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Effect of Pseudo Cereal Flours on Technological, Chemical and Sensory Properties of Pan Bread

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Abstract: Bread is a major staple food consumed daily in all parts of the world. In this study, the wheat flour (WF) replacement with pseudo-cereals such as sorghum flour (SF), millet flour (MF) and buckwheat flour (BF) at level 50 and 100% were used to produce pan bread formulas. The pan bread was evaluated for technological, chemical and sensory properties. The results cleared that, physical evaluation showed that, the specific volume of bread decreased with increasing flour replacement level of pseudo cereal in the blends. Also, In addition, replacement of WF with SF, MF and 100% BWF level causes an increase of hardness compared with 50% level. Chemical properties showed that the replacement WF with 100% MF and BWF increase in mineral content in breads, especially iron, zinc, calcium, potassium, phosphors, magnesium and cupper in comparison with control wheat bread. The bread produced with a 50% SF gave well organoleptic. The result of this study recommended that replacement of WF by pseudo- cereals in manufacture acceptable pan bread with enhance nutritional value.

Key words: Pseudo-cereals · Sorghum · Millet · Buckwheat · Mineral · Hardness

INTRODUCTION

The use of pseudo-cereals for bread making is to fortify the deficiency of nutritional value in wheat flour. Other objective of substitution pseudo-cereals in bread formulation is a very recent development across the globe owing to some economic reasons because wheat imports can be reduced and elevate the use of locally grown grains. However, the capability of the wheat proteins (gluten) to transform wheat flour and water into a glutinous mass is currently limited to wheat, which upon baking, becomes bread [1]. Gluten is important to obtain the desired volume and texture in a dough system through its role in gas retention. The development of a strong protein network required for the viscoelasticity and good dough rheology is therefore essential. Glutenin and prolamin or gliadin is the major fractions in gluten. Prolamin is responsible for viscosity and extensibility in a dough system whereas glutenin develops dough elasticity and cohesiveness [2]**.** Beyond improving the bread appearance, gluten is also important for crumb structure of wheat derived products [3]. Non-wheat flours are typically characterized by their lack of gluten. The resulting dough does not have the cohesive and elastic properties, because of the absence of gluten [4].

Sorghum has actual nutritional value in principle, because of its content of protein, vitamins, fat-soluble (D, E and K) and of B group (except for B12), as well as minerals, such as iron, phosphorus and zinc [5]. Sorghum grain compares favorably with some other cereals: it has a similar protein content to wheat but higher than maize and rice, while the essential amino acid composition of sorghum is comparable to maize or wheat due to the limited content of threonine, arginine and especially, lysine [6]. Iron content of sorghum is lower than millet but is higher than wheat, maize and rice [6]. As a further interesting aspect, sorghum is considered suitable for people with coeliac disease and gluten intolerance due to the lack of gluten [7, 8]. Indeed, individuals with coeliac disease may not consume enough dietary fiber; thus, sorghum whole grains could usefully complement their diets. Grain sorghum contains phenolic compounds like flavonoids which have been found to inhibit tumor development [9]. The starches and sugars in sorghum are released more slowly than in other cereals [10] and that could be beneficial to diabetic patients. Sorghum is consumed into a wide variety of foods, such as baked products, tortillas, couscous, gruel, steam-cooked products semi-leavened breads, popped form, fermented or non-fermented porridges and alcoholic or non-alcoholic beverages [11].

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Millets are the rich source of minerals i.e. calcium, phosphorus, potassium, iron, zinc and higher dietary fibers than rice or wheat and contains 9-14% protein, 70-80% carbohydrates [12, 13]. Millet is nutritionally superior to other cereals and deserves recognition for potential health benefits. Millet can be used as sources of nutraceutical and functional food ingredients in health promotion, mainly due to the antioxidant, antimicrobial, anti-inflammatory, antiviral, anticancer, antiplatelet aggregation and cataract genesis inhibitory activities [14, 15]. Furthermore, millet can be used to develop special foods for coeliacs and diabetics diets as it does not contain gluten and is known to contain a relatively high proportion of unavailable carbohydrate [16]. Aprodu and Banu [17] showed that wheat flour substitution by millet flour in different ratios (10, 20, 30, 40 and 50%) had significant effects on texture and crumb-cell structure of the baked products. The blends containing up to 30% millet flour were favorable for obtaining breads with desirable specific volume, porosity and low rate of firmness increase during storage. High levels of millet flour (40 and 50%) had lower specific volumes and negatively influenced the loaf volume, crumb texture and taste and led to significantly harder and less-cohesive. Incorporating wheat flour (WF) with little millet flour (LMF) at various proportions (10, 30 and 50%) in the bread preparation, Show that the loaf volume, weight, height and specific volume were decreased significantly with increased levels of LMF when substituted with IMF There was an increase in the percentage of micronutrients such as Iron, Zinc, Copper, Phosphorus and also fiber which improved the nutritional value [18]. Kamaraddi and Shanthakumar [19] reported that the substitution of wheat flour with millet flour was possible from the 10% to 20% level. The percentage increase of millet blend was not possible beyond 20% possibly due to the lack of gluten-forming abilities in millets. The percentage of millet in the composite flour blend can be increased by adding some external gluten.

Buckwheat an important raw material for functional food production with balanced amino acid composition, high digestible protein content and high contents of dietary fibre, vitamins, minerals, polyunsaturated essential fatty acids, sterols, flavanoids (rutin, quercetin and quercitrin) and fagopyratol [20-22]. Alvarez-Jubete *et al.* [23] showed that bread prepared from buckwheat flour had significant higher contents of oleic acid, magnesium and dietary fibre in comparison with wheat bread. Bread, biscuits and cakes are traditionally made from wheat flour. Other cereal flours like rye, barley, sorghum and maize have been used either alone or in combination with wheat flour for baked products in various parts of the world. Some studies indicated the possibility of the incorporation of millet flours in wheat flours at various levels [19, 24]. Such composite flours can be used for making bread, biscuits and other snacks. Bhatt and Gupta [25] reported that the composite flour bread was prepared using refined wheat flour, whole wheat flour, whole grain buckwheat flour, whole grain chickpea flour, whole grain sorghum flour, sprouted wheat and sprouted barley flour with an aim to formulate enriched flour which is high in protein, fiber content. These flours not only increase the bread rheology, but also increase the nutritional value of the product.

This study was carried out to preparation and evaluation of pan bread products by using gluten-free pseudo cereals i.e. sorghum, millet and buckwheat flour with wheat flour at the level of 50% and 100% for each flour in order to create the best suitable product.

MATERIALS AND METHODS

Materials: Wheat flour (WF, 72% ext.) was obtained from Five Stars Company, Swiss City, Egypt. Whole Buckwheat grains were obtained from King Saud University, Faculty of Agriculture and Food Science, Saudi Arabia. Sorghum and millet grains were obtained from Field Crops Research Institute, Agricultural Research Center Giza, Egypt. It was milled using Hummer mill to obtain whole meal flour. Whole buckwheat, sorghum and millet flour were sieved through 40 mm sieve to obtain required refined flour from it. Carboxy methyl cellulose (CMC) and di-acetyl tartaric ester of monoglycerides (DATEM) were obtained from Egyptian International Trade Company, Giza. All other ingredients like sugar, salt, yeast and corn oil were purchased from the local market.

Bread Making: The straight-dough method was used for the production pan bread according to the method described by A.A.C.C [26]. The formula used to make breads is shown in Table 1.

Analytical Methods

Proximate Composition of Raw Materials and Bread Samples: Moisture, ash, protein, crude fiber and crude fat were determined according to the method of A.A.C.C. [26]. Minerals content was estimated by atomic absorption spectrophotometer (model 3300, Perkin-Elimer, Beaconsfield, UK) and digestion according to the procedure outlined by A.O.A.C. [27].

Table 1: The formula of pan bread

	Pan bread samples						
Ingredients	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Wheat flour (%)	100	50		50	--	50	--
Sorghum flour (%)	--	50	100	--	--	--	--
Millet flour (%)	--	--	--	50	100	--	--
Buckwheat flour (%)	--	--	--	--	--	50	100
Sugar (%)	5	5	5	5	5	5	5
Corn oil (%)	3	3	3	3	3	3	3
Yeast (%)	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Salt (%)	1	1	1	1	1	1	1
DATEM*	0.6	0.6	0.6	0.6	0.6	0.6	0.6
CMC**	1	1	1	1	1	1	1

*(DATEM) di-acetyl tartaric ester of monoglycerides, **(CMC) carboxymethylcellulose

Physical Measurements of Pan Bread: Loaf weight (g) of the resulting pan bread was measured after cooling for one hour, on digital scale, while loaf volume (cm^3) of bread was measured using rapeseed replacement method according to the procedure of A.A.C.C [26]. Specific volume (cm^3/g) of bread was calculated by dividing loaf volume by its weight.

Texture Profile Analysis of Pan Bread: Bread texture (firmness, cohesiveness and chewiness) was determined using Texture Profile Analyzer (TPA) [28]. Crumb texture was determined by universal testing machine (Conetech, B type, Taiwan) provided with software.

Sensory evaluation: Loaves were organoleptically evaluated for their external and internal properties by a ten stuff members of Food Tech. Res. Inst. Agric. Res. Center, Giza, according to Lawless and Heymann [29].The panelists were asked to score for crust color (10), texture (15), grain (15), crumb color (10), softness (15), aroma (10), taste (20) and overall acceptability (100).

Statistical Analysis: The obtained results were statistically analyzed by analysis of variance (ANOVA) followed by multiple comparisons applying least significant difference (LSD) according to Snedecor and Cochran [30].

RESULTS AND DISCUSSION

Chemical Composition of Raw Materials: Sorghum, millet and buckwheat flour as bread replacement that have high nutritional values pseudo cereals. The obtained results presented in Table 2 indicated that, the chemical composition of raw materials used in preparation of pan bread. It could be demonstrated that, millet flour (MF) contained the highest values in ash and crude fat (2.25 and 3.74%). While buckwheat flour (BWF) contained the highest values in protein, ash, fat and crude fiber (12.19, 2.10, 2.79 and 3.44%, respectively), whereas it was showed the lowest values in total carbohydrates (79.48%) than the flour samples under this study. On the contrary wheat flour (ext. 72%) contained the lowest values of ash (0.54%), crude fat (0.75%) and crude fiber (0.61%), while it showed the highest values in protein and carbohydrate (10.90 and 87.20%). These results are in agreement with previous studies [31-33]. From the same Table 2, it could be noticed that, the pseudo cereals (Sorghum, millet and buckwheat flour) are generally a good source of important minerals [34]. The MF had the highest value of Iron (Fe), Zinc (Zn), Calcium (Ca) and Potassium (K) (6.24, 3.49, 40.3 and 278.60 mg/100g, respectively). While, BWF contained the highest values of Magnesium (Mg), Copper (Cu) and Phosphorus (P) (193, 0.51 and 316.31mg/100g) whereas wheat flour (72% extraction rate) showed lesser contents of some mineral. The above mentioned results are in harmony with other previous findings [32-36].

Chemical Composition of Pan Bread: The chemical composition of the pan bread samples containing different sources of pseudo cereals (sorghum, millet and buckwheat flour) are presented in Table 3. Data show that, the samples of pan bread which contains 100% MF had the highest value of ash and crude fat. This may be due to the MF is a good source of the same previous parameters. Also the samples of pan bread which contains 100% BWF had the highest values in protein, fat and crude fiber. All samples of pan bread except control had protein content ranged from 9.30-11.19%, ash 2.03-3.13%, crude fat 3.79-5.44% and crude fiber 1.19-3.14%, while control pan bread (100% WF) had 10.00% protein, 1.47% ash, 3.03% fat, 0.69% crude fiber and 84.81% total carbohydrate. These results are in agreement with those reported by Angioloni and Collar [31].

Table 2: Chemical composition of raw materials

Components (%)	Wheat flour (WF)	Sorghum flour (SF)	Millet flour (MF)	Buckwheat flour (BWF)
Protein	10.90	10.43	10.13	12.19
Ash	0.54	1.39	2.25	2.10
Crude Fat	0.75	2.65	3.74	2.79
Crude fiber	0.61	2.51	2.00	3.44
Total carbohydrate	87.20	83.02	81.88	79.48
	Minerals (mg/100g)			
Fe	1.48	5.31	6.24	3.51
Zn	0.73	3.14	3.49	2.34
Mg	32.85	78.61	100.08	193
Ca	26.50	24.98	40.3	23.60
K	128.60	227.60	278.60	263
Cu	0.31	0.20	0.28	0.51
P	133.46	275.94	316.31	332

Table 3: Chemical composition of produced pan bread

Parameter (%)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Protein	10.00	9.80	9.58	9.66	9.30	10.65	11.19
Ash	1.47	2.03	2.58	2.42	3.13	2.36	2.91
Crude Fat	3.03	3.79	4.57	4.23	5.44	3.84	4.67
Crude fiber	0.69	1.42	2.30	1.19	1.82	1.85	3.14
Total carbohydrate	84.81	82.96	80.97	82.5	80.31	81.3	78.09

(1) Control 100%Wheat flour 72% ext. (WF); (2) 50% Wheat flour 72% ext. (WF) + 50% Sorghum flour (SF); (3) 100% Sorghum flour (SF); (4) 50% Wheat flour 72% ext. (WF) + 50% Millet flour (MF); (5)100% Millet flour (MF); (6) 50% Wheat flour 72% ext. (WF) + 50% buckwheat flour (BWF); (7) 100% Buckwheat flour (BWF).

Table 4: Mineral contents of pan breads (mg/100 g)

Pan bread	Fe	Zn	Mg	Ca	K	Cu	P
(1)	1.75	0.64	29.81	29.15	86.08	0.23	87.28
(2)	3.65	1.70	50.57	28.54	119.77	0.19	133.87
(3)	3.69	2.76	71.33	27.70	153.66	0.15	180.46
(4)	4.14	2.85	60.31	37.02	136.92	0.22	147.08
(5)	6.70	3.07	90.81	44.69	187.36	0.21	206.88
(6)	2.68	1.35	102.47	27.78	131.88	0.31	152.21
(7)	2.77	2.06	175.13	26.17	176.86	0.38	217.13

(1) Control 100%Wheat flour 72% ext. (WF); (2) 50% Wheat flour 72% ext. (WF) + 50% Sorghum flour (SF); (3) 100% Sorghum flour (SF); (4) 50% Wheat flour 72% ext. (WF) + 50% Millet flour (MF); (5)100% Millet flour (MF); (6) 50% Wheat flour 72% ext. (WF) + 50% buckwheat flour (BWF); (7) 100% Buckwheat flour (BWF).

Mineral Content of Pan Bread: Data presented in Table 4 show that, the samples of pan bread which contains MF at level 50 or 100% had the highest values in minerals content (i.e. Fe, Zn, Ca, K and P) compared with control bread. While samples of pan bread which contains BWF at level 50 or 100% had the highest values in Mg and Cu. The increase in their mineral content, especially Fe, Zn, Ca, K, P, Mg and Cu due to their higher amounts in MF and BWF compared to control sample. The above mentioned results are in harmony with previous studies reported by Mannuramath *et al.* [18] and Ragaee *et al.* [35].

Physical Properties of Bread: The effect of replacement of wheat flour with SF, MF and BWF on loaf weight, loaf volume and specific volume is shown in Table 5. It can be noticed that the weights of the bread with level of replacement 50% SF, MF and BWF was similar to breads made with wheat flours (control). The weight of the bread was increased by increasing flour replacement 100% SF, MF and BWF (for each flour). Loaf volumes decreased as flour replacement of SF, MF and BWF of pan bread increased. Highest loaf volume was given by control bread, without any replacement of gluten-free pseudo cereals. Ballolli *et al.* [37] reported a decrease in loaf volume with a progressive increase in the proportion of non-gluten flour such as millet flour. Higher specific volume is desirable for good quality of bread [38]. Also, data in Table 5 show that, the bread specific volume decreased with increasing flour replacement in the blends. The highest bread specific volume for the bread made from 100% wheat flour was (3.30cm^3/g), followed by bread

Table 5: Physical properties of produced pan breads

Pan bread	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)
(1)	110.00	363	3.30
(2)	109.53	360	3.29
(3)	118.55	315	2.66
(4)	110.08	285	2.59
(5)	116.80	269	2.30
(6)	109.73	355	3.24
(7)	119.35	280	2.35

*Average of 10 group of biscuits (measurements/10). (1) Control 100%Wheat flour 72% ext. (WF); (2) 50% Wheat flour 72% ext. (WF) + 50% Sorghum flour (SF); (3) 100% Sorghum flour (SF); (4) 50% Wheat flour 72% ext. (WF) + 50% Millet flour (MF); (5)100% Millet flour (MF); (6) 50% Wheat flour 72% ext. (WF) + 50% buckwheat flour (BWF); (7) 100% Buckwheat flour (BWF).

Table 6: Texture parameters of pan bread over 3 days

Pan breads	Hardness (N)	Cohesiveness	Chewiness
(1)	7.40	0.71	8.20
(2)	10.53	0.69	8.66
(3)	16.73	0.63	13.90
(4)	15.29	0.58	7.40
(5)	17.71	0.56	18.0
(6)	14.66	0.56	5.70
(7)	17.12	0.52	14.80
	1 Day		
(1)	8.80	0.63	8.44
(2)	12.63	0.65	8.91
(3)	17.15	0.59	14.15
(4)	16.32	0.55	7.60
(5)	18.12	0.53	18.52
(6)	15.12	0.53	5.91
(7)	17.94	0.50	14.40
	2 Day		
(1)	10.43	0.58	8.70
(2)	13.31	0.61	9.15
(3)	18.30	0.55	14.70
(4)	17.13	0.52	7.87
(5)	18.91	0.50	18.97
(6)	15.94	0.50	6.09
(7)	18.85	0.47	14.86
	3 Day		
(1)	11.61	0.57	8.98
(2)	14.48	0.58	9.37
(3)	19.06	0.53	15.12
(4)	21.93	0.48	8.18
(5)	19.22	0.47	19.72
(6)	16.29	0.47	6.32
(7)	19.78	0.38	15.41

(1) Control 100%Wheat flour 72% ext. (WF); (2) 50% Wheat flour 72% ext. (WF) + 50% Sorghum flour (SF); (3) 100% Sorghum flour (SF); (4) 50% Wheat flour 72% ext. (WF) + 50% Millet flour (MF); (5)100% Millet flour (MF); (6) 50% Wheat flour 72% ext. (WF) + 50% buckwheat flour (BWF); (7) 100% Buckwheat flour (BWF).

containing 50% SF (3.29 cm^3/g) and bread containing 50% BWF (3.24 cm^3/g). While, lowest specific volume of bread containing 100% MF was (2.30cm^3/g). These results are in agreement with those obtained by Sibanda *et al.* [39], who reported that there was significant decrease in bread volume with sorghum replacement of higher than 20%. Also, increasing the level of millet flour in dough formulations leads to reduced gas-retention capacity of the dough [40]. Therefore, the bread samples with high levels of millet flour (40 and 50%) had lower specific volumes [17].

Textural Properties of Bread: The results from textural analyzer measurements of the bread crumb are shown in Table 6. Pan bread texture was determined as hardness, cohesiveness and chewiness using the Texture profile

Table 7: Sensory evaluation of the produced pan breads

Samples	Crust color (10)	Texture (15)	Grain (15)	Crumb color (10)	Softness (15)	Aroma (15)	Taste (20)	Overall acceptability (100)
(1)	8.0^{c}	13.8^{e}	13.2^{e}	8.0^{c}	13.67^{e}	13.9^{e}	18.6^{e}	89.17^{f}
(2)	6.2^{b}	12.5^{c,d}	12.1^{d}	7.0^{b}	12.54^{c,d}	12.1^{d}	17.5^{d}	79.94^{e}
(3)	5.5^{a}	10.1^{a}	10.7^{b}	6.0^{a}	10.11^{a}	10.9^{b}	15.0^{a}	68.31^{a}
(4)	5.5^{a}	12.1^{c}	11.7^{c,d}	7.5^{b,c}	12.04^{c}	10.3^{a}	15.5^{b}	74.64^{c}
(5)	5.3^{a}	11.4^{b}	10.0^{a}	7.0^{b}	11.30^{b}	10.5^{a,b}	15.5^{b}	71.00^{b}
(6)	5.3^{a}	12.8^{d}	11.8^{c,d}	6.0^{a}	12.84^{d}	11.4^{c}	17.6^{d}	77.74^{d}
(7)	5.1^{a}	13.0^{d}	11.5^{c}	6.2^{a}	12.33^{c,d}	11.4^{c}	16.0^{c}	74.53^{c}

Means within the same columns with the same letters are not significantly ($p<0.05$) different. (1) Control 100%Wheat flour 72% ext. (WF); (2) 50% Wheat flour 72% ext. (WF) + 50% Sorghum flour (SF); (3) 100% Sorghum flour (SF); (4) 50% Wheat flour 72% ext. (WF) + 50% Millet flour (MF); (5)100% Millet flour (MF); (6) 50% Wheat flour 72% ext. (WF) + 50% buckwheat flour (BWF); (7) 100% Buckwheat flour (BWF)

Analyzer (TPA). The crumb hardness is major quality factor in baked goods, as it is strongly associated with consumers' perception of bread freshness [41]**.** Indeed, in white pan bread, most consumers prefer a soft, resilient and short crumb as they relate these attributes to product freshness [42]. Initial hardness of control bread was 7.40N after baking and increased to 8.80, 10.43 and 11.61N on the first, second and third day of storage respectively. As the amount of replacement flours increased (SF, MF and BWF for each) in the blends, the hardness of the pan bread crumb increased on the day of baking, compared with the control bread sample. In addition, replacement of WF with SF, MF and 100% BWF level causes an increase of hardness compared with 50% level of SF, MF or BWF. The lowest hardness was found for bread containing 50% SF (10.53N) followed by bread containing 50% BWF (14.66N)**.** While, the highest hardness bread was (17.71N) found for bread 100% MF. Ballolli *et al*. [37] stated that incorporation of millet has increased the hardness and grainy texture of millet breads. Cohesiveness characterizes the extent to which a material can be deformed before it raptures. It could be noticed that, decreased cohesiveness in all bread by increasing the level of substitution compared with the control (wheat flour). All bread samples replacement with 50% SF, MF and BWF similar cohesiveness on the day of baking. In addition, 100% gluten-free pseudo cereals cause a slight decreased cohesiveness but harder than the control bread sample. A big decrease of cohesiveness during storage negatively influences consumer's acceptance of bread. In the case of chewiness (product of hardness and cohesiveness), replacement of bread at level 50% SF, MF or BWF resulted in reduction of chewiness compared to the control bread sample on the day of baking. Also, noticed that the chewiness is increased in all bread samples during periods of storage.

Sensory Evaluation of Bread: The sensory evaluation scores for the breads prepared from WF with SF, MF and BWF at level 50 and 100% are presented in Table 7. Control bread samples recorded the highest score for all attributes. The maximum acceptance in sensory characteristics of the produced bread was given by pan bread prepared from WF 100% (89.17 score) followed by bread containing 50% SF (79.94 score) and bread containing 50% BWF (77.74 score). In addition, replacement of WF with SF, MF and BWF 100% level had lower score when compared to other breads replacement with SF, MF and BWF at level 50%. The statistical analysis revealed that there was no significant difference among bread containing 50% and 100% MF in crust color and crumb color, while bread containing 50% and 100% BWF were no significant difference in crust color and aroma. Sibanda *et al*. [39] concluded that the crust colour of the bread containing 40% whole buckwheat flour (WBF) and additives was found lower than that of control bread due to the dark colour of the WBF. WBF provided the breads darker crust as a result of natural pigmentation. Also, the addition of WBF as a non-gluten flour diluted the gluten content and weakened the structure of the bread samples**.** In addition, it was not able to reach to 100% replacement without additives. Additives are commonly used in the baking industry to improve the quality of the bakery products. The use of these additives in the bakery products is increasing all over the world because of the advantages they offer.

CONCLUSION

From this study it could be concluded that replacement of wheat flour with sorghum, millet and buckwheat flour 50% and 100%, to enhance the nutritional value of pan bread. It is recommended that incorporation pseudo cereals in bakery products. Also, using pseudo cereals for making gluten-free bakery products for celiac disease.

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