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THE INVESTIGATION OF THE USE OF DRIED *MORCHELLA CONICA* POWDER ON LIPID OXIDATION, COLOUR, TEXTURAL AND SENSORY PROPERTIES OF SUCUKS DURING FERMENTATION

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The influences of dried *Morchella conica* powder (MCP) on quality and sensory properties of sucuks were determined. Sucuks were prepared by adding 0% (control), 1.5% MCP, 3% MCP, 0.02% butylated hydroxytoluene (BHT), and sodium nitrate/nitrite (0.01% $NaNO_3$ /0.005% $NaNO_2$) and lipid oxidation, colour, texture, and sensory features were analysed. Sucuks with the addition of MCP had much lower (P<0.05) peroxide values than with the addition of BHT and nitrate/ nitrite and the control samples. It was found that the L* and a* values of sucuks with the addition of 1.5% and 3.0% MCP decreased significantly (P<0.05) compared to sucuks with nitrate/nitrite and BHT addition and control samples during fermentation. Hardness and chewiness values decreased with the addition of MCP (P<0.05) during fermentation. The sucuks with MCP added at 1.5% and 3% showed the highest overall sensory acceptance. Thus, proper amount of dried MCP addition may be effective on enhancing sucuk quality properties.

Keywords: sucuk, colour, texture, *Morchella conica*

Morchella conica, an edible mushroom species, belongs to the *Morchella* family. *Morchella* spp. are used as delicious, nutritious foods in many countries, but are also widely used in traditional medicine. Recently, *M. conica* has been widely used as functional food and food flavouring material (Meng et al., 2010). The bioactive ingredients of *M. conica* comprise polysaccharides, proteins, fat, mineral elements, and dietary fibre (Meng et al., 2010). A fairly high percentage of insoluble fibre, including chitin and other structural polysaccharides in *M. conica*, appears to be nutritionally beneficial. The existence of essential amino acids is nutritionally contributed, while the proportion of sn-3 fatty acid is negligible (Gençcelep, 2011). Sucuk is the most popular Turkish dry-fermented meat product and manufactured from beef and/or water buffalo meat, sheep tail fat and/or beef meat fat, salt, sugar, various spices (such as garlic, cumin, red/ black pepper), curing salt (sodium nitrite/nitrate), and added starter culture (Gençcelep, 2011). Fermentation is very important in sucuk production, since desired physical quality parametres such as texture, colour, odor, and flavour of sucuks are formed during this period. Colour and texture attributes of sucuks are the two most important factors in customer satisfaction (Bozkurt & Bayram, 2006). Additionally, lipid oxidation is a main problem in production, since sucuk includes high ratio of fat. There are many synthetic antioxidants, such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), nitrite, potassium sorbate, and acidified sodium chloride, in sucuk production to prevent lipid oxidation. But consumers are concerned about the effects of synthetic antioxidants on human health. So consumers prefer more natural additives (Wang et al., 2018). *M. conica* has high antioxidant properties, so it may be used as natural antioxidant

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material (Turkoglu et al., 2006). Many researches reported the antioxidant activity of *Morchella* spp. (Turkoglu et al., 2006; Gursoy et al., 2009; Ozturk et al., 2010). Elmastas and co-workers (2006) reported that ethanolic extracts of *M. esculenta* and *M. vulgaris* scavenged DPPH radicals by 94% and 95% at 180l g ml^{-1}, respectively. Drying is a cheaper method for increasing the shell life of mushrooms. However, information of the influence of dried *M. conica* on lipid oxidation, colour, texture, and sensory properties in sucuks is limited. Thus, the purpose of this study was to examine the influence of dried *M. conica* powder on lipid oxidation, colour, texture, and sensory properties of sucuks, delivering an option for increasing the quality properties and satisfaction of fermented sucuks during ripening.

1. Materials and methods

1.1. Materials

Sun dried *M. conica* was purchased for the experiments from Saklı Orman Company in Tekirdağ. Dried *M. conica* was passed through the blender and pulverised. Fresh boneless lamb meat (shoulder) and beef meat (whole brisket), commercial virgin olive oil, artificial collagen case, spices, salt, tail fat, and sugar were purchased from Coskoy Company in Osmaniye. A mixture of *Lactobacillus plantarum*, *Pediococcus pentosaceus, Staphylococcus carnosus*, and *Staphylococcus xylosus* was provided by Biocarna (Wiesby Biofermentation GmbH, Niebüll, Germany). The rest of the additives such as butylated hydroxytoluene (BHT), sodium nitrate ($NaNO_3$), and sodium nitrite ($NaNO_2$) were provided by Merck.

1.2. Sucuk preparation

Sucuks were produced in Food Engineering Laboratory in Osmaniye. The mixtures of beef and lamb with tail fat, olive oil, starter culture, spices, salt, clean dry garlic, and sugar were used for sucuk dough according to the following proportions; 450 g beef (about 6% fat), 450 g lamb (about 8% fat), 200 g tail fat, 2.1 g olive oil, 11.42 g all spice, 11 g red pepper, 5.5 g black pepper, 18 g salt, 20.76 g garlic, 4.4 g sugar, 5.5 g cumin, 1.1 g cinnamon, and 0.48 g clove. Additives with different percentages, such as dried *M. conica* powder (1.5% MCP and 3% MCP), BHT (0.02%), sodium nitrate/nitrite (0.01% $NaNO_3$/0.005 % $NaNO_2$), were added to sucuk dough. There were no additives in the control sample. The meat was chopped in the grinder (Tefal, HV8 PRO, France). The other ingredients with the exception of the tail fat were added and mixed with chopped meat in a cutter for 15 min. At the same time starter culture was added as a 20 g commercial culture mixture per 100 kg of meat. Sucuk dough was left to rest for 12 h at 0–4 °C, and then the chopped-cooled tail fat was put into the sucuk dough in a cutter. Then, artificial collagen casings (35 Q, Yildiz Food Company, Turkey) of 38 mm diameter were filled with dough under hygienic conditions by the filling machine (Tefal, HV8 PRO, France) at 4 °C (Bozkurt, 2006). The fermentation process was performed under the specified conditions: 1 day at relative humidity (RH) 95% and 24 °C, 2 days at RH 90% and 22 °C, 2 days at RH 80% and 20 °C, 2 days at RH 75% and 20 °C, 2 days at RH 70% and 18 °C, and 3 days at 60% RH and 18 °C.

1.3. Sampling and sample preparation

About 200 g sucuk was homogenised for the determination of lipid oxidation levels of samples (peroxide value). The samples of sucuks were taken from each batch on the 0^{th}, 3^{rd}, 6th, 9th, and 12th days of ripening for analysis. Lipid oxidation (peroxide value), colour, texture, and sensory properties were determined, and all analyses were conducted in triplicate.

1.4. Lipid oxidation

A 10 g sucuk sample was extracted with hexane solution by using Soxhlet extraction device. The extracted lipid (2 g) was dissolved in 50 ml mixture of acetic acid:chloroform (60:40), added to 0.5 ml of saturated potassium iodide solution, and kept in the dark for 5 min. Then 30 ml of distilled water was added to the mixture. The lipid peroxidation was determined by titrating with sodium thiosulphate solution. The peroxide level was described as the oxidised potassium iodide amount, shown as g/100 g of lipid (AOCS, 1990).

1.5. Determination of colour

Sucuks were held at room temperature (20 °C) about 30 min for conditioning. After that, cut surface colour was measured in triplicate. The measurement of colour parameters (L*, a*, b*) was carried out with a Konica Minolta Chroma meter CR 400 (The illuminants: C (Y:93.6; x: 0.3132; y:03193), $D_{65,}$ (Y:93.6, x:0.3157; y:0.3321); aperture: r=15 mm).

1.6. Texture profile analysis (TPA)

Texture profile analysis (TPA) was performed as expressed by Bozkurt and Bayram (2006) with some modifications using Brookfield Texture Analyzer (CT3, Load cell: 4500 g) to detect hardness (g), springiness (mm), cohesiveness, and chewiness (g×mm). For TPA, 38 mm diameter of sucuk samples were cut into cylinders with a height of 20 mm and held for equilibration at room temperature. The conditions were: cylinder probe (50.88 mm diameter); test speed 1 mm/s; pre-test speed 2 mm/s, post-test speed 1 mm/s; compression (strain) 50%; and 4500 g load cell. The data calculation was performed with the Texture Pro CTV1.4 Built 17.

1.7. Sensory analysis

The sensory parameters (ease of cutting, flavour, and colour) of 25 g of sucuk were investigated as twice at each sampling time, by a panel of 20 trained panellists. Three sessions were conducted for sensory analysis. Panellists tested 3 samples and gave scores as 1 (worst) to 10 (best) for flavour and colour of each sample. Cutting score (from 10 (best) to 1 (worst)) was examined by panellists by evaluating whether the sucuk was cut easily or stick to the cutter (Bozkurt & Bayram, 2006). In addition, the overall sensory properties were calculated as

$$\text{Overall sensory quality}=(\text{flavour}\times 0.50)+(\text{colour}\times 0.25)+(\text{cutting}\times 0.25) \qquad \text{(Eq. 1)}$$

1.8. Statistical analysis

All analyses were made in triplicate and they were evaluated with one-way analysis of variance (ANOVA) to find significal differences at $P<0.05$ using the SPSS version 18.0 (SPSS Inc., Chicago, IL, USA, 2009). ANOVA was used to determine the effect of *M. conica* powder on lipid oxidation, colour, texture, and sensory properties within the samples and estimate the degree of variation and significance of difference. Duncan's multiple range test (significance $P<0.05$) was applied to assess the difference between means using the SPSS Statistics software**.**

2. Result and discussion

2.1. Effect of M.conica *powder on lipid oxidation*

Peroxide levels are basic markers of lipid oxidation of meat and meat products, especially sucuks. The influences of BHT, nitrate/nitrite, and MCP incorporation on peroxide levels of sucuks are displayed in Figure 1. There were significant differences (P<0.05) between the values of peroxide of control and groups with incorporated MCP during fermentation. The highest peroxide level was determined in control (30.40), while the lowest was seen in the 3% MCP group (14.90) (Fig. 1). These results could be associated with phenolic substances and flavonoids of *M. conica*, which have high antioxidant capacity. Many studies have reported that *M. conica* has phenolic compounds with antioxidant properties (Elmastas et al., 2006; Turkoglu et al., 2006; Gursoy et al., 2009). The similar study reported that the emulsion type sausages treated with 0.5% w/w *Ganoderma lucidum* powder with 80 ppm nitrite displayed the lowest peroxide value (Ghobadi et al., 2018). Additionally, another study found that incorporation of Shiitake significantly retarded lipid oxidation during storage (Pil-Nam et al., 2015). Similarly, it is mentioned that lipid oxidation was inhibited by the addition of variable concentrations of *Agaricus blazei* Murrill powder to pork sausages (Stefanello et al., 2015).

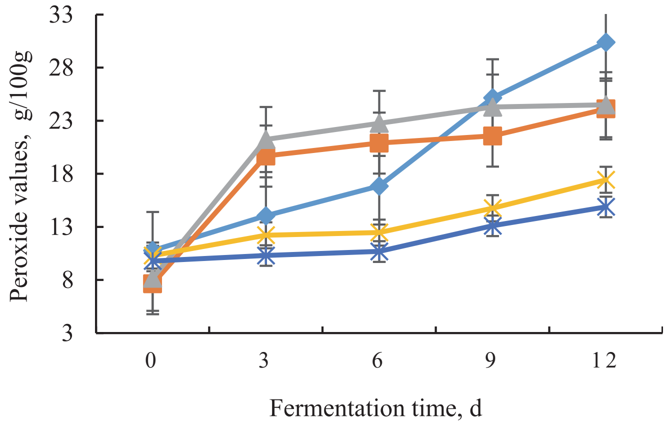

Fig. 1. Effect of *M. conica* powder on lipid oxidation
: Control; : BHT; : Nitrate; : 1.5% MCP; : 3% MCP

2.2. Effect of M.conica *powder on colour properties*

L*, a*, and b* values in sucuks with different levels of MCP, BHT, and nitrate/nitrite addition during fermentation are shown in Figure 2A, B, and C. The lightness (L*) level decreased (P<0.05) during fermentation (Fig. 2A). This reduction in L* value could be associated with the browning reaction (Bozkurt & Bayram, 2006). Similarly, Kayaardi and Gok (2003) and Bozkurt and Bayram (2006) reported that L* values of sucuk decreased during fermentation. During fermentation, the highest L* levels (P<0.05) were obtained in the control and sucuks incorporated with nitrate/nitrite. The L* levels of sucuks with the addition of 1.5% and 3.0% MCP were significantly lower compared to sucuks with added nitrate/nitrite and BHT and control samples (P<0.05). Low L* level of sucuks with addition of MCP could be explained by the fact that dried *M. conica* mushrooms demonstrated lower lightness compared to fresh samples due to the nonenzymatic Maillard process arising during drying (Tian et al., 2016; Wang et al., 2018). The redness (a*) values increased (P<0.05) for all samples during fermentation (Fig. 2B). During fermentation, nitric oxide produced from nitrite formed by the reduction of nitrate reacts with myoglobin to create the red colour desired by the consumer (Ordonez et al., 1999; Bozkurt & Erkmen, 2004). Similar results were obtained by Muguerza and co-workers (2002) that a* values of sucuks increased during ripening. Sucuks incorporated with nitrate/nitrite presented the highest a* values (P<0.05) among all groups during fermentation due to these curing agents that preserve colour in meat products (Fig. 2B). The changes of redness (a*) value with MCP treatment of sucuks were not significant (P>0.05) at the end of fermentation. This result shows that addition of MCP did not affect the a* value of sucuks. At the beginning of the fermentation, b* values of all sucuks ranged 18–22, and then this value decreased to the range of 18–15 by the end of fermentation (Fig. 2C). This reduction may be associated with browning reactions due to melanoidins, which have a brown colour (Bozkurt & Bayram, 2006). Also similar results were reported by Kayaardi and Gok (2003) and Pérez-Alvarez and co-workers (1999). b* values of sucuks supplemented with *M. conica* were higher than with the addition of BHT and nitrate/nitrite and the control samples (P<0.05) at the end of fermentation. This result could be associated with the fact that *M. conica* is an ample resource of dietary fibre. It was found that the fibre with whitish/yellowish colour added to meat caused an increase in b* levels (Henning et al., 2016). In addition, there was no significant difference between b* values of 1.5% and 3.0% MCP groups (P> 0.05). Similarly, Jo and co-workers (2018) found that winter mushroom powder did not adversely affect the colour features of chicken sausages.

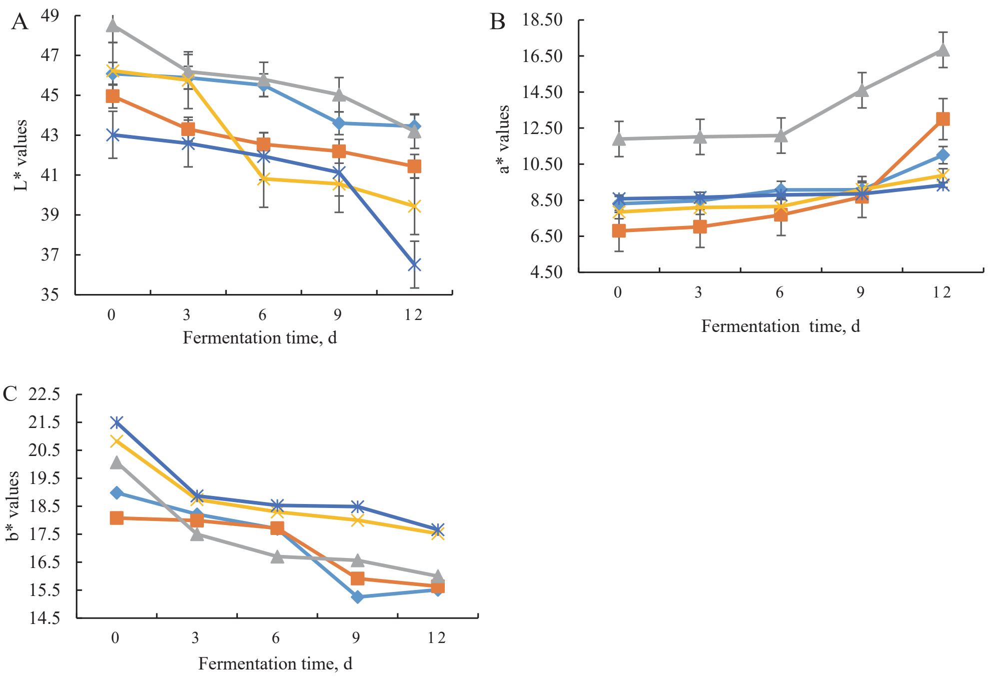

Fig. 2. Effect of *M. conica* powder on colour properties (A: L* values; B: a* values; C: b* values)
: Control; : BHT; : Nitrate; : 1.5% MCP; : 3% MCP

2.3. Effect of M.conica *powder on texture properties*

Texture properties of sucuk (hardness, springiness, cohesiveness, and chewiness) were monitored during fermentation and findings are shown in Figure 3A–D. Hardness value of all sucuk samples increased (P<0.05) during fermentation (Fig. 3A) because of the coagulation of protein at low moisture content and pH (Bozkurt & Bayram, 2006). The highest hardness value was 6555 g in the control samples, whereas the lowest hardness value was 2564 g in sucuks produced with the addition of 3.0% MCP at the end of fermentation (P<0.05) (Fig. 3A). It was found that addition of MCP had significant effect (P<0.05) on the hardness value of sucuks. Chewiness values increased significantly (P<0.05) for all sucuk samples during fermentation (Fig. 3B). The increased chewiness value suggests that the sucuk is becoming of a tougher structure (Szczesniak, 2002). Sucuks with added MCP had lower hardness and chewiness than the control (P<0.05). The MCP reduced the textural values of the sucuks due to the high fibre content of *M. conica*. Similarly, Choe and co-workers (2018) found reduced texture properties in meat and meat products with the incorporation of dietary fibre. Additionally, Wang and co-workers (2019) reported that dried *Flammulina velutipes* addition decreased hardness and chewiness values of sausages. However, in another study, authors indicated that the incorporation of the shiitake mushrooms did not affect the texture of frankfurters (Pil-Nam et al., 2015). The springiness and cohesiveness values of all sucuk samples (P<0.05) decreased from 1.96 mm to 0.22 mm and from 0.85 to 0.62 during fermentation, respectively (Fig. 3C, D). The decrease in springiness, which is associated with the elastic properties of the sucuk, means that the elastic properties of the sucuk are reduced due to the loss of water during fermentation (Bozkurt & Bayram, 2006).

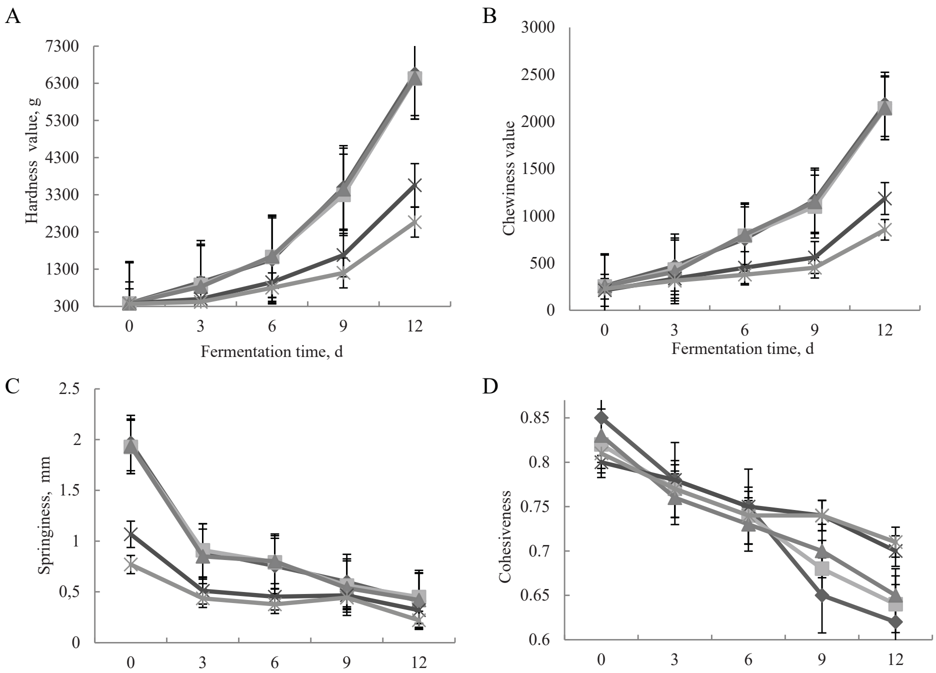

Fig. 3. Effect of *M. conica* powder on texture properties: hardness (A), chewiness (B), springiness (C), and cohesiveness (D)

: Control; : BHT; : Nitrate; : 1.5% MCP; : 3% MCP

Cohesiveness of sucuks with addition of 1.5% MCP and 3.0% MCP was higher than that of the control ($P>0.05$). Springiness of sucuks with the addition of 3.0% MCP was significantly lower than that of control ($P<0.05$). There was no significant difference ($P>0.05$) between springiness values among BHT and nitrate/nitrite added sucuks and the control at the end of fermentation. Wan Rosli and co-workers (2015) reported that the highest cohesiveness and springiness values were seen in chicken frankfurter samples incorporated with 6% oyster mushroom.

2.4. Effect of M. conica *powder on sensory properties*

Flavour, colour, and cutting values of sucuk were deteremined by sensory assay at the end of fermentation. Overall sensory scores from Eq. (1) were analysed and findings are presented in Figure 4. At the end of fermentation, the highest value of flavour was found for sucuks treated with 3% MCP followed by 1.5% MCP, and the lowest value was obtained in the control. This result could be related to mushrooms rich in free amino acids contributing to the flavour features of sucuks (Hospital et al., 2015). Colour scores of sucuks supplemented with *M. conica* powder were lower than the ones with the addition of nitrate/ nitrite ($P<0.05$) at the end of fermentation. This may be related to the nitrite/nitrate providing the desired colour. Cuttting scores were found the same for all samples at the end of fermentation. As for overall satisfaction, the highest score was obtained for sucuks with 1.5% and 3% MCP (Fig. 4). These findings suggest that flavour plays the most important part in customer satisfaction. The similar study found that the addition of shiitake improved flavour and acceptability of frankfurters (Pil-Nam et al., 2015).

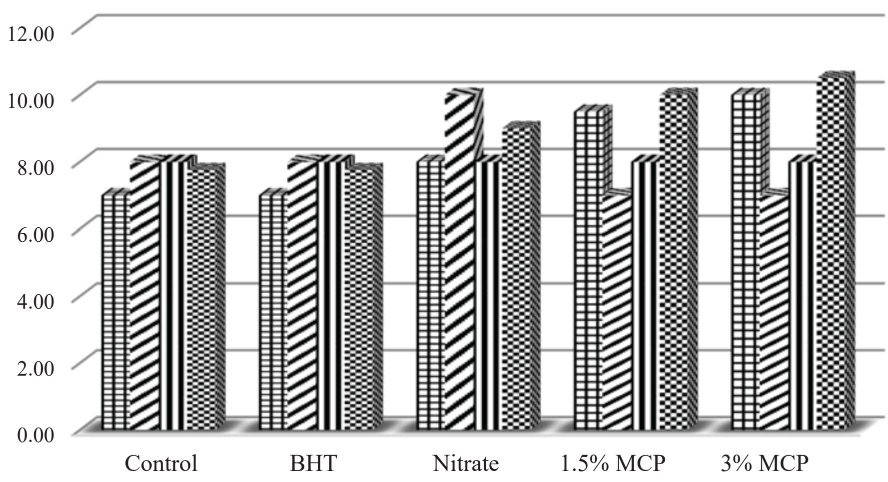

Fig. 4. Effect of *M. conica* powder on sensory properties at the end of fermentation
▦: Flavor sores; ▨: Color scores; ▥: Cutting scores; ▩: Overall sensory scores

3. Conclusions

M. conica is a commercially preferred mushroom species because of its desirable flavour and nutritional compounds. This study denotes that the addition of dried *M. conica* powder could be an option to improve the quality of sucuks by preventing lipid oxidation during fermentation. As for sensory analysis scores, even when *M. conica* powder is added in a small amount to sucuks, it plays an important role in customer satisfaction at the end of fermentation. Future research is needed to improve colour and texture properties of sucuks.

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