted sample had the highest pH (5.27) while the least pH (4.70) was recorded in the oil obtained from freezing method. The pH value of the oil samples are comparable to 4.40 to 5.00 recorded in the research of Idu*et al.* (2018). The peroxide values include 8.03mgKOH/g, 7.28mgKOH/g and 9.24mgKOH/g for the mechanically extracted oil, solvent extracted oil and oil from freezing method respectively. Peroxide value (PV) is an indication of deterioration and also the initial stages of oxidation in oil. Peroxide values between 20mgKOH/g and 40mgKOH/g result to rancid taste (Pearson, 2000). Hence the low peroxide values recorded in this work implies that the coconut oil samples are fresh.

From Table 1, the range of the phenol content of the coconut oil samples is in the range of 0.20mgKOH/g to 0.39mgKOH/g. It was observed that the sample produced by using Oil from solvent extraction method (sample B) reduced the phenol content of the coconut oil more compared to the rest of the samples hence the lowest phenol value (0.20mgKOH/g) was recorded in

the sample B followed by the mechanically extracted sample with value 0.34mgKOH/gwhile the oil from freezing method sample had the highest phenol content (0.39mgKOH/g). The thiobarbituricvalues include 1.89mgTBA/kg, 2.07mgTBA/kg and 2.35mgTBA/kg for samples mechanically extracted, extracted with solvent and frozen respectively. The result indicates that the oil obtained from freezing method (sample C) had the highest TBA value 2.35mgTBA/kg while the least value (1.89mgTBA/kg) was recorded in the mechanically extracted sample (sample A). The values obtained from this study exceeded 1 to 2mgTBA/kg which is the sensory threshold level of detecting rancidity (Calhom*et al*., 1999). Hence going by the thiobarbituric acid level of these samples, the coconut oil samples are not safe for direct consumption. The TBA test measures a secondary product of lipid oxidation, Malonaldehyde (Souza *et al.*, 2010).

Mineral content of coconut oil

From the results in Table 2, the potassium content of the coconut oil samples is from 4.22mg/l to 14.18mg/l. It was observed that the oil obtained from freezing method (sample C) had the highest value 14.18mg/l while the lowest value 4.22mg/l was recorded in the sample extracted with solvent (sample B). The oil is a poor source of potassium compared to the daily requirement of 2000-3500mg/day (FAO, 1999). Therefore the oil cannot serve as a dependable source of potassium to human body. Potassium, according to Soetan*et al*. (2010) plays a vital role in protein synthesis, nerve conduction, control of heart beat, muscle contraction and synthesis of nucleic acid.The sodium content of the coconut oil samples is within 1.94mg/l to 2.34mg/l. The oil produced by solvent extraction method (sample B) had the highest sodium content (2.34mg/l) followed by the oil obtained from freezing method (sample C) which had 2.14mg/l sodium content while the oil produced by press method (sample A) had the lowest (1.94mg/l). This oil is a poor source of sodium with reference to 2300mg/day recommended by FAO (1999). Hence the coconut oil samples can be recommended for hypertensive patients or anybody whose blood pressure is tending towards threshold. Sodium keeps fluids and electrolytes balanced in the body and it is essential for muscular contraction and nervous cell communication (Sani*et al.*, 2014).

Table 2: Mineral composition (mg/l) of the coconut oil samples

PARAMETER	SAMPLES			
A B	C	LSD		
Potassium (mg/l)	$4.84^{b}\pm0.01$	$4.22^{c}\pm0.01$	$14.18^{a}\pm0.03$	0.05
Sodium (mg/l)	$1.94^{c}\pm0.05$	$2.34^{a}\pm0.04$	$2.14^{b}\pm0.03$	0.11
Zinc (mg/l)	$1.77^{a}\pm0.04$	$1.33^{c}\pm0.00$	$1.57^{b}\pm0.02$	0.08

Values are means of triplicate analysis and standard deviation. Means with different superscript along the columns are significantly ($P < 0.05$) different.

Note: A = Oil from mechanical method, B = Oil from solvent extraction method, C = Oil from freezing method.

The result revealed that the highest zinc value (1.77mg/l) was found in the mechanically extracted sample (sample A) followed by the oil obtained from freezing method (sample C) with value of 1.57mg/l while the sample extracted with solvent (sample B) had the lowest value 1.33mg/l. Zinc dependent enzymes are involved in macronutrient metabolism and cell replication (Arinola, 2008).

Vitamin Content of Coconut Oil

The result (Table 3) shows that the oil obtained from freezing method (sample C) recorded the highest vitamin C value (3.72%) while the least value (3.32%) was recorded in the mechanically extracted sample. This implies that press method probably preserved the vitamin C content of the coconut oil. In living organisms, ascorbic acid (vitamin C) is an anti-oxidant. It protects the body against oxidative stress (Padayatty*et al*., 2003).

Table 3: Vitamin C and E contents (%) of the coconut oil samples

PARAMETER	SAMPLES			
A	B	C	LSD	
Vitamin C (%)	$3.32^{b}\pm0.12$	$3.71^{a}\pm0.09$	$3.72^{a}\pm0.06$	0.14
Vitamin E (%)	$1.40^{c}\pm0.01$	$1.47^{b}\pm0.02$	$1.50^{a}\pm0.01$	0.02

Values are means of triplicate analysis and standard deviation. Means with different superscript along the columns are significantly ($p < 0.05$) different.

Note: A = Oil from mechanical method, B = Oil from solvent extraction method, C = Oil from freezing method.

The vitamin E values include 1.40%, 1.47% and 1.50% for samples A, B and C respectively. The highest (1.50%) vitamin E content was recorded from the oil obtained from freezing method followed by the sample extracted with solvent (sample B) with value 1.47% while the mechanically extracted (sample A) had the lowest value (1.40%). Vitamin E is a fat-soluble antioxidant that stops the production of reactive oxygen species formed when fat undergoes oxidation (Herrera, 2001).

Conclusion

This study showed the successful production of coconut oil by pressing (mechanical), solvent and freezing method respectively. The oil was found to be low in potassium, sodium and zinc as well as vitamin C and E. The research also revealed that the iodine, free fatty acid and peroxide values were within the standard range stated in literature. The high saponification value further revealed its potential use for industrial purposes (eg. soap making). The qualities of oils generally proved that mechanical, solvent extraction and freezing method are respectively effective and suitable for production of coconut oil.

Recommendation

The extraction of coconut oil using pressing (mechanical), solvent and freezing method is hereby respectively encouraged. This information should be disseminated to the society for both domestic and industrial scale production of coconut oil. Also the consumption of coconut oil is further advised due to its nutrient content such as vitamin E and low sodium. Further investigation on the fatty acid content of the oil should be conducted as well as comparative study of coconut oil from different species of coconuts.

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