***Original Research Article***

**Proximate Composition and Colour profile of Soup-Based Powder Mix using Foam mat Drying**

**Abstract**

This study aimed atdetermining the proximate composition and colour profile of soup-based powder mix using foam mat drying**.** Three different quantities of vegetables (garden eggs: tomato : pepper) was used in the ratio 60:30:10,50:40:10 and 40:40:20 respectively. The moisture, ash, crude fat, crude fiber, and crude protein were determined using standard methods. The Carbohydrate was calculated by difference and the energy was obtained by the Atwater factor. The colour profile of the soup base was determined by standard methods. The results showed moisture, ash, crude fat, crude fiber, crude protein, carbohydrate and energy were 6.33-7.68%, 7.42-8.87%, 0.58- 1.67%, 13.32-19.02%,6.19 -8.88%, 57.45-65.07%, and 203.74 -300.07 kcal/100g respectively. The colour profile showed a range of L\* (46.19-46.31), a\*(9.82-11.33), and b\* (9.84-10.31). The study showed that the soup base powder will provide adequate levels of crude fiber, proteins, carbohydrates, and energy when used as part of a balanced diet. The high crude fiber and moderate carbohydrate level of the soup base samples will be beneficial to consumers especially those who are on weight management. The product's lightness and redness values make it more desirable to customers. Further research can explore how the soup base can be adapted for vegan, or allergen-free dietary needs, and investigate the packaging solutions that enhance soup base powder’s shelf-life.

**Keywords:** Soup, proximate-composition, colour-profile, foam mat drying, vegetables

**1.0 Introduction**

Customers are demanding high-quality food with a fresh appearance, low-calorie content, ease of preparation, sufficient shelf life, and excellent nutritional quality since they are growing more health conscious (Bader *et al.,* 2022). Due to the modern consumer's need for convenience foods, prepared dishes like soups are now taking the place of traditional home-cooked meals (Bader *et al.,* 2022).

The growing need for value of convenience foods from customers may be met by soups, like processed soups, that have health-promoting qualities in addition to being safe, nourishing, natural, and homemade (Bader *et al.,* 2022; Makhungu, & Njue, 2019). Soups are regarded as a nutrient-rich, less processed food that is safe to consume (Manhivi *et al.,* 2020). One of the earliest foods to be prepared for consumption since the invention of jars and pots is soups (Sugumar, & Guha, 2020). Soups can be processed into different varieties such as dehydrated, canned, frozen, instant, and chilled soups. Organoleptic acceptability, nutritional content and quality, and ease of use all have a big impact on soup sales. Around the world, a lot of people eat soups, and depending on the area, culture, and ingredients that are easily accessible, a variety of recipes and ingredients can be used (Chukwu & Oakley 2024). This has led to the development of numerous inventive recipes for different cuisines.

The broad range of raw materials used in vegetable soups and creams has led to their increasing popularity among customers globally. The healthy source of raw materials from the farm or market used in soup formulation can help maintain the good health and well-being of consumers. When canning was developed in the 19th century, commercial soup gained popularity, and there are now many different types of soup available (Sugumar, & Guha, 2022). It is possible to make canned soup "ready-to-eat" or condensed, which requires adding water. Soups can also be marketed as dry soup mixes that must be reconstituted with hot water before consumption. Additional fresh ingredients can then be added to enhance the soup's flavor (Fernández-López *et al.,* 2020). One benefit of dried soup powders is that they are resistant to oxidative and enzymatic deterioration and maintain their flavor for extended periods between 6-12 months at room temperature. Additionally, they can be quickly reconstituted for use by consumers in different fields such as the army, schools, hospitals, and homes.

Vegetables are produced from many distinct kinds of plants and they can undergo deterioration, therefore require preservation. Some vegetable species are cultivated annually because they have a short life span while others have two years life span (Hanan *et al.,* 2020). Different varieties of vegetables are cultivated in Ghana some of which include okra, ayoyo, cabbage, 'kontomire’, alefu, garden eggs and bean leaves, and fruits such as pineapple, banana, and watermelon are grown and eaten (Kpodo & Mensah, 2015). Tomato, pepper, and garden eggs among others which can go bad after harvest, can be preserved into soup-based powder using different preservation methods. One method of getting around perishability issues and guaranteeing a steady supply of high-quality food is to improve the post-harvest handling and processing of the vegetables (Sridhar *et al.,* 2021).

Selection of a suitable drying method is very important in cost and final quality of a dried product. However, essential aspect of ensuring availability, diversification, convenience and transportation have not been purposively pursued (Ezekiel *et al.,* 2021). In addition, there is no combined soup-based powder made from garden tomato and pepper.

In an attempt to reduce this waste, different drying methods have been used but these methods are expensive and have adverse effects on volatiles and bioactive ingredients present in the food products (Buljat *et al.,* 2019; Bogusz *et al.,* 2024). Foam-mat drying is a technique that involves the generation of foam from a liquid. The liquid is aerated to create a stable foam, which is subsequently dried on a foam pad at low temperatures. This method is suitable for heat-sensitive, viscous, and adhesive materials that are unsuitable for alternative drying methods, such as spray drying (Thuy *et al.,* 2022). The foam mat drying method is a quick and affordable substitute for the expensive spray and freeze-drying method. Due to its quick drying at low temperatures, fast reconstitution, and preservation of nutritional value, it is significantly less expensive. (Mohamed *et al.,* 2022; Kadam *et al.,* 2011). The research conducted by Kanha *et al*. (2022), demonstrated that the total anthocyanin content and encapsulation effectiveness of foam-mat-dried powders were comparable to, and in some cases exceeded, those of spray-dried and freeze-dried anthocyanin powders derived from black rice bran. A variety of fruits and vegetables, including mangoes, bananas, and tomatoes, have been dehydrated utilizing foam mat drying technique (Thuy *et al.,* 2022). However, the use of foam mat drying method in producing soup-based powder mix containing different vegetables and proteins has not been studied. This study therefore seeks to determine the proximate composition and colour profile of soup base powder mix using the foam mat drying method.

**2.0 Materials and Methods**

## **2.1 Materials**

The study was carried out using three different quantities of vegetables (garden eggs: tomato : pepper) in the ratio 60:30:10,50:40:10 and 40:40:20 respectively. This study was carried out in Bomaa Senior High School in the Ahafo region of Ghana, at the department of home economics.

## **2.1.1 Preparation of powdered soup mixtures**

Fresh tomato, garden eggs and chili pepper species were obtained from commercial production units and Bomaa market. The vegetables were selected according to their degree of ripeness observed by visual analysis and soluble solids concentration. All vegetables and spices used in this study were obtained from the local markets in Bomaa community. Maturity of vegetables used is shown in table 1.

**Table 1: Vegetables for the soup base preparation**

|  |  |  |  |
| --- | --- | --- | --- |
| Item | Description | Maturity level | Total Quantity/kg |
| 1 | Fresh tomato | Full ripe (red) | 440 |
| 2 | Fresh garden eggs | Yellow ripe | 600 |
| 3 | Fresh chili pepper | Full ripe (red) | 160 |

**2.1.2 Processing of Vegetables into Puree**

About 440kg of tomato was obtained from the Market. The tomatoes were sorted and washed thoroughly under running water to remove any dirt. The stem and any blemish on the tomatoes were cut off. The tomatoes were blanched/ boiled for 3-5 minutes and placed in a bowl of ice-cold water. This was carried out to stop the cooking process. The tomatoes were poured into a blender (Silver Crest 4L (8 BLADES) 8000W, made in Germany) and blended until smooth. The obtained tomato puree was finally poured out into a dry bowl.

About 160kg of pepper was obtained from the market, sorted, and washed thoroughly under running water to remove any dirt or impurities. The stems and any blemishes on the pepper were cut off and the pepper blanched/boiled for 3- 5 minutes. The pepper was removed from the pot with a slotted spoon, and placed in a bowl of ice-cold water to stop the cooking process. The pepper was poured into a blender (Silver Crest 4L (8 BLADES) 8000W, made in Germany) and blended until smooth and finally poured out into a dry bowl.

About 600kg of garden eggs were obtained from the market, sorted, and washed thoroughly under running water to remove any dirt. The stems and any blemishes on the garden eggs were cut off and boiled for 5 minutes. The garden eggs were removed from the pot with a slotted spoon, and placed in a bowl of ice-cold water to stop the cooking process and make it easier to remove the skin. The garden eggs were poured into a blender (Silver Crest 4L (8 BLADES) 8000W, made in Germany) and blended until smooth. The obtained garden egg puree was finally poured out into a dry bowl.

## **2.1.3 Preparation of Egg White into Foam Texture**

Preparation of egg white into foam was adopted from Altalhi, (2013) with few modifications. Egg white foam was prepared using a standard kitchen whisk (Stainless Steel and Silicone Non-Stick Coated Whisk Set, 8") with 5 stainless steel beaters. A 50 g of egg white solutions was weighed into a glass bowl (6.35 cm diameter) and used to make foam by whipping at 20°C for 5 min at normal whipping speed by hand to generate stable foams. Upon completion of whipping, the beaters were removed from the foam gently to minimize disruption of the foam. Each formulation used 10g of whisked egg white foam. An egg was cracked into a mixing bowl and the yolk was removed with a spoon. Using a fork, the egg was whisked and allowed to settle for an hour.

**2.1.4 Preparation of Soup Base Powder Mix**

All the vegetable puree from garden eggs, tomato, and pepper were mixed in a large bowl. The mixture was stirred thoroughly to ensure a homogenous mixture. It was then mixed with whisked egg albumen. The new mixture was spread on a grease-proof paper and dried in a microwave (AILYONS LMO-2003 - Electric Microwave Oven - 20L – White). The dried product was milled into a powered form using an electronic blending machine (Silver Crest 4L (8 BLADES) 8000W, Made in Germany). All the vegetables were processed into powder by using the foam mat dehydration method with a microwave as described.

fresh vegetables (garden eggs, pepper and tomato)

whisking an egg albumen into foam texture (5 minutes). Add 2 tablespoons of egg foam to blended vegetables and mix

sorting, cleaning, and washing

cutting/chopping of vegetables

blanching vegetables for 3-5 minutes

package milled vegetables based on the 3 formulations (1,2 & 3) into zip locks

allow to cool in cool water to stop further cooking

mill the dehydrated product 2-3 minutes (power tech)

blending of vegetables for 2 -3minute using electric blender (power tech)

sieve the milled vegetables by using 40 mesh size (test sieve)

pour 6g of the mixture on grease proof paper and dehydrate it for 5 minutes

transport the samples to the laboratory for analysis

*Figure 1.0 Flow chart of the process of foam mat dehydration of fresh vegetables*.

**2.2 Methods**

**2.2.1 Physicochemical Analysis of Soup base samples**

**2.2.1.1 Moisture**

The AOAC 32.1.03 technique was used to determine the samples' moisture content. Using a pair of tongs, a clean, coded can be cooled to room temperature in a desiccator after being in the oven for 20 mins. The empty can’s weight was measured and recoded (Joanlab Analytical balance FA2003S, Made in China). A weight of roughly 3g of the sample was recorded and put into the container. After spreading the sample throughout the can to promote equal evaporation, the moisture was allowed to evaporate in an air oven (THERMO SCIENTIFIC Precision 3510). It was then transferred into a desiccator to cool after drying. The sample and can were weighed when it was cold. The moisture percentage of the sample was then calculated.

W1=initial weight of sample; W2=weight of the dried sample

**2.2.1.2 Ash**

The ash of the samples was determined using the AOAC 32.1.5 method. Porcelain crucibles were heated and cooled at room temperature. About 3 g of the sample was weighed into the porcelain crucibles and placed into a muffle furnace ( Thermo Scientific Thermolyne F30428C-80 XL)for 8 hours at 550°C. The ash was then cooled in a desiccator to room temperature and weighed.

**Calculations**

**2.2.1.3 Crude Fat**

The extraction beakers, also known as fat flasks, were first carefully cleaned before being dried in a hot air oven to assess the amount of crude fat. After that, it was dried (to avoid moisture content) in a desiccator. A weight and record were kept for the extraction beakers. A non-absorbent cotton was placed in a thimble. A filter paper was used to weigh and fold approximately 1g of dry samples. The filter paper was then placed within the thimble and coated with non-absorbent cotton. After that, the thimble was put inside the extraction beakers, and pet ether was added until the beakers were nearly full. The extraction took almost five hours to complete. After the extraction, the extraction beakers were placed into the oven for the Pet-ether to be evaporated for about 20 minutes followed by cooling of the extraction beakers in a desiccator. The mass of the extraction beakers was weighed and recorded; the percentage of fat present was calculated from the difference in mass.

**2.2.1.4 Crude Fibre**

For the study of crude fiber, the same sample that was used to determine fat was also used. After the sample was defatted, it was put into a 500 ml Erlenmeyer flask, filled with 200 ml boiling H2SO4 at 1.25% and 0.5 g of asbestos, connected to a condenser on a hot plate. Boiling for thirty minutes, the flask's contents were filtered out and the water was cleaned until it no longer had any acidic residue. Re-filling the flask with the leftovers, we linked it to the condenser and boiled it for thirty minutes using 200 milliliters of 1.25% NaOH. After filtering and boiling water and washing until the filtrate was no longer basic, a final washing was performed with 15 milliliters of alcohol. The residues were dried (100℃) in an oven (FISHER Isotemp® Oven, SENIOR MODEL) for an hour. The weight was recorded after allowing it to cool. After being lit for 30 minutes in a muffle furnace, the crucibles and their contents were cooled in a desiccator, weighed, and the weight loss was calculated. The amount of crude fiber was then determined. Each sample underwent the process three times (AOAC, 2010).

W1= Weight of dried sample

W2 = Weight of ashed sample

W3 = Weight of defatted sample

**2.2.1.5 Protein**

The AOAC 4.2.09 technique was used to determine the protein test. First, the samples underwent acid digestion. Following acid digestion using concentrated H2SO4 and Kjeldah tablets as a catalyst, the sample becomes acidic, resulting in the presence of ammonium ions (NH4+). After the material has been digested, the NaOH neutralizes it and produces ammonium gas (NH3). The final product has a modest basicity due to the strong base and comparatively weak acid. The resulting gas evaporates into the titration tank, where the boric acid traps it. After that, titration is performed using the trapped gas NH3 and the titrant HCL.

**Calculations**

This is for when titration is done manually, this formula is used for the calculation of % nitrogen.

Va- volume in ml of standard acid used in titration

Vb- volume in ml of standard acid used in blank

NA- normality of acid

W- Weight of sample taken

**2.2.1.6 Carbohydrate**

The total carbohydrate (including fibre) was determined by difference.

**2.2.1.7 Energy**

The energy value was estimated using Atwater factors.4 (CHO) 4(Protein) 9(Fat).

**2.3 Colour**

Colour was determined according to the method of (Pearl, 2018). The chroma meter (CR-410, Konica Minolta) measured the colour properties of the samples and was recorded in values of CIELAB colour scales. The three-dimensional colour space (L\*, a\*, and b \*), is defined by the L\* value (lightness 0- 100; black to white); a\* value (redness or 0 −60), and the b \* value (yellowness or blueness (0 −60). Before the sample study, the chroma meter was calibrated using a white. coloured tile. The samples were then analyzed in duplicates and their averages recorded

**2.4 Statistical Analysis**

Statistical analyses were conducted using Statistical Package for Social Science (SPSS version 21). Also, descriptive statistics were conducted, and this encompassed means, standard deviation, coefficient of variations as well as significant differences. The Analysis of Variance (ANOVA) was conducted by use of the Duncan test at a confidence level of 95%.

**3.0 RESULTS AND DISCUSSIONS**

**3.1 Proximate composition of soup base powder mix**

The moisture content of the samples ranged between 6.33 and 7.68%, with sample 1 having the highest (7.68%) moisture content and sample 2 having the least (6.33%). There was a significant difference in the moisture content of the samples (p<0.05). This was similar to the findings of Bamidele *et al.* (2015), who reported the moisture content of ogbono powder mix soup to be from 6.20-14.36%. Another research by Loem (2020) reported a low moisture content of 2.67% of Cambodian Korko soup. Manhivi *et al.* (2020), also reported a moisture content of vegetable soup (5.4%) lower than the results obtained in this research work. Sinchaipanit *et al.* (2023), reported a moisture content (5.08-5.30% dehydrated soup base) lower than this research. The differences in these results could be attributed to differences in ingredients used for the various soups as well as drying methods used. The soup base's moderate moisture content is an indication that they have a high shelf value because it may be kept for an extended period of time without going bad (Abubakar *et al.,* 2021). The ash content revealed that sample GTP1 had the highest (8.87%), followed by sample GTP3 (8.68%) and sample GTP2 having the least (7.42%). The ash content of the samples showed a significant difference (p<0.05) however, no significant difference was observed between samples GTP1 and GTP3 (p˃0.05). This was similar to work done by Bamidele *et al.* (2015), and Abubakar et al. (2021), who reported the ash content of instant ogbono powder mix soup and Nigerian traditional soup to be from 6.98-9.20% and 0.5-8.5% respectively. Manhivi et al. (2020), reported an ash content of vegetable soup (9.9%) higher than the results of this study. The nutritional value of food is influenced by its ash content. It provides details on the mineral content, including essential nutrients (Harris *et al.,* 2017). Minerals are essential for human nutrition to maintain the acid-base balance, as well as general physical and mental health (Kalsoom et al., 2021). The high ash content of the soup base samples is indicative of the vital nutrients it can provide to consumers. The fat content of the samples ranged from 0.58 to 1.67%. Sample GTP2 had the highest fat content (1.67%) and sample GTP3 had the least fat (0.58%). There was a statistically significant difference in the fat content of the samples (p<0.05), however, no significant difference was observed between samples GTP1 and GTP2 (p˃0.05). This was similar to work done by Sinchaipanit *et al.* (2023), who reported the fat content of soup to be 1.81%. However, Bamidele *et al.* (2015), reported high fat content of ogbono powder soup mix (20.16-34.62%) than the results of this study. Another study by Abubakar et al., (2021) reported high fat in Nigerian traditional soup (10.50-30.80%) than this study. The ingredients and methods used in these studies could be the reason for the differences. The low-fat content of the soup-base samples would be beneficial to consumers especially those with metabolic issues as it will help in managing high cholesterol (Poli *et al.,* 2021). The fiber content showed significant differences (p<0.05). in the samples with sample 3 having the highest fiber (19.02%), followed by sample GTP1 (15.17%), and sample GTP2 having the least (13.32%). This was in agreement with work done by Manhivi *et al.* (2020), who reported a fiber content of 19% for vegetable soup. The fiber content of the soup base samples in this study was higher than that reported by Bamidele *et al.* (2015), of ogbono powder soup mix (0.26-0.98%). Consuming dietary fiber has many health benefits which include a lower risk of various illnesses, including diabetes, cancer, diverticulosis, constipation, irritable colon, and cardiovascular disorders (Ivanisová *et al.,* 2015). The soup base's high fiber content may be beneficial in preventing these diseases. The protein content of samples GTP1, GTP2, and GTP3 were 8.88%, 6.19% and 7.08% respectively. There was a statistically significant difference in the protein content of the samples (p<0.05). This was different from the work done by Bamidele et al. (2015), of ogbono powder soup mix (18.42-24.13%). However, the protein contents of the soup base samples were similar to the results by Manhivi et al. (2020) and Sinchaipanit et al. (2023), who reported protein content of 7.7% for vegetable soup and 4.9% protein for dehydrated soup base respectively. The amount of protein in food is essential for maintaining muscular function and health as well as overall nutritional balance. Protein's ability to promote fullness can help reduce hunger and prevent overindulging (Nutrients, 2018). The soup-based samples will be a good source of proteins for consumers. The carbohydrate content was highest in sample 2 (65.07%), followed by sample GTP1(57.78%), with sample GTP3 having the least (57.45%). There was a statistically significant difference in the carbohydrate content of the samples (p<0.05). This is not in agreement with work done by Sugumar, and Guha (2020) who reported the carbohydrate content of functional soup mix to be 27.3%. However, Bader *et al.,* (2022) reported higher carbohydrate content of dried vegetable soup (56.41-72.09%). The difference could be due to the different ingredients used. Diets heavy in fiber and carbohydrates have been shown to be effective in promoting weight loss. Additionally, the Tsimane population of hunter-gatherers in South America, who follow a high-carbohydrate diet combined with high-fiber consumption, provides evidence in favor of this diet as they have the lowest rates of chronic disease (Buyken et al., 2018). The high fiber and moderate carbohydrate content of the soup base samples can be beneficial to consumers especially those who are on weight management. The energy levels of the samples revealed that sample GTP2 had the highest energy (300.07kcal/100g) content followed by sample GTP1(281.22 kcal/100g), with sample GTP3 having the least energy content (203.74 kcal/100g). This was significantly (P≥0.05) different from work done by Sinchaipanit *et al.* (2023) who reported the energy levels of vegetable soup to be 105.5 kcal/100g. The development of deficiency disorders can be halted and the risk of toxicity associated with overindulging in some food groups can be decreased with an adequate energy intake and energy balance (Awuchi *et al.,* 2020). The soup base samples can provide adequate energy for consumers (Figure 3).

**Figure 2 Proximate Composition of Soup base samples**

Sample GTP1:60% garden eggs, 30% tomatoes, 10% pepper, Sample GTP2:50% garden eggs, 40% tomatoes, 10% pepper, Sample GTP3:40% garden eggs, 40% tomatoes, 20%pepper,

**Figure 3 Energy Composition of Soup base samples**

Sample GTP1:60% garden eggs, 30% tomatoes, 10% pepper, Sample GTP2:50% garden eggs, 40% tomatoes, 10% pepper, Sample GTP3:40% garden eggs, 40% tomatoes, 20%pepper,

**3.2 Colour profile of soup base samples**

Table 2 shows the colour opponent space with dimensions L\* for lightness and a\* and b\* for the colour opponent dimensions. The Lightness of the samples ranged from 46.19 to 46.31. Sample 2 had the highest lightness (46.31) and sample 1 had the lowest (46.19). There was no statistically significant difference in the lightness of the samples (p>0.05). This was in agreement with work done by Sugumar and Guha (2020), who reported the lightness of the functional soup mix to be 47.85. However, this differed from the work done by Loem (2020) who reported an L\* value of 62.07 for the Cambodian Korko soup base. This difference could be attributed to the different ingredients and methods used. The product's lightness suggests that consumers will choose it when it is available on the market since light colours can increase consumers' satisfaction with consumption and generate favorable thoughts about the product (Cetinkaya, 2022). The red/green coordinates revealed that all samples were statistically significantly different (p<0.05) in the redness from each other with sample 3 having the maximum (11.33) redness followed by sample 2 (9.95) and sample 1 having the minimum (9.82) redness. However, there was no significant difference in the redness of samples 1 and 2 (p˃0.05). The results of this study were higher than what was reported by Sinchaipanit (a\*5.52) of ready-to-eat soup and work done by Sugumar and Guha (2020), (a\*1.93) for Cambodian Korko soup base. The greater redness values imply that the soup has more tempting hues, which will make it more desirable to customers. The results (Table 2) also showed that all the samples were yellow with sample 3 (10.31) having the maximum yellowness and sample 1 having the minimum yellowness (9.84). There was a significant difference in the yellowness of the samples (p<0.05). This result was in agreement with work done by Sugumar and Guha (2020), (b\*9.64) for Cambodian Korko soup base but differed from that reported by Sinchaipanit (b\*56.71) of ready to eat soup. This difference could be attributed to the different ingredients used.

**Table 2 Colour profile of soup base samples**

|  |  |  |  |
| --- | --- | --- | --- |
| Attributes | Samples |  |  |
|  | GTP1 | GTP2 | GTP3 |
| L\* | 46.19±0.10a | 46.31±0.21a | 46.23±0.11a |
| a\* | 9.82±0.21a | 9.95±0.01a | 11.33±0.02b |
| b\* | 9.84±0.02a | 9.95±0.01a | 10.31±0.07b |

*Means of different superscripts in the same row are significantly different at p˂0.05*

**4.0 Conclusion**

The study showed that the soup base powder mix had adequate levels of crude fiber, proteins, carbohydrates, and energy value. The high crude fiber and moderate carbohydrate level of the soup base powder mix will be beneficial to consumers especially those who are on weight management. With regards to the colour profile of the soup base powder mix, the product's lightness and redness values imply that the soup may have more tempting hues, which will make it more desirable to customers. Further research can explore how the soup base can be adapted for vegan, or allergen-free dietary needs consumers, and investigate the packaging solutions that enhance product shelf-life while maintaining colour, flavor, and nutrient integrity.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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