

## Effect of Drying Methods on Phytochemical Composition of Orange Fruit (*Citrus sinensis*, L.) Peel Flour in Biscuit Making

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**Abstract:** Sweet orange fruit (*Citrus sinensis*, L.) peels were dried to constant weight using oven, box solar and sun drying methods. The dried orange fruit peels were processed into flours and used to substitute 10, 20 and 30 % wheat flour (WF) in biscuits. The orange peel flours were analyzed for photochemical composition. The biscuits were analyzed for photochemical composition and evaluated for sensory properties. The content of flavanoids (0.48 mg/100g) of the solar dried orange fruit peel flour (SOFPF), saponins (0.73 mg/100g), tannins (0.91 mg/100g) and alkaloids (0.99 mg/100g) of oven dried orange fruit peel flour (ODOFPF) were higher than those of the sun dried orange fruit peel flour (SDOFPF). The carotenoids (0.32 mg/100g), flavanoids (0.38 mg/100g) of 30 % SDOFPF biscuit, saponins (0.33 mg/100g), tannins (0.59 mg/100g) and alkaloids (0.82 mg/100g) of the 30 % ODOFPF based biscuit were higher than those of the other biscuits. The 100 % WF biscuit (control), followed by 10 % SDOFPF biscuit had higher overall acceptability scores of 8.0 and 7.1, respectively than the other biscuits. The overall acceptability score of 5.5 for biscuit containing 30 % ODOFPF was the lowest.

**Keywords:** Biscuit, Drying methods, Orange fruit peel flour, Phytochemicals

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### I. Introduction

World demand for phytochemicals such as flavonoids, alkaloids, and carotenoid is increasing. Thus, more food phytochemicals are required from both conventional and new sources [1]. Phytochemicals provide health benefits due to risk reduction of chronic illness such as cancer and cardiovascular diseases [2]. For instance, flavonoids have a wide range of biological effects such as inhibition of key enzymes in mitochondrial respiration, protection against coronary heart diseases, anti-inflammatory, anti-tumor and antimicrobial activities. [3]. It is therefore, necessary to explore ways for supplying phytochemicals in diets. A high percentage of orange fruit peels is rejected after eating or processing of orange fruits. The waste of these peels pollutes the environment. However, for food products to be utilized later, they need to be preserved. Several process technologies have been employed on an industrial scale to preserve food products; the major ones are canning, freezing and dehydration. Among these technologies, drying is especially suited for developing countries with poorly established low-temperature and thermal processing facilities. Drying offers a highly effective and practical means of preservation to reduce post-harvest losses and offset the shortages in supply. In direct solar drying called sun drying, the product is heated directly by the sun's rays and moisture is removed by natural circulation of air due to density differences. For solar drying, the moisture is taken away by the air entering into the cabinet from below and escaping through at the top exit. Solar drier reduces losses and contamination from insects, dust and animals. Solar driers protect food from sunlight, better preserving nutrients and color. Today's (modern) lifestyle has influenced food consumption habits worldwide where some foods such as baked products are eaten in offices, bus, classrooms, conference rooms etc. Baked foods especially, biscuits are among these ready to eat foods used at home. However, they contain a very limited amount of therapeutic substances (phytochemicals) and digestion facilitating substances such as dietary fibers. These substances can be obtained through partial supplementation of wheat with flour prepared from orange fruit peels. These peels are rich in nutraceuticals and dietary fibers; to utilize them as food ingredients is in the way of conducting waste management related to new food sources research and development. For this reason, this study was carried out to reduce the wastage of orange fruit peels by processing them into flour to supplement wheat flour in biscuit.

### II. Materials and Methods

#### 2.1. Materials

The materials in this study were ripe orange fruit peels and commercial wheat flour. The peels of sweet orange fruits were collected from orange juice processing plant and brought to the Food Science and Technology laboratory, University of Rwanda/College of Agriculture, Animal Sciences and Veterinary Medicine, Rwanda. The peels were cleaned in tap water, divided into three portions and dried to constant weight. One portion was dried in passive box solar drier at  $38.5 \pm 8.6$  °C at air flow pressure lower than 1mPa,

another portion was dried in the oven at  $50 \pm 1$  °C at air flow pressure at lower than 1mPa and the third portion was sun dried at  $16.5 \pm 5.5$  °C at wind movement pressure higher than 1mPa. The dried peels were milled in an attrition mill and sieved through 0.2 mm mesh sieve. The peel flours from different drying methods were blended with wheat flour in the ratios of 10, 20 and 30 % and used to produce biscuits. The dried orange fruit peel flours and wheat flour were analyzed for phytochemical composition. The biscuits were evaluated for phytochemical composition and sensory properties.

## 2.2. Analytical methods

### 2.2.1. Determination of phytochemical composition

The determination of alkaloids and flavanoids in orange fruit peel flour and wheat flour were done as described by [4]. Determination of saponins was carried out as described by [5]. The tannins and carotenoids were determined as outlined by [6].

### 2.2.2. Sensory evaluation of biscuits

The biscuit samples were evaluated for sensory attributes of color, flavor, texture, taste, appearance and overall acceptability by trained 10-member panel, using a 9-point Hedonic scale where 1 represented dislike extremely and 9 like extremely [7].

### 2.2.3. Experimental design and statistical analysis

The experiment was 3x3 factorial design in randomized complete block (RCB). Data were subjected to one way analysis of variance (ANOVA) using SPSS (Statistical Package for the Social Sciences) software, version 20. Means with significant ( $p < 0.05$ ) differences were separated by the Least Significant Difference (LSD) test outlined [10].

## III. Results and Discussion

### 3.1. Phytochemical composition of orange fruit peel flour and wheat flour

The effect of drying methods on the phytochemical composition of orange fruit peel flour is shown in Table 1.

**Table 1.** Effect of drying methods on the phytochemical composition of orange fruit peel flours

| Phytochemical content<br>( mg/100g) | Wheat flour       | Orange fruit peel flours |                    |                   |
|-------------------------------------|-------------------|--------------------------|--------------------|-------------------|
|                                     |                   | Oven dried peel          | Solar dried peel   | Sun dried peel    |
| Carotenoids                         | $0.2^b \pm 0.0$   | $0.3^a \pm 0.03$         | $0.3^a \pm 0.0$    | $0.3^a \pm 0.015$ |
| Flavanoids                          | $0.22^d \pm 0.01$ | $0.28^c \pm 0.01$        | $0.48^a \pm 0.01$  | $0.41^b \pm 0.01$ |
| Saponins                            | $0.02^d \pm 0.0$  | $0.73^a \pm 0.02$        | $0.60^b \pm 0.0$   | $0.50^c \pm 0.1$  |
| Tannins                             | $0.20^d \pm 0.01$ | $0.91^a \pm 0.01$        | $0.78^b \pm 0.025$ | $0.72^c \pm 0.02$ |
| Alkaloids                           | $0.42^d \pm 0.01$ | $0.99^a \pm 0.085$       | $0.91^b \pm 0.01$  | $0.81^c \pm 0.02$ |

Values are means  $\pm$  SD of 3 replications. Means within a row with the same superscript were not significantly ( $p > 0.05$ ) different

The drying methods affected significantly ( $p > 0.05$ ) the flavanoids, saponins, tannins and alkaloids contents of orange peel flours with oven drying exerting lesser effect. However, the carotenoids were not significantly ( $p > 0.05$ ) affected by oven, solar and sun drying methods as the content remained 0.3 mg/100g for all of the orange peel flours. Similar observation was also reported [8]. The solar dried orange peel flour, followed by sun dried orange peel flour, had higher level of flavanoids (0.48 mg/100g and 0.41 mg/100g, respectively) than that of oven dried orange fruit peel flour (0.28 mg/100g). The low level of flavanoids for oven dried orange fruit peel flour may have been caused by the high temperature treatment used in the oven drying. The loss of macromolecules like flavonoids during heat treatment might be due to the harsh drying conditions, in particular, the temperature used [9]. Contrarily, the levels of saponins, tannins and alkaloids which were 0.73 mg/100g, 0.91mg/100g and 0.99 mg/100g, respectively, were higher in the oven dried orange fruit peel flour than those of solar and sun dried orange fruit peel flours. This may be attributed to the absence of sunlight and low oxygen in the oven which may have favoured the formation and development of saponins, tannins and alkaloids in the orange peel tissue. The thermal processing can affect the phytochemicals by thermal breakdown that affect the integrity of the cell structure which then results in the migration of components, leading to losses by leakage or breakdown by various chemical reactions involving enzymes, light and oxygen [10].

### 3.2. Phytochemical composition of biscuits

The phytochemical composition of biscuits supplemented with orange fruit peel flour is shown in Table 2

**Table 2.** Phytochemical composition of biscuits supplemented with orange fruit peel flour

| Drying methods | Biscuits  | WF : OPF | Carotenoids (mg/100g)     | Flavanoids (mg/100g)      | Saponins (mg/100g)        | Tannins (mg/100g)         | Alkaloids (mg/100g)       |
|----------------|-----------|----------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Oven           | WF:ODOFPF | 100 : 0  | 0.16 <sup>a</sup> ± 0.03  | 0.18 <sup>a</sup> ± 0.01  | 0.01 <sup>f</sup> ± 0.0   | 0.14 <sup>a</sup> ± 0.02  | 0.34 <sup>g</sup> ± 0.01  |
|                |           | 90 : 10  | 0.18 <sup>a</sup> ± 0.01  | 0.20 <sup>a</sup> ± 0.0   | 0.24 <sup>cd</sup> ± 0.02 | 0.43 <sup>bc</sup> ± 0.01 | 0.75 <sup>de</sup> ± 0.0  |
|                |           | 80 : 20  | 0.23 <sup>a</sup> ± 0.01  | 0.24 <sup>a</sup> ± 0.03  | 0.27 <sup>bc</sup> ± 0.03 | 0.53 <sup>ab</sup> ± 0.01 | 0.76 <sup>de</sup> ± 0.01 |
|                |           | 70 : 30  | 0.29 <sup>ab</sup> ± 0.01 | 0.28 <sup>a</sup> ± 0.01  | 0.33 <sup>a</sup> ± 0.03  | 0.59 <sup>a</sup> ± 0.05  | 0.82 <sup>a</sup> ± 0.02  |
| Solar          | WF:SOFPF  | 100 : 0  | 0.16 <sup>a</sup> ± 0.03  | 0.18 <sup>a</sup> ± 0.03  | 0.01 <sup>f</sup> ± 0.0   | 0.14 <sup>a</sup> ± 0.02  | 0.34 <sup>g</sup> ± 0.01  |
|                |           | 90 : 10  | 0.18 <sup>a</sup> ± 0.04  | 0.30 <sup>a</sup> ± 0.02  | 0.21 <sup>cd</sup> ± 0.01 | 0.30 <sup>a</sup> ± 0.01  | 0.55 <sup>de</sup> ± 0.01 |
|                |           | 80 : 20  | 0.24 <sup>a</sup> ± 0.03  | 0.33 <sup>ab</sup> ± 0.03 | 0.23 <sup>cd</sup> ± 0.03 | 0.38 <sup>a</sup> ± 0.02  | 0.56 <sup>de</sup> ± 0.04 |
|                |           | 70 : 30  | 0.30 <sup>a</sup> ± 0.0   | 0.36 <sup>ab</sup> ± 0.02 | 0.29 <sup>bc</sup> ± 0.01 | 0.44 <sup>a</sup> ± 0.04  | 0.62 <sup>de</sup> ± 0.02 |
| Sun            | WF:SDOFPF | 100 : 0  | 0.16 <sup>a</sup> ± 0.03  | 0.18 <sup>a</sup> ± 0.01  | 0.01 <sup>f</sup> ± 0.0   | 0.14 <sup>a</sup> ± 0.02  | 0.34 <sup>g</sup> ± 0.01  |
|                |           | 90 : 10  | 0.18 <sup>a</sup> ± 0.02  | 0.31 <sup>a</sup> ± 0.01  | 0.18 <sup>a</sup> ± 0.0   | 0.17 <sup>a</sup> ± 0.02  | 0.34 <sup>g</sup> ± 0.04  |
|                |           | 80 : 20  | 0.25 <sup>ab</sup> ± 0.03 | 0.34 <sup>ab</sup> ± 0.02 | 0.20 <sup>ab</sup> ± 0.01 | 0.23 <sup>a</sup> ± 0.03  | 0.42 <sup>de</sup> ± 0.02 |
|                |           | 70 : 30  | 0.32 <sup>a</sup> ± 0.02  | 0.38 <sup>a</sup> ± 0.01  | 0.26 <sup>ab</sup> ± 0.06 | 0.29 <sup>a</sup> ± 0.01  | 0.48 <sup>de</sup> ± 0.0  |

Values are means ± SD of 3 replications. Means within a row with the same superscript were not significantly ( $p > 0.05$ ) different. WF: Wheat flour, OPF: Orange fruit peel flour, ODOFPF: Oven dried orange fruit peel flour, SOFPF: Solar dried orange fruit peel flour, SDOFPF: Sun dried orange fruit peel flour.

The phytochemicals significantly increased in biscuits with increase in the addition of orange peel flour in the blends due to addition effect (Table 1). However, the carotenoid content of 10 % ODOFPF, 10 % SOFPF and 10 % SDOFPF biscuits were not significantly ( $p > 0.05$ ) different from that of 100 % WF biscuit. The amounts of carotenoids (0.32 mg/100g) and flavanoids (0.38 mg/100g) for 30 % SDOFPF biscuit were the highest. Carotenoids are anti-oxidants, important anti-aging, enhance immune function, balance blood sugars and reduce risk of cardiovascular diseases and cancers (especially prostate and lung cancers). Flavanoids are anti-oxidants, lower cholesterol, inhibit tumor formation, decrease inflammation and protect against cancer, heart disease [2]. The contents of saponin (0.33 mg/100g), tannin (0.59 mg/100g) and alkaloid (0.82 mg/100g) were higher in 30 % ODOFPF biscuit than those of other biscuits. The lowest levels of saponin (0.18 mg/100g), tannin (0.17 mg/100g) and alkaloid (0.34 mg/100g) were in the 10 % SDOFPF based biscuit. The saponin and tannin contents of 10 % SDOFPF biscuit were not significantly ( $p > 0.05$ ) different from those of 100 % WF biscuit. Saponins have hypolipidemic and anticancer activity, antioxidant and anti-mutagenic properties and are also necessary for activity of cardiac glycosides [11]. Tannins are used as antiseptic. Tannin rich medicinal plants are used as healing agents for a number of diseases like leucorrhoea, rhinorrhoea and diarrhoea [12]. Alkaloids have pharmacological applications as anesthetics and Central Nervous System (CNS) stimulants, muscle relaxant, antibiotics, anti-cancer, anti-arrhythmic and sedative [13]. The increase in alkaloids, saponins, tannins content in supplemented biscuits was also reported [14].

### 3. 3. Sensory properties of biscuits

The sensory properties of biscuits supplemented with orange fruit peel flour are given in Table 3

**Table 3.** Sensory properties of biscuits supplemented with orange fruit peel flour

| Drying methods | Biscuits  | WF : OPF | Color                   | Flavor                  | Taste                   | Texture                 | Appearance               | Overall acceptability   |
|----------------|-----------|----------|-------------------------|-------------------------|-------------------------|-------------------------|--------------------------|-------------------------|
| Oven           | WF:ODOFPF | 100 : 0  | 6.8 <sup>a</sup> ± 0.2  | 8.6 <sup>a</sup> ± 0.2  | 7.2 <sup>a</sup> ± 0.2  | 7.7 <sup>a</sup> ± 0.4  | 7.9 <sup>a</sup> ± 0.9   | 8.0 <sup>a</sup> ± 2.0  |
|                |           | 90 : 10  | 6.8 <sup>a</sup> ± 1.3  | 6.7 <sup>bc</sup> ± 0.1 | 6.7 <sup>a</sup> ± 0.2  | 6.6 <sup>a</sup> ± 0.2  | 6.8 <sup>ab</sup> ± 0.2  | 6.8 <sup>ab</sup> ± 0.2 |
|                |           | 80 : 20  | 6.4 <sup>ab</sup> ± 0.1 | 5.6 <sup>cd</sup> ± 0.3 | 6.4 <sup>a</sup> ± 0.2  | 6.2 <sup>a</sup> ± 0.4  | 6.2 <sup>ab</sup> ± 0.2  | 6.4 <sup>ab</sup> ± 0.2 |
|                |           | 70 : 30  | 5.7 <sup>a</sup> ± 0.2  | 4.6 <sup>a</sup> ± 0.2  | 5.0 <sup>a</sup> ± 0.0  | 5.8 <sup>a</sup> ± 0.2  | 6.8 <sup>ab</sup> ± 0.10 | 5.5 <sup>a</sup> ± 0.1  |
| Solar          | WF:SOFPF  | 100 : 0  | 6.8 <sup>a</sup> ± 0.2  | 8.6 <sup>a</sup> ± 0.2  | 7.2 <sup>a</sup> ± 0.2  | 7.7 <sup>a</sup> ± 0.4  | 7.9 <sup>a</sup> ± 0.90  | 8.0 <sup>a</sup> ± 2.0  |
|                |           | 90 : 10  | 6.6 <sup>ab</sup> ± 0.0 | 7.4 <sup>a</sup> ± 0.4  | 6.9 <sup>a</sup> ± 0.1  | 7.4 <sup>a</sup> ± 0.1  | 7.5 <sup>a</sup> ± 0.20  | 7.0 <sup>ab</sup> ± 2.0 |
|                |           | 80 : 20  | 6.5 <sup>ab</sup> ± 0.3 | 6.0 <sup>a</sup> ± 2.0  | 6.6 <sup>a</sup> ± 0.1  | 6.8 <sup>ab</sup> ± 0.4 | 6.8 <sup>ab</sup> ± 0.1  | 6.6 <sup>ab</sup> ± 0.1 |
|                |           | 70 : 30  | 5.7 <sup>a</sup> ± 0.7  | 5.6 <sup>cd</sup> ± 0.6 | 6.0 <sup>ab</sup> ± 2.0 | 6.6 <sup>a</sup> ± 0.0  | 5.8 <sup>a</sup> ± 0.3   | 5.6 <sup>a</sup> ± 0.1  |
| Sun            | WF:SDOFPF | 100 : 0  | 6.8 <sup>a</sup> ± 0.2  | 8.6 <sup>a</sup> ± 0.2  | 7.2 <sup>a</sup> ± 0.2  | 7.7 <sup>a</sup> ± 0.4  | 7.9 <sup>a</sup> ± 0.9   | 8.0 <sup>a</sup> ± 2.0  |
|                |           | 90 : 10  | 6.8 <sup>a</sup> ± 0.6  | 7.4 <sup>a</sup> ± 0.1  | 7.0 <sup>a</sup> ± 1.0  | 7.2 <sup>ab</sup> ± 0.2 | 6.9 <sup>ab</sup> ± 0.2  | 7.1 <sup>ab</sup> ± 0.1 |
|                |           | 80 : 20  | 6.5 <sup>ab</sup> ± 0.1 | 6.5 <sup>bc</sup> ± 0.1 | 6.5 <sup>a</sup> ± 0.0  | 6.6 <sup>a</sup> ± 0.2  | 6.5 <sup>ab</sup> ± 0.2  | 6.7 <sup>ab</sup> ± 0.1 |
|                |           | 70 : 30  | 6.4 <sup>ab</sup> ± 0.4 | 6.4 <sup>bc</sup> ± 0.2 | 6.2 <sup>a</sup> ± 0.2  | 6.3 <sup>ab</sup> ± 0.3 | 6.0 <sup>ab</sup> ± 3.0  | 6.0 <sup>ab</sup> ± 1.0 |

Values are means ± SD of 7 replications. Means within a row with the same superscript were not significantly ( $p > 0.05$ ) different. WF: Wheat flour, OPF: Orange fruit peel flour, ODOFPF: Oven dried orange fruit peel flour, SOFPF: Solar dried orange fruit peel flour, SDOFPF: Sun dried orange fruit peel flour.

The overall acceptability score of 8.0 for the 100 % WF biscuit was the highest and followed by 7.1 for the biscuit containing 10 % SDOFPF. The overall acceptability score (5.5) for biscuit containing 30 % ODOFPF was the lowest. Generally, the preference for the biscuits by panelists was associated with the low level of

bitterness. It is the reason why 100 % WF biscuit received the highest score as it was less bitter than other biscuits. The astringent taste and bitterness encountered in biscuits were caused by the alkaloids, tannins and saponins in the orange fruit peel [15].

#### **IV. Conclusion**

The drying methods affected the quality of flours and biscuits prepared from the peels of sweet orange fruits (*Citrus sinensis*, L.). The oven, solar and sun dried orange fruit peel flours were significantly ( $p < 0.05$ ) different in phytochemical composition. The oven dried orange peel flour had higher amounts of alkaloids, tannins and saponins than the other dried orange peel flours. The oven, solar and sun dried orange peel flours contained higher levels of flavanoids, tannins, saponins and alkaloids than wheat flour. The supplemented biscuits had higher amounts of carotenoids, flavanoids, saponins, tannins and alkaloids than 100 % wheat flour biscuit (control). The 100 % wheat flour biscuit, followed by the biscuit containing 10 % sun dried orange peel flour were the most organoleptically preferred biscuits. The overall acceptability score for biscuit containing 30 % ODOFPF was the lowest. The use of flour from orange fruit peels dried by oven, solar and sun drying methods improved the phytochemical composition and sensory characteristics of the biscuit.

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