Recipe Optimization to Produce Functional Anti-Motion Sickness Compressed Biscuits

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Abstract. Anti-motion sickness, especially the seasickness, as one of the most common seen symptoms in long-term journey, can affect the normal work and life of crew members seriously. The purpose of this study is to investigate the anti-seasickness, anti-fatigue and functional constipation improving effects of anti-motion sickness biscuits in mouse model. Behavioral experiments together with biochemical indicators of mice were investigated under different doses of compressed biscuits. Results of the study indicate that mice fed with compressed biscuits containing medium and high doses of the anti-motion sickness ingredient can significantly improve the learning, memory and swimming ability compared to the control group. Furthermore, glycogen, LA and LDH levels of the mice can be increased with decreased BUN and Passe levels under the treatment of anti-motion sickness compressed biscuits. The results suggest that the compressed biscuits have anti-seasickness and anti-fatigue effects. In addition, the impact of pear residue in the compressed biscuits on the functional constipation of mice was also discussed in this paper.

1. Introduction
Motion sickness, also known as kinetosis and travel sickness, is a condition in which a disagreement exists between visually perceived movement and the vestibular system's sense of movement. Depending on the cause, it can also be referred to as seasickness, car sickness, simulation sickness or airsickness. Among them, seasickness is most seen in normal life. Generally, seasickness can occur within minutes or hours of sea travel. However, the seasickness of crew members cannot be relieved via vessel stopping or deceleration, since the particularity of long-term sailing. Dizziness, fatigue and nausea are the most common symptoms of motion sickness, that affect normal life and work of crew members seriously. Till now, no specific functional food for motion sickness treatment has been developed. With the increasing popularity of functional products among consumers, food companies need to face the call for the manufacture of such products in order to appropriately relieve the discomfort of seasickness[1-2].The compressed biscuits are popular and convenient food products due to their ready to eat nature in the market. Furthermore, owning to its storable profile, compressed biscuits provides a perfect matrix to contain functional ingredients, which can be used to release the anti-motion sickness for long-term sailing people. Here, we outlined several ingredients to explore their potential function in anti-motion sickness compressed biscuits.

Ginger is the rhizome of a perennial plant belonging to the genus Zingiber within the family Zingiberaceae. Fresh and dried ginger have been used as spices and Chinese herbs for several centuries [3]. Due to its unique aroma and pungent taste, ginger has been widely used in many food and
medicinal products, such as ginger ale, pickled ginger, ginger yogurt, ginger cream, ginger-flavored biscuits, etc\cite{4}. In Asian countries, ginger is widely used in medications for the common cold, diseases of the digestive system and rheumatism. In addition, ginger is also a remedy for many conditions, such as nausea, car sickness or seasickness\cite{5}. Shukla and Singh performed a review on the cancer preventive properties of ginger\cite{6}, while Ali et al. performed a review on recent research on the phytochemical, pharmacological and toxicological properties of ginger\cite{7}. In another study, it was found that ground ginger had better car sickness-relieving effects compared to vitamins and placebo\cite{8}, while the results of double blind, placebo controlled crossover trials have indicated that compared to placebo, ginger root had significantly greater effectiveness in alleviating induced nausea and vertigo\cite{9-10}.

Glutamine-bioactive peptides (GBPs) are bioactive peptides that have recently emerged as a popular topic in research. Glutamine is a nitrogen precursor for the synthesis of purine, pyrimidine and nucleotides in the body, and is an important energy source within muscles. Large amounts of glutamine flow within muscle cells, and make up approximately 60% of free amino acids in muscles. Besides having advantages such as high water solubility, high stability, low sensitivity and ease of absorption, GBPs also retain multiple nutrients and functions of glutamine, such as antioxidant properties, anti-stress properties, energy provision, enhancement of organism immunity, regulation of pH balance, etc\cite{11}. Studies have shown that GBPs can facilitate the accumulation of high-energy matter and enhance physical stamina in mice. Glutamine supplementation in animals can result in increased survival rates, enhanced immune function, reduced incidence of toxemia, enhanced intestinal barrier function and suppression of intestinal mucosal atrophy, and provide significant protection against intestinal mucosal damage caused by trauma, chemotherapy and radiotherapy\cite{12}.

Pear residue refers to waste material leftover after the extraction of juice from fresh pears through juice processing. It mainly consists of cell walls of pear fruit and certain amounts of pear kernels and stems, and accounts for 40-50% of the weight of the original fruit. Pear residue is rich in dietary fiber, which facilitates the digestion and absorption of food, and also plays a positive role in the prevention of gastrointestinal diseases and the maintenance of gastrointestinal health in the human body\cite{13}.

Compressed biscuits are food products mainly made of wheat flour, sugar and oil. Characteristics of compressed biscuits include small volume, high energy density, high satiety value, long shelf life, and convenience in carrying and consumption. Therefore, as long-lasting food products with high nutrition value and convenience, compressed biscuits are widely used as emergency food rations in the military, especially during fieldwork or field exercises. The consumption of compressed biscuits in militaries worldwide has steadily increased over the years, and compressed biscuits have become an essential component of logistics supplies in militaries of various countries, which has resulted in increasing demands on the quality of such biscuits. At present, the compressed rations of the Chinese military possess several shortcomings, such as lack of flavor variety, nutritional imbalance, difficulty in digestion and absorption, and high likelihood of spoilage during improper storage.

In this study, mice were used as model to invest the anti-motion sickness function of compressed biscuits with different doses of the anti-motion sickness ingredients with dimenhydrinate as positive control. Behavioral experiments of mice on learning, memory and swimming abilities were performed, and biochemical indicators such as glycogen, lactic acid, lactate dehydrogenase (LDH), blood urea nitrogen (BUN), and ATPase levels in mice were measured to investigate the anti-seasickness and anti-fatigue effects of the anti-motion sickness compressed biscuits. Finally, small intestinal propulsion and defection experiments were used to invest the functional constipation improvement effect of such biscuits.

2. Experimental Section

2.1. Preparation of compressed biscuits
An appropriate amount of palm oil was weighed, liquefied and cooled. Granulated white sugar, ginger powder, soluble dietary fiber from pear residue, full cream milk powder, table salt, baking soda and
ammonium bicarbonate were then added to the liquefied palm oil in accordance with the biscuit formula in Table 4, and the contents were thoroughly mixed to obtain a homogenous mixture. Soluble dietary fiber was extracted from pear residue by acid hydrolysis, and measured by the enzymatic-gravimetric method. A water content of 16% was added to the mixture, with one-third of the water used for the dissolution of the leavening agent, and two-thirds used for the dissolution of granulated white sugar. The mixture was then pressed into molds and baked with a top heat of 180℃ and a bottom heat of 150℃ for 8 min. After being cooled, the biscuits were broken into crumbs, then palm oil, taurine, GBPs, soy protein powder, vitamins, minerals, antioxidants and glucose were added to the crumbs in accordance with the biscuit formula in Table 1-4, and the contents were thoroughly mixed. In particular, GBPs were prepared using the double-enzyme fractional hydrolysis method. Compressed biscuits were then obtained by placing the crumb mixture in a compression machine. The detailed preparation process is shown in Figure 1.

### Table 1. Compressed biscuit formula

| Component                  | Percentage (%) | Component                  | Percentage (%) |
|----------------------------|----------------|----------------------------|----------------|
| Palm oil                   | 8              | Antioxidants<sup>a</sup>   | 0.002          |
| Glucose                    | 12             | Multivitamins              | 0.033          |
| Soy protein powder         | 5              | Multiminerals              | 0.16           |
| Taurine                    | 0.05           | Biscuit crumbs             | 73.355         |
| Glutamine-bioactive peptides | 0.4          | Water                      | 1              |

<sup>a</sup> Antioxidants BHA:PG=3:1

### Table 2. Multivitamin formula

| Component | Percentage (%) | Component | Percentage (%) |
|-----------|----------------|-----------|----------------|
| VA        | 0.597          | VB<sub>12</sub> | 0.004          |
| VD        | 0.003          | VB<sub>1</sub> | 1.194          |
| VE        | 5.97           | VB<sub>2</sub> | 1.194          |
| VB<sub>6</sub> | 4.478      | VC        | 74.62          |
| VPP       | 11.94          |           |                |

### Table 3. Multiminerals formula

| Component | Percentage (%) | Component | Percentage (%) |
|-----------|----------------|-----------|----------------|
| Calcium   | 96.42          | Zinc      | 1.93           |
| Iron      | 1.61           | Selenium  | 0.01           |
| Iodine    | 0.03           |           |                |

### Table 4. Biscuit crumb formula

| Component                                      | Percentage (%) | Component                                      | Percentage (%) |
|------------------------------------------------|----------------|-----------------------------------------------|----------------|
| Flour<sup>a</sup>                             | 100            | Full cream milk powder                        | 9              |
| Palm oil                                       | 20             | Granulated white sugar                        | 6              |
| Soluble dietary fiber from pear residue        | 4              | Table salt                                    | 1              |
| Baking soda                                    | 1              | Water                                         | 16             |
| Ginger powder                                  | 0.35           |                                               |                |

<sup>a</sup> Flour comprising 35% whole-wheat flour and 65% wheat flour was used as the measuring basis for this formula.
2.2. Experimental Animals and Groups

195 male ICR mice (purchased from the market) with body weights of 20±2 g were randomly assigned to 13 groups according to body weight after 5 days of acclimation: Group A: control group, Group B: seasickness induced group, Group C: dimenhydrinate group, Group D: low dose group (ginger powder content=0.2%), Group E: medium dose group (ginger powder content=0.35%), Group F: high dose group (ginger powder content=0.5%), Group G: control group, Group H: dimenhydrinate group, Group I: taurine group (taurine content=0.05%), Group J: GBP group (GBP content=0.4%), Group K: combination group (taurine:GBP =1:5), Group L: combination group (taurine:GBP =1:6.5), Group M: combination group (taurine:GBP=1:8).

The control groups had free access to food and drinking water, while the dimenhydrinate groups were fed with dimenhydrinate based on body weight (dosage for human adults=50 mg/dose, based on an average human adult body weight of 60 kg, the calculated daily dosage for mice=50/60×10=8.333 mg/kg/dose). The low, medium and high dose groups were fed with anti-motion sickness compression biscuits with the corresponding ginger powder content. During the feeding period, a temperature of 20±2℃ and a relative humidity of approximately 60% was maintained in the animal room. 0.5h after each feed, all groups received 2h of seasickness-inducing stimulation for 3 consecutive days. The learning and memory ability experiment and swimming experiment were performed in Groups A to F immediately after stimulation.

For Small intestinal propulsion and defecation experiment, 60 8-week-old male KM mice and 48 female mice with body weights of 20±2 g were used in this experiment. The male KM mice were randomly assigned to 5 groups with 12 mice each according to body weight after 3-5 days of acclimatization: solvent control group, constipation model group (i.e. compound diphenoxylate group), and low, medium and high dose soluble dietary fiber from pear residue compressed biscuit groups, with the respective doses being 2%, 4%, 6%.

2.3. Seasickness-inducing stimulation

Mice were placed unbound in an organic glass cage of a seasickness simulator, and subjected to 2h of seasickness-inducing stimulation through varying accelerated motion. The maze experiment was then performed immediately after stimulation.

2.4. Maze experiment

After acclimatization in the maze for 3 min, each mouse was placed at the entrance of the maze, and food was placed at the exit as bait. The time taken for each mouse to travel from the entrance to the exit was then recorded. Each mouse was tested 3 consecutive times, and the experiment was performed over 3 consecutive days.

2.5. Seasickness-inducing stimulation

Mice were placed unbound in an organic glass cage of a seasickness simulator, and subjected to 2h of seasickness-inducing stimulation through varying accelerated motion. The learning and memory ability experiment was then performed immediately after stimulation.

2.6. Learning and memory ability experiment

Mice were placed individually in an electric maze, and the escape responses to electric shocks were observed. Learning and memory ability test results were expressed as the number of correct escape responses after 15 bouts of stimulation.
2.7. Swimming experiment
After the third day of seasickness-inducing stimulation, each mouse was immediately placed in a cylinder and subjected to a swimming experiment. Sufficient water was placed in the cylinder to prevent mice from supporting their body weight from the base of the cylinder with their tails. Water temperature was maintained at 25-26℃, and the swimming time up to final submersion was recorded for each mouse.

2.8. Determination of glycogen, lactate dehydrogenase (LDH), lactic acid (LA) and blood urea nitrogen (BUN) and ATPase.
After 3 consecutive days of seasickness-inducing stimulation, mice in Groups F to L were sacrificed by decapitation, and liver tissues were immediately obtained for glycogen determination by the anthrone colorimetric method.

Saline(saline concentration=0.4%) was added to muscle tissue with a mass-to-volume ratio of 1:9. The mixture was homogenized in an ice bath and centrifuged at 2500 r·min⁻¹ for 10 min at 4℃. The resulting supernatant was obtained for the determination of LDH activity and LA content by the colorimetric method, which was performed according to instructions provided with the detection kit (Nanjing Jiancheng Bioengineering Institute, China).

The test substance was orally administered to the mice for 30d. 30 min after the last administration, mice were placed into a swimming tank with water filled to a depth of 30 cm at a temperature of 30℃. 5 mice were placed into the tank at one time, and subjected to 90 min of swimming without load. After exercise, the mice were rested for 60 min, eye areas of the mice were wiped clean, and eyeball removal was performed for the extraction of 0.5 mL of blood in each mouse. The diacetyl-monoxime thiosemicarbazide method was used for determination of BUN. Urea nitrogen in serum is stable for up to 24h under refrigeration.

Saline(saline concentration=0.4%) was added to muscle tissue with a mass-to-volume ratio of 1:9. The mixture was homogenized in an ice bath and centrifuged at 2500 r·min⁻¹ for 10 min at 4℃, then the resulting supernatant was obtained for analysis. The relative ATP content in muscle tissue (μmol·mg⁻¹) was expressed in terms of the ratio of ATP concentration to protein concentration in lysate, and the process of determination was performed according to instructions provided with the test kit (Nanjing Jiancheng Bioengineering Institute, China).

2.9. Small intestinal propulsion experiment
After 10d, all mice were fasted for 24h with free access to drinking water. Subsequently, the constipation model was established in all groups except the solvent control group with the use of 0.025% compound diphenoxylate. 0.5h after model establishment, normal indicator ink was administered to the solvent control and constipation model groups by gastric gavage, while indicator inks containing the respective doses of the test substance (i.e. 0.30, 0.60 and 1.20g/(kg·d) of compressed biscuits) were administered to the corresponding dose groups. After 20min, the mice were sacrificed and dissected. The full length of the small intestine and distance between the pylorus and the front line of the indicator ink were measured in each mouse, and the small intestinal propulsion rates were calculated based on Equation (1):

\[
\text{Small intestinal propulsion rate, } \% = \frac{\text{Ink movement distance, cm}}{\text{Full length of small intestine, cm}} \times 100
\]

2.10. Defecation experiment
Each mouse was kept in individual cages, and care was taken to ensure that the mice had sufficient intake of feed and water. 6h after administration of indicator ink, the defecation status of the mice was observed, and the defecation time of the first black feces as well as the total quantity and mass of feces deposited after 6h were recorded. The feces deposited within 6h for each mouse were dried to a constant mass at a fixed temperature of 65℃, and the resultant mass was the dry fecal mass. The water content of feces for each mouse was calculated based on Equation (2):

\[
\text{Water content of feces, } \% = \frac{\text{Initial mass of feces} - \text{Dry mass of feces}}{\text{Initial mass of feces}} \times 100
\]
Water content, % = \frac{\text{Total fecal mass, } g - \text{Dry fecal mass, } g}{\text{Total fecal mass, } g} \times 100 \tag{2}

3. Results and discussion

3.1. Impact of compressed biscuits on seasickness.

The maze experiment was utilized to investigate the efficiency of ginger in compressed biscuits on the seasickness symptom. From Table 5, the mean maze completion time for the seasickness-inducing group was significantly longer than that of the control group, which indicates the effectiveness of the seasickness-inducing stimulation. Then, the treatment with dimenhydrinate, 3.5% ginger and 5% ginger can effectively reduce the maze completion time compared with the seasickness inducing group. Whereas, the mice treated with ginger in low dosage (0.2%) doesn’t show significant improvement in maze completion time. These indicate the ginger as anti-seasickness ingredient can relieve the seasickness symptom and show a dose-dependent manner.

Next, the learning and memory abilities of mice were also investigated. As shown in Table 5, the seasickness can cause serious negative impact on the learning and memory abilities of mice in the seasickness inducing group compared with vehicle group. The correct response numbers of learning and memory abilities in dimenhydrinate group are 10.6 and 12 which are close to that of the control group. In the experimental groups, the learning and memory abilities of mice can be improved by compressed biscuits with ginger powder in a dose dependent manner. The medium and high doses of ginger powder and dimenhydrinate were able to enhance the learning and memory abilities of mice which had been negatively influenced by seasickness-inducing stimulation, which were consistent with the results of the maze completion time.

The swimming time experiment shown in Table 5 confirmed the positive efficiency of compressed biscuits with ginger powder on the seasickness symptom.

In summary, the medium and high dosage ginger powder in compressed biscuits can largely improve the symptom of seasickness induced mice. Considering the disfavored flavor of ginger, the medium dose of ginger powder (0.35%) was selected for the final recipe of anti-seasickness compressed biscuit.

Table 5. Impact of compressed biscuits with different ginger powder content on various abilities in mice ($\bar{x} \pm s$)

| Group | n  | Maze completion time (s) | Learning test results (No. of correct responses) | Memory test results (No. of correct responses) | Swimming time (min) |
|-------|----|--------------------------|--------------------------------------------------|-----------------------------------------------|---------------------|
| A     | 15 | 87.22±8.5                | 12.8±2.4                                         | 13.6±2.32                                     | 20.32±1.92          |
| B     | 15 | 170.25±30.2              | 8.6±1.68                                         | 9.6±1.37                                      | 12±1.25             |
| C     | 15 | 94.29±26.88<sup>a</sup>  | 10.6±1.71                                        | 12±2.11<sup>a</sup>                           | 23.99±2.21<sup>b</sup> |
| D     | 15 | 159.18±25.7<sup>a</sup>  | 10.8±2.08<sup>a</sup>                            | 10.6±1.28                                     | 13.94±1.3           |
| E     | 15 | 99.16±16.8<sup>c</sup>   | 12.4±2.15<sup>a</sup>                            | 12.8±2.35<sup>b</sup>                         | 19.75±2.38<sup>b</sup> |
| F     | 15 | 92.76±20.3<sup>c</sup>   | 12.8±2.37<sup>b</sup>                            | 13.4±2.51<sup>b</sup>                         | 19.81±2.32<sup>b</sup> |

<sup>a</sup> Compared to the control group P <0.05  
<sup>b</sup> Compared to the control group P<0.01  
<sup>c</sup> Compared to the dimenhydrinate group P <0.05

3.2. Impact of compressed biscuits on glycogen, LDH, LA, BUN and ATPase levels in mice

Taurine and GBP, recognized as effective anti-fatigue and liver protection agents, were included in the compressed biscuits recipe. Here, the impact of taurine and GBP on body indicators of seasickness induced mice were studied in order to decide optimal content and ratio of them in the final recipe of compressed biscuits.
Glycogen is an important source of energy during exercise, and exercise abilities are directly affected by the amount of glycogen in the organism. An increased glycogen storage is of great importance to the enhancement of speed and endurance. In this study, glycogen levels in the combination and experimental groups were significantly higher compared to the control and dimenhydrinate groups, and an increasing trend was observed within the combination groups, with the glycogen concentration in Group L being as high as 48.7 mg/g. This indicates that a taurine to GBP ratio of 1:8 can effectively increase glycogen storage in organisms, which enhances the organisms’ adaptive abilities to exercise loads, thus achieving an anti-fatigue effect.

Lactate dehydrogenase (LDH) is typically found in tissues such as cardiac muscle and skeletal muscle, and in red blood cells as well. It catalyzes the dehydrogenation of lactic acid to pyruvic acid, thus eliminating lactic acid buildup in the body. An increase in LDH activity within a certain range indicates an increase in the organism’s ability in lactic acid removal. In this study, LDH levels after 3 days of seasickness-inducing stimulation in the combination and experimental groups were significantly higher compared to the control and dimenhydrinate groups. The mean LDH levels in the liver tissues of the control group and combination group L were 305 U/100 mL and 537 U/100 mL respectively, with highly significant differences existing between group L and both the control and dimenhydrinate groups (P<0.01).

Lactic acid (LA) is a product of anaerobic glycolysis, and an excessive buildup of LA after prolonged periods of vigorous exercise can affect the relative stability of the body’s internal environment and the normal metabolic processes within the body, thus resulting in exercise-induced fatigue. Table 6 shows that the mean LA levels in mouse muscles of the control and dimenhydrinate groups were 4.34 mmol/L and 3.71 mmol/L respectively, and the LA levels of the combination and experimental groups were significantly lower compared to the control and dimenhydrinate groups. This indicates that compressed biscuits can reduce LA level by increasing LDH activity, and this is a key mechanism by which the enhancement of anti-fatigue abilities in organisms is facilitated.

Blood urea nitrogen (BUN) is a final product of protein metabolism. During vigorous exercise, glycogen consumption is increased due to strong muscular contractions, which leads to an imbalance in energy supply and demand. In order to ensure adequate energy supply, protein catabolism increases, which reduces the body's ability to adapt to exercise load. As the amount of BUN produced increases with increased protein catabolism, BUN level is regarded as an ideal and sensitive indicator of fatigue status. It is shown in Table 6 that the BUN levels of the experimental and combination groups were lower compared to the control and dimenhydrinate groups. A dose-dependent trend was also observed within the combination groups, with BUN concentration being the lowest for a taurine to GBP ratio of 1:8, which indicates that this dose provides the most significant protein catabolism-reducing effect.

Table 7 shows that ATPase activity in mouse muscles of the combination and experimental groups were increased after seasickness-inducing stimulation. The Na+/K+ATPase and Ca2+/Mg2+ATPase activities of the experimental groups were significantly higher compared to the control group, and...
slightly higher than that of the dimenhydrinate group. This indicates that the compressed biscuits had certain anti-fatigue effects.

Table 7. ATPase activity in muscle tissues of mice (\(\bar{x} \pm s\))

| Group | n  | Na+/K+ATPase(μmol Pi/mgprot/hour) | Ca\(^{2+}\)/Mg\(^{2+}\)ATPase(μmol Pi/mgprot/hour) |
|-------|----|---------------------------------|-----------------------------------------------|
| F     | 15 | 0.43±0.05                       | 0.42±0.06                                     |
| G     | 15 | 0.46±0.07                       | 0.42±0.09                                     |
| H     | 15 | 0.61±0.18<sup>ac</sup>          | 0.66±0.15<sup>ac</sup>                        |
| I     | 15 | 0.66±0.17<sup>ac</sup>          | 0.63±0.13<sup>ac</sup>                        |
| J     | 15 | 0.73±0.20<sup>bc</sup>          | 0.71±0.15<sup>bc</sup>                        |
| K     | 15 | 0.81±0.16<sup>bc</sup>          | 0.77±0.18<sup>bc</sup>                        |
| L     | 15 | 0.89±0.18<sup>bd</sup>          | 0.81±0.17<sup>bd</sup>                        |

<sup>a</sup> Compared to the control group P <0.05  
<sup>b</sup> Compared to the control group P<0.01  
<sup>c</sup> Compared to the dimenhydrinate group P <0.05  
<sup>d</sup> Compared to the dimenhydrinate group P <0.01

Based on the above results, it can be concluded that with a taurine/GBP combination at a ratio of 1:8, maximum glycogen storage, maximum LDH activity, minimum LA level, minimum BUN level, maximum ATPase activity, and maximum anti-fatigue effects can be achieved.

3.3. Impact of compressed biscuits on the improvement of functional constipation in mice

It is shown in Table 8 that the constipation model group had a significantly lower mean small intestinal propulsion rate compared to the solvent control group, with the differences being highly significant (P<0.01), which indicates successful model establishment. The mean small intestinal propulsion rates of the 3 dose groups were respectively 15.1%, 37% and 48.66% higher than that of the constipation model group. In particular, differences between the medium and high dose groups and the control group were highly significant (P<0.01).

Table 8. Impact of compressed biscuits on small intestinal propulsion rate in mice (\(\bar{x} \pm s\), n=12)

| Group               | Dose/(g/(kg·d)) | Small intestinal propulsion rate (%) |
|---------------------|-----------------|-------------------------------------|
| Solvent control group | 0.00            | 48.95±3.25<sup>b</sup>                |
| Constipation model group | 0.00    | 26.85±2.09                          |
| Low dose group      | 2.0             | 30.94±3.18                           |
| Medium dose group   | 4.0             | 35.75±3.61<sup>b</sup>               |
| High dose group     | 6.0             | 39.41±3.45<sup>b</sup>               |

<sup>a</sup> Significant difference compared to the constipation model group (P<0.05)  
<sup>b</sup> Highly significant difference compared to the constipation model group (P<0.01)

From Table 9, it can be found that highly significant differences existed between the constipation model group and the solvent control group for all parameters besides the water content of feces, which proves the successful establishment of the model. The mean defecation time of the first black feces of the 3 dose groups were respectively 10.72%, 22.4% and 19.24% shorter than that of the constipation model group (P<0.05), with the fastest defecation time of the first black feces achieved in the medium dose group. Compared with the constipation model group, the mean quantity of feces of the 3 dose groups were respectively 36.6%, 79.2% and 77.63% higher (P<0.05), and the total mass and dry mass of feces deposited within 6h for the 3 dose groups were also significantly higher. In particular, the total mass of feces deposited within 6h were respectively 40%, 59.1% and 106.82% higher (P<0.05), while the dry mass of feces deposited were respectively 28%, 60% and 92% higher (P<0.05). Among the various defecation parameters in the experiment, water content was the only parameter with no significant differences detected between groups (P>0.05).
Table 9. Impact of compressed biscuits on defecation parameters in mice ($x \pm s$, n=12)

| Group                | Dose (g/kg) | No. of feces deposited within 6h | Defecation time of first black feces (min) | Total mass of feces deposited within 6h (g) | Dry mass of feces deposited within 6h (g) | Water content (%) |
|----------------------|-------------|----------------------------------|------------------------------------------|---------------------------------------------|------------------------------------------|-------------------|
| Solvent control group| 0.00        | 50.37±2.88b                      | 135.75±5.89b                             | 0.95±0.08b                                  | 0.45±0.04b                                | 52.63±4.15        |
| Constipation model group | 0.00    | 22.89±2.35                       | 287.12±8.15                              | 0.40±0.04                                   | 0.24±0.03                                 | 40.01±3.54        |
| Low dose group       | 2.0         | 31.42±2.14a                      | 254.44±8.05                              | 0.56±0.05a                                  | 0.31±0.03a                                | 44.64±4.83        |
| Medium dose group    | 4.0         | 42.89±2.42b                      | 221.80±6.54b                             | 0.70±0.05b                                  | 0.38±0.03b                                | 45.71±5.24        |
| High dose group      | 6.0         | 44.23±2.43b                      | 217.42±4.58b                             | 0.84±0.0b                                   | 0.44±0.06b                                | 47.62±5.17        |

*a* Significant difference compared to the constipation model group (P<0.05)

*b* Highly significant difference compared to the constipation model group (P<0.01)

4. Conclusion

New functional anti-seasickness compressed biscuits were developed. The added value of biscuits derived from the beneficial effects of ginger powder, taurine, GBP and pear residue that were added to the formulation in proper amounts, as assessed by seasickness induced mouse model. The final experimental results are as follows: the addition of ginger powder in biscuit powder is 0.35%, the addition of taurine in compressed biscuit formula is 0.05%, and GBP is 0.4%.

It is suggested that the ingredients of ginger powder, taurine and GBP in compressed biscuits can increase glycogen reserves in mice and enhance the high-energy matter usage abilities of skeletal muscle cells, thus achieving anti-fatigue and anti-seasickness effects. The soluble dietary fiber from pear residue in the compressed biscuits had a highly significant effect on the increase of small intestinal propulsion rate in mice (P<0.01), and also significantly reduced the defecation time of the first black feces and increased the quantity and mass of feces (P<0.05). These results have demonstrated that such functional compressed biscuits can efficiently relieve the symptom of seasickness.

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