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Quality of Mozzarella Cheese as Affected by Levels of Sun Flower Oil and Storage Period

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Abstract: The effect of levels of sun flower oil and storage period on quality of mozzarella cheese was investigated. Four mozzarella cheese samples were prepared from skim cow milk, standardized at four different levels of sun flower oil (0, 1, 2 and 3%, respectively) and stored at 4±2°C for 40 days. The stored samples were examined for quality changes at 10 days interval. The total solid, fat, ash and titratable acidity increased significantly ($p \leq 0.05$) with the levels of sun flower oil and storage time, while the pH values decreased throughout the storage. The protein content decreased with levels of sun flower oil and increased during storage period. The total volatile fatty acids and formal ripening index showed increasing trend as the levels of sun flower oil increased and storage time progressed. Organoleptic quality of mozzarella cheese revealed that, 2% sun flower oil secured the best acceptability (4.70), followed by 1% (4.60), 3% (4.50) and the worst score (4.00) was recorded for sample 0% sun flower oil.

Key words: Mozzarella cheese, sun flower oil, storage period

INTRODUCTION

Mozzarella cheese is a mild, white fresh cheese made by a special process where the curd is dipped into hot whey then stretched and kneaded to the desired consistency. At one point, mozzarella was made only from water buffalo milk. Now, it is usually made with cow's milk. There are two forms, regular and fresh. Regular mozzarella is available in low-fat and non fat forms and has a semi-soft, elastic texture and is drier than fresh mozzarella. Fresh mozzarella is made from whole milk and has a softer texture and sweet, delicate flavour and is typically packed in water or whey (Kosikowski, 1966).

Mozzarella cheese has been introduced to Sudanese markets very recently and research concerning it in Sudan is very limited. In a survey, 23% of the respondents reported that they had stopped eating dairy products because of their high fat content (Barr, 1990). There is a great deal of emphasis on reduction in fat intake due to research showing significant correlation between fat intake and mortality rates from coronary heart disease (Renaud and Lorgeril, 1992).

Milk fat plays essential organoleptic and functional roles in dairy products, It carries, enhances, releases the flavour of other ingredients and interacts with other ingredients to develop texture, colour, flavour perception, flavour stability flavour generation and the overall sensation of dairy products (Giese, 1996; Kebary *et al*., 1998). Therefore reduced fat cheese that exhibit undesirable lack of flavor and affirm rubbery texture (Banks *et al*., 1989; Anderson and Mistry, 1994). Reduced fat cheese may exhibit the characteristics of traditional full-fat cheese become more popular, because the health. Problems associated with fat such as diabetes, hypertension, atherosclerosis, gallbladder diseases, liver diseases and heart disease (William, 1985; Giese, 1996).

Using fat replacers as a possibility of manufacturing dairy products with a reduced or low fat content has attracted great attention in past few years (Tamine *et al*., 1994; Drake *et al*., 1995; McMahon, 1996; Haque *et al*., 1997; Ma *et al*., 1997). Many commercial fat replacers are available and they can be classified as carbohydrate based, protein based and fat-based fat replacers (Giese, 1996).

All edible oils consumed in Sudan are vegetable oils which are produced locally. The vegetable oils are produced for both local consumption and exportation.

Sun flower oil has been considered as one of the best vegetable oils, due to high linoleum acid content. Biological value of sun flower oil is estimated on the basis the composition of fatty as well as on the content of liposoluble vitamins, particularly the vitamin E. The oil should contain large quantities of linoleum and alpha-tocopherol (Bashir, 1986).

The objective of this study is to study the effect of levels of sun flower oil and storage period on quality of mozzarella cheese.

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MATERIALS AND METHODS

Milk: Fresh cow milk obtained from the Khartoum University dairy farm was skimmed.

Milk fat replacer: Sun flower oil obtained from local market Khartoum North. Sudan.

Rennet: Chr-Hansen's laboratory, Denmark.

Salt: From local market, Khartoum North. Sudan.

Preparation and manufacture of mozzarella cheese: Four mozzarella cheese samples were prepared form skim cow milk which were standardized at four different sun flower oil levels (0, 1, 2 and 3%) heated to 45°C and cool to 37°C. After standardization, the rennet powder was introduced at rate 0.05% (for each 20 liter of milk) and left for 30-40 min for coagulation. After coagulation, the curd was cut in to cubes about 3 centimeter with stainless steel knives and heated for 10 min before stirring and whey is drained. The curds were formed in to blocks and left in open areas to drain off the remaining whey. The drained curd exposed to warm temperature until required acidity reached at critical pH (5.2-5.3). The curd was then put in hot water at 75-80°C and mixed properly for 5 min until a smooth elastic mass was obtained, stretched in to proper forms using stainless steel container for 3 h, slightly salted in 50% cold brine solution (sodium chloride) for 2 h. The cheese removed from the brine dried slightly weighted and packed in polyethylene. The resultant cheese was analyzed for physicochemical and biochemical analysis and organoleptic properties, when fresh and during storage periods of 0, 10, 20 and 40 days interval at 4±2°C.

Physicochemical and biochemical analyses: Cheese sample were analyzed for total solids, fat, ash, titratable acidity and protein according to AOAC (1990). The pH values were measured by using pH meter (model puslmuchen 15-126017, Germany) as described by Newlander and Atherton (1964). Total volatile fatty acid were determined by the direct distillation methods of Kosikowski (1982). The formal ripening index were determined according to Abdel-Twab and Hofi (1966).

Organoleptic properties of cheese: The sensory evaluation of mozzarella cheese was evaluated by scoring procedures described by Ihekoryne and Ngoddy (1985).

Statistical analysis: Statistical analysis were done using the statistical analysis system SAS (1997).

RESULTS AND DISCUSSION

Physicochemical and biochemical properties of mozzarella cheese

Total solid: Table 1 shows changes in total solids (TS) of mozzarella ($p \leq 0.05$) with progress in storage period. Sample 3% sun flower oil gave the highest TS (55.40%) compared to values, 2% (54.00%), 1% (52.50%) and 0% sun flower oil recorded lowest TS (46.50%). The increase in TS of mozzarella cheese during storage could attributed to the decrease in the moisture content and or to difference in sun flower oil (EL-Sheikh, 1997; Siber, 1998; Abdel Razig *et al*., 2002).

Fat content: Table 2 shows changes in fat content of mozzarella cheese during storage as affected by levels of sun flower oil and storage period. The fat content increased significantly ($p \leq 0.05$) with storage time. Sample 3% sun flower oil had the highest fat content (9.45%) significantly ($p \leq 0.05$) higher than respective values of 2% (7.75%), 1% (6.15%) and 0% sun flower oil (2.90%). The fat content increased in all cheese samples due to the loss of moisture content during the storage. The same trend of these results was reported by Kumar and Jha (1997) and Abdel-Hamid *et al*. (2001) and Ali (2011) and Abdel-Razig *et al*. (2001).

Protein content: Table 3 shows changes in protein content of mozzarella cheese as affected by levels of sun flower oil and storage period. The protein content increased significantly ($p \leq 0.05$) during storage whereas increasing level of oil resulted in a substantial increase on protein level, at the end of the storage (40 days) the protein content of 0% sun flower oil was higher than other samples. EL-Koussy *et al*. (1995) found that, the protein content of mozzarella cheese increased during storage. Kim *et al*. (1992) mentioned that, the protein content of cheddar cheese showed a tendency to increase during storage due to the rapid decrease of moisture.

Ash content: Table 4 shows changes in ash content of mozzarella cheese as affected by levels of sun flower oil and storage period. The ash content increased significantly ($p \leq 0.05$) with progress in storage period. Samples 3% sun flower oil recorded the highest (3.85%) compared to values 2% (3.65%), 1% (3.40%) and 0% sunflower oil (2.95%). The increase in ash content of mozzarella cheese during storage could be attributed to the decrease in moisture content (Amer *et al*., 1978; Siber, 1998; Kebary *et al*., 1998; Sameen *et al*., 2008; Abdel-Razig and Babiker, 2009). Ali (2011) found that, the ash content of mozzarella cheese increased during storage period.

Titratable acidity: Table 5 shows changes in titratable acidity of mozzarella cheese as affected by levels of sun flower oil and storage period. The titratable acidity

Table 1: Effect of levels of sunflower oil (%) on total solids (%)* of Mozzarella cheese during storage period

	Levels of sunflower oil (%)			
Storage period (days)	0	1	2	3
0.0	46.50±0.09^{l}	52.50±0.13^{j}	54.00±0.11^{h}	55.40±0.18^{g}
10	49.52±0.12^{k}	55.60±0.15^{g}	56.85±0.13^{e}	58.30±0.16^{bc}
20	51.15±0.08^{j}	56.28±0.14^{f}	57.40±0.17^{d}	58.95±0.18^{b}
30	51.60±0.19^{j}	56.86±0.20^{e}	58.11±0.16^{c}	59.47±0.12^{a}
40	52.05±0.11^{i}	57.25±0.17^{d}	58.58±0.14^{bc}	59.95±0.18^{a}

*Mean±SD having different superscript letters in columns and rows are significantly different ($p \leq 0.05$)

Table 2: Effect of levels of sunflower oil (%) on fat content (%)* of Mozzarella cheese during storage period

	Levels of sunflower oil (%)			
Storage period (days)	0	1	2	3
0.0	2.90±0.08^{n}	6.15±0.02^{j}	7.75±0.05^{i}	9.45±0.06^{f}
10	4.16±0.03^{m}	7.80±0.04^{i}	8.95±0.07^{g}	10.65±0.09^{cd}
20	4.45±0.11^{l}	8.12±0.05^{h}	10.05±0.12^{e}	11.70±0.03^{b}
30	4.58±0.07^{kl}	8.40±0.12^{gh}	10.28±0.09^{d}	11.95±0.04^{ab}
40	4.65±0.06^{k}	8.80±0.13^{gh}	10.75±0.12^{c}	12.16±0.14^{a}

*Mean±SD having different superscript letters in columns and rows are significantly different ($p \leq 0.05$)

Table 3: Effect of levels of sunflower oil (%) on protein content (%)* of Mozzarella cheese during storage period

	Levels of sunflower oil (%)			
Storage period (days)	0	1	2	3
0.0	38.83±0.07^{c}	35.58±0.09^{ef}	33.55±0.08^{hi}	31.82±0.06^{j}
10	40.52±0.11^{b}	37.17±0.06^{de}	35.26±0.13^{f}	33.58±0.16^{hi}
20	40.94±0.04^{b}	37.53±0.18^{de}	35.64±0.19^{ef}	33.94±0.05^{h}
30	41.36±0.18^{a}	37.94±0.14^{d}	35.90±0.12^{ef}	34.25±0.03^{g}
40	41.57±0.17^{a}	38.15±0.14^{c}	36.13±0.16^{e}	34.46±0.13^{g}

*Mean±SD having different superscript letters in columns and rows are significantly different ($p \leq 0.05$)

Table 4: Effect of levels of sunflower (%) oil on ash content (%)* of Mozzarella cheese during storage period

	Levels of sunflower oil (%)			
Storage period (days)	0	1	2	3
0.0	2.95±0.13^{m}	3.40±0.12^{l}	3.65±0.11^{k}	3.85±0.14^{i}
10	3.45±0.15^{l}	3.85±0.18^{i}	3.95±0.17^{h}	4.01±0.16^{g}
20	3.61±0.09^{k}	4.07±0.08^{g}	4.14±0.19^{ef}	4.25±0.09^{d}
30	3.73±0.20^{j}	4.10±0.11^{f}	4.25±0.18^{d}	4.40±0.15^{b}
40	3.95±0.17^{h}	4.22±0.13^{e}	4.32±0.14^{c}	4.55±0.18^{a}

*Mean±SD having different superscript letters in columns and rows are significantly different ($p \leq 0.05$)

increased significantly ($p \leq 0.05$) during storage period. Sample 3% sun flower oil recorded the highest titratable acidity (0.46%) compared to values 2% (0.41%), 1% (0.39%) and 0% sun flower oil (0.37%) EL-Koussy *et al.* (1995) found that, the acidity of mozzarella cheese increased during storage period. The increase in acidity during storage was mainly due to the lactic acid formed by predominating lactic acid bacteria. Abdel-Razig (1996) and Mahran *et al.* (2000). EL-Safty *et al.* (2004) and Sameen *et al.* (2008) mentioned that, the titratable acidity of mozzarella cheese increased during storage.

pH value: Table 6 shows changes in the pH values of mozzarella cheese as affected by levels of sun flower oil and storage period. The pH decreased significantly ($p \leq 0.05$) within storage time. Sample 3% sun flower oil had the lowest pH (4.45) significantly ($p \leq 0.05$) lower than respective values of 2% (4.60), 1% (4.75) and 0% sun flower oil (4.83). The decrease in pH value of samples may be due to an increase in titratable acidity (Kosikowski, 1982; Ghosh and Singh, 1992; EL-Koussy *et al.*, 1995; Kebary *et al.*, 1998; Pintaro *et al.*, 2000; Mahran *et al.*, 2000; EL-Safty *et al.*, 2004).

Total volatile fatty acids: Table 7 shows changes in total volatile acids (TVFA) of mozzarella cheese as affected by levels of sun flower oil and storage period. The TVFA of mozzarella cheese increased significantly ($p \leq 0.05$) with storage time. Sample 3% sun flower oil produced the significantly highest value (27. 50 ml 0.IN NaOH).

El-Zubeir *et al.* (2014) stated that, the volatile fatty acids content of Sudanese soft cheese samples were significantly ($p \leq 0.05$) increased as the storage period progressed, the VFA could be attributed to the lipolytic activity of milk fat. This result may account for the higher lipolytic enzyme activities by the indigenous milk enzymes, or microbial enzymes of intentional and unintentional microorganisms which can have a greater access to the disrupted fat globule membranes by

Table 5: Effect of levels of sunflower oil (%) on titratable acidity (%)* of Mozzarella cheese during storage period

	Levels of sunflower oil (%)			
Storage period (days)	0	1	2	3
0.0	0.37±0.03^{n}	0.39±0.05^{m}	0.41±0.06^{l}	0.46±0.04^{kl}
10	0.64±0.05^{k}	0.70±0.01^{j}	0.75±0.07^{ij}	0.78±0.06^{ij}
20	0.86±0.04^{h}	0.94±0.11^{g}	0.98±0.08^{g}	1.05±0.04^{f}
30	1.08±0.09^{ef}	1.25±0.03^{d}	1.36±0.08^{c}	1.45±0.11^{b}
40	1.11±0.07^{e}	1.35±0.06^{cd}	1.45±0.09^{b}	1.55±0.06^{a}

*Mean±SD having different superscript letters in columns and rows are significantly different ($p \leq 0.05$)

Table 6: Effect of levels of sunflower oil (%) on pH-value* of Mozzarella cheese during storage period

	Levels of sunflower oil (%)			
Storage period (days)	0	1	2	3
0.0	5.45±0.05^{e}	5.24±0.03^{b}	5.15±0.06^{c}	5.05±0.07^{d}
10	5.13±0.02^{c}	5.02±0.09^{e}	4.74±0.08^{h}	4.65±0.11^{jk}
20	5.03±0.03^{de}	4.95±0.05^{f}	4.70±0.06^{i}	4.58±0.02^{l}
30	4.95±0.12^{f}	4.87±0.06^{g}	4.68±0.09^{j}	4.50±0.07^{lm}
40	4.83±0.13^{g}	4.75±0.08^{h}	4.60±0.12^{k}	4.45±0.06^{m}

*Mean±SD having different superscript letters in columns and rows are significantly different ($p \leq 0.05$)

Table 7: Effect of levels of sunflower oil (%) on total volatile fatty acid (ml 0.1NNaOH)* of Mozzarella cheese during storage period

	Levels of sunflower oil (%)			
Storage period (days)	0	1	2	3
0.0	15.00±0.20^{o}	16.50±0.19^{n}	17.60±0.23^{m}	18.75±0.18^{l}
10	19.60±0.17^{k}	20.80±0.16^{i}	21.70±0.15^{h}	22.75±0.25^{g}
20	20.50±0.13^{j}	22.05±0.14^{g}	23.15±0.16^{f}	24.50±0.20^{de}
30	20.80±0.19^{ij}	23.00±0.11^{f}	24.60±0.12^{d}	25.85±0.22^{c}
40	21.25±0.16^{h}	24.15±0.19^{cd}	26.75±0.17^{b}	27.50±0.14^{a}

*Mean±SD having different superscript letters in columns and rows are significantly different ($p \leq 0.05$)

Table 8: Effect of levels of sunflower oil (%) on formal ripening index* of Mozzarella cheese during storage period

	Levels of sunflower oil (%)			
Storage period (days)	0	1	2	3
0.0	20.50±0.15^{m}	23.30±0.13^{l}	25.60±0.16^{k}	27.50±0.12^{i}
10	23.80±0.11^{l}	26.50±0.14^{j}	28.75±0.09^{h}	30.05±0.18^{g}
20	25.40±0.19^{k}	29.30±0.15^{gh}	30.85±0.11^{ef}	32.25±0.17^{d}
30	27.85±0.13^{i}	31.65±0.14^{e}	33.50±0.16^{cd}	35.75±0.18^{c}
40	30.15±0.12^{f}	34.30±0.15^{cd}	37.50±0.17^{b}	39.85±0.14^{a}

*Mean±SD having different superscript letters in columns and rows are significantly different ($p \leq 0.05$)

cream separation and subsequent cheese processing and storage as mentioned by Perotti *et al*. (2005). The volatile free fatty acids of chain length C_2-C_8 were reported to contribute to the cheese flavor (Abdel-Razig, 1996; Mahran *et al*., 2000). Abdel-Razig *et al*. (2002) reported that, the TVFA of Sudanese semi hard cheese increased during storage.

Formal ripening index: Table 8 shows changes in formal ripening index (FRI) of mozzarella cheese as affected by levels of sun flower oil and storage period. The FRI of cheese increased significantly ($p \leq 0.05$) with storage period. Sample 3% sun flower oil had the highest FRI (39.85%) significantly ($p \leq 0.05$) higher than respective values of 2% (37.50%), 1% (34.30%) and 0% (30.15%). Yun *et al*. (1993) mentioned that, the FRI of mozzarella cheese increased during storage period. Abdel-Razig *et al*. (2002) reported that, the FRI of Sudanese semi hard cheese increased during storage period. The changes in FRI of mozzarella cheese ran paralled to protein break down (Abdel-Razig *et al*., 2001; Ali, 2011).

Organoleptic quality of mozzarella cheese

Appearance: Table 9 shows changes in appearance of mozzarella cheese as affected by levels of sun flower oil. and storage period. The score of appearance improved with storage time. Sample 2% sun flower oil gave the best score (4.7) significantly ($p \leq 0.05$) better than 1% (4.5), 3% (4.3) and 0% sun flower oil (4.1). Abdel-Rafee *et al*. (2004) concluded that, the appearance score of mozzarella cheese improved with homogenization and during storage. Sameen *et al*. (2008) and Bashir (1986) reported that, the colour of sun flower oil from Alabama and Minnesota as 1.0 yellow tint and 0.1 red tint 2.0 yellow tint and 0.3 red tint, respectively.

Texture: Table 9 shows changes in texture of mozzarella cheese during storage as affected by levels of sun

Table 9: Effect of levels of sunflower oil (%) and storage period on organoleptic quality* of Mozzarella cheese

	Levels of sunflower oil (%)															
	Appearance (Scores)			Texture (Scores)			Flavour (Scores)			Overall acceptability (Scores)						
SP (day)	0.0	1.0	2.0	3.0	0.0	1.0	2.0	3.0	0.0	1.0	2.0	3.0	0.0	1.0	2.0	3.0
0	2.70±0.09^{i}	3.30±0.08^{gh}	3.50±0.04^{f}	3.10±0.05^{h}	2.80±0.11^{fg}	3.40±0.08^{de}	3.60±0.06^{bc}	3.20±0.04^{f}	2.60±0.08^{gh}	3.60±0.07^{bc}	3.70±0.06^{b}	3.50±0.05^{de}	2.80±0.07^{fg}	3.60±0.03^{bc}	3.80±0.04	3.40±0.05^{de}
10	3.70±0.06^{d}	4.20±0.05^{b}	4.30±0.04^{ab}	4.10±0.07^{c}	3.70±0.05^{d}	4.10±0.02^{bc}	4.20±0.03^{ab}	4.00±0.07^{c}	3.80±0.06^{d}	4.40±0.03^{ab}	4.70±0.02^{a}	4.30±0.04^{b}	3.60±0.06^{bc}	4.40±0.05^{ab}	4.60±0.03^{a}	4.20±0.02^{c}
20	4.10±0.06^{c}	4.50±0.03^{a}	4.70±0.01^{a}	4.30±0.05^{ab}	4.00±0.06^{c}	4.40±0.02^{ab}	4.60±0.01^{a}	4.30±0.04^{b}	4.00±0.05^{c}	4.60±0.02^{a}	4.80±0.01^{a}	4.50±0.03^{ab}	4.00±0.05^{c}	4.60±0.03^{a}	4.70±0.02^{a}	4.50±0.02^{b}
30	3.90±0.07^{d}	4.30±0.06^{ab}	4.50±0.02^{a}	4.20±0.05^{b}	3.80±0.04^{d}	4.20±0.06^{b}	4.40±0.03^{ab}	4.10±0.05^{b}	3.70±0.04^{e}	4.40±0.03^{ab}	4.70±0.02^{a}	4.20±0.06^{b}	3.70±0.05^{e}	4.40±0.04^{ab}	4.50±0.02^{a}	4.20±0.03^{b}
40	3.80±0.09^{de}	4.20±0.06^{b}	4.40±0.05^{ab}	4.10±0.07^{c}	3.60±0.08^{e}	4.00±0.07^{c}	4.10±0.04^{bc}	3.90±0.05^{d}	3.50±0.06^{ef}	4.20±0.04^{b}	4.50±0.03^{a}	4.10±0.05^{b}	3.60±0.03^{bc}	4.10±0.06^{b}	4.30±0.04^{a}	3.90±0.05^{d}

*Mean±SD having different superscript letters in columns and rows are significantly different ($p \leq 0.05$). SP: Storage period

flower oil and storage period. The score of texture improved with storage time then decreased until the end of storage period. Sample 2% sun flower oil gave the best score (4. 6) significantly ($p \leq 0.05$) better than 1% (4.4), 3% (4.3) and 0% sunflower oil (4.0). Abdel-Hamid *et al*. (2001) and Sameen *et al*. (2008) found that, the texture of mozzarella cheese improved during storage period.

Flavour: Table 9 shows changes in flavour of mozzarella cheese during storage as affected by levels of sun flower oil and storage period. The score of flavour of mozzarella cheese improved with storage time. 2% Sun flower oil gave best score (4.8) significantly better ($p \leq 0.05$) than 1% (4.6), 3% (4.5) and 0% sun flower oil (4.0) Sameen *et al*. (2008) stated that, flavour of mozzarella cheese improved during storage. The improvement of cheese flavour, was mainly attributed to the production of acid by lactic acid bacteria (Kosikowski, 1982). Sun flower oil is highly flavoured by the food processing industries because of its lack of colour and odour (Bashir, 1986).

Overall acceptability: Table 9 shows changes in over all acceptability of mozzarella cheese as affected by levels of sun flower oil and storage period. The score of acceptability of mozzarella cheese improved with storage period, Sun flower oil 2% gave the best score (4.7) significantly better ($p \leq 0.05$) than 1% (4.60), 3% (4.5) and 0% (4.0) sun flower oil.

Storage period significantly ($p \leq 0.05$) affected the appearance, texture, flavour and acceptability. The best score (4.70, 4.6, 4.8, 4.7, respectively) were obtained at the day 20 and the worst score (2.70. 2.8, 2.6, 2.80), respectively at the beginning of the storage. Ghosh and Kulkarni (1996) found that, milk containing 3% sun flower oil was the most suitable method for making low-cholesterol mozzarella cheese. Abdel-Rafee *et al*. (2004) observed that, the flavor and appearance score of mozzarella cheese improved during storage while body texture score decreased. Sameen *et al*. (2008) concluded that the sensory attribute of mozzarella cheese (appearance, texture and overall acceptability) were improved during storage period.

Conclusion: Total solids, fat, protein, ash, titratable acidity, FRI and TVFA increased during storage, while the pH values decreased. Overall acceptability of cheese containing 2% sun flower oil was the best than in the other samples followed by 1, 3 and 0% sun flower oil. Storage 20 days is found to be quite satisfactory for mozzarella cheese to obtain good quality.

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