Effects of Chicken Extract on the Recovery from Fatigue Caused by Mental Workload

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Abstract. Folk wisdom suggests that chicken extract is useful for recovery from physical and mental fatigue. To explore this question, the physiological effect of Brand's Essence of Chicken (BEC), a popular chicken extract used as a traditional remedy, was assessed during recovering from mental stress. We quantitated the blood levels of stress-related substances, and examined the task performance and subjects' mood states during mental workloads. Subjects were 20, healthy male students who have never tasted BEC. They took two bottles of BEC or a placebo (70 ml/bottle) daily in the morning for 7 days. On the final experimental day, two mental workload tests were performed: (A) a mental arithmetic test (MAT; 1600 trials of two or three figure-addition or subtraction for 40 min). (B) a short-term memory test (SMT; 20 trials of memorizing 9 digit numbers). Blood was collected before and after each workload task. After the mental workload, the recovery of mean cortisol level of subjects who consumed BEC was significantly faster than that for those consuming the placebo. The task performance of subjects performing the MAT and SMT was also improved with BEC consumption compared with placebo. According to the profile of mood state questionnaire, subjects felt more active and less fatigued during the workload when they took BEC regularly. We conclude that the extract of chicken has the potential to metabolize stress-related substance in blood and to promote recovery from mental fatigue.


Keywords: chicken extract, mental fatigue, workload, serum cortisol, profile of mood state (POMS)

Introduction

Folk wisdom holds that chicken extract works for the recovery from physical and mental fatigue. Chicken essence and chicken soup are widely taken, particularly in Chinese communities in Southeast Asia, as traditional remedies for various aims including (A) physical recovery from and nutritional supplement for the sickness that often afflicts postpartum women; (B) the physical development of athletes; (C) recovery from mental stress; and (D) stimulating and enhancing mental efficiency of students. In recent years there has been a resurgence of interest in traditional remedies. However, few reports can be found in the literature relating to the effects of chicken and other meat essences upon human performance. The acute thermic response to chicken essence in humans has been reported (Geissler and Boroumand-Naini, 1989). These authors report that mean metabolic rate was significantly increased after administering the essence, and that the response was greater than expected from the total energy and protein content of the essence. As for the effect of the chicken extract on recovery from blood donation, iron nutrition has been improved in human experiments (Williams and Schey, 1993).

On the other hand, some reports have been found in the literature relating the desirable effects of food essences on both recovery from mental stress and efficiency in performing mental tasks. Recently, it is reported that docosahexaenoic acid (DHA), a metabolite of (\(\omega-3\))linolenic acid found abundantly in fish oil, had the potential to enhance mental work in behavioral experiments using animals. In the reports, a lack of DHA in the brain caused some disorders of learning. The effects of DHA on recovery from mental fatigue have also been reported (Nakashima et al., 1993; Yamamoto et al., 1987; Yokogoshi et al., 1992). It is shown that L-carnosine (CAR: \(\beta\)-alanyl-L-histidine), which is a natural antioxidant of meat extract, accelerates the metabolism of stress-related substances such as cortisol (Nagai K et al., 1990). A derivative of CAR, anserine (ANS: \(\beta\)-alanyl-1-methyl-L-histidine), is also present in a large amount in
chicken meat and may have same activities related to CAR. These results, however, were based on animal studies.

In the present study, we attempted to prove the effect of chicken extract on mental activity in humans. Essence of chicken is made by extracting water soluble substances under mild heating conditions for several hours. It contains mainly protein, amino acids, and peptides such as CAR and ANS, found particularly in chicken flesh. We evaluated the blood levels of stress-related substances by requiring the human subjects to perform a set of mental tasks as a workload. We also assessed changes in the subjects' mood states during the workload.

**Materials and Methods**

**Subjects**

Subjects were 20 healthy male students who had never taken BEC. We did not take female subjects because their menstrual cycle would affect their performance in mental workload. They were all recruited from university students in Indonesia. A written consent was obtained from each one of them prior to participation in the experiment. Ages ranged from 18 to 24 years (mean: 21.1 years), and body weight ranged from 42 to 80 kg (mean: 57.6 kg).

**Test drinks**

Brand's Essence of Chicken (BEC; 70 ml/bottle: Cerebos Pacific Ltd., Singapore) was used for the test sample of the chicken extract. A 7.2% gelatin with 0.3% caramel solution, which had the same appearance and calorific content as BEC, was given for the placebo.

**Administration schedule**

The subjects were divided into two groups (group A and group B) according to a pre-arithmetic calculation test to equalize in both groups the abilities to perform tasks. Following this division, group A subjects consumed two bottles (140 ml) of BEC (BEC condition) and group B subjects consumed 140 ml of placebo (placebo condition) both daily in the morning for 7 days. (See Fig. 1.) On the final administering day, mental workload tests (test session-1) were given to the both groups of subjects. After a 3-week-wash-out period, the same mental workload tests (test session-2) were performed in the same way except that the sample intakes were reversed, i.e., the group A was given the placebo condition for 7 days and group B was given the BEC condition (Fig. 1). We compared the results between the BEC and placebo intake conditions with a within-subject-design.

**Experimental schedule**

Subjects received two types of mental workload tests, a mental arithmetic test (MAT) and a short-term memory test (SMT). The MAT consisted of 1600 trials of two- or three-figure addition or subtraction printed on 40 sheets, i.e., each sheet contained 40 questions and the subjects were instructed to get as many answers as possible within one minute time limit per sheet. The SMT was a memory test of numbers. The subjects read a sequence of 9 numbers. After 5 seconds, they had to write down in 5 seconds the 9 digit numbers in the correct sequence they had just heard. Twenty trials were given. MAT and SMT were run in a row on the final day of administering each solution. Blood was collected from the subjects before and after each workload. The profile of mood state questionnaire (McNair and Lorr, 1964) was administered for analyzing subjective feelings during the test.

**Analyses of blood sample**

Serum cortisol levels were determined for indices of mental stress. They were assayed by a standard immunochemiluminescence method.

**Results**

Four subjects refused to continue the test series half way through the experiment. The data described below were therefore compiled from 16 subjects.

**Stress-related substances in blood**

Serum cortisol levels from the 16 subjects were compared between the BEC- and Placebo-intake conditions. The results are shown in Fig. 2. A two factor ANOVA showed a main effect of Condition (F(1,30)=8.86, p<.01), a main effect of Time (F(2,30)=28.89, p<.0001), and an effect of Condition by Time interaction (F(2,30)=4.09, p<.05). All effects were significant. By further statistical analyses, the recovery of mean cortisol level in BEC condition, (normalized to the pre-workload
condition) was significantly faster than in Placebo condition (t(15)=3.141, p<.01).

Task performance on mental workload test

As shown in Table 1, the number of completed answers, the number of correct answers and the performance rate on MAT remained at high levels in subjects consuming either BEC or placebo, and there were no significant differences between the two conditions. The mean error rate on MAT (%) was, however, nearly significantly different between the two conditions (t(15)=1.765, p<.10). The means were 7.15 and 7.91, respectively, in BEC and placebo condition (Fig. 3).

The mean error rate on the SMT was averaged for every 10 answers, thereby evaluating performance change as a function of time on task. The scores on SMT were generally higher during BEC condition, but no statistically significant difference was found between the two conditions. For SMT, a further analysis of variance was conducted on two factors: "time" and "consumption", with respect to the recall error rate for 10 trials in the earlier half and 10 trials in the latter half of the task (Fig. 4). The major effect for "time" yielded a borderline significance, F(1,30)=3.37, p<.10, but neither a major effect for "condition" nor interaction of "time" and "condition" was found. While statistically significant

Table 1 Task performance of mental arithmetic test (MAT)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Correct answers</th>
<th>Filled out answers</th>
<th>Performance rate (%)</th>
<th>Error rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLACEBO</td>
<td>429 ± 19</td>
<td>466 ± 21</td>
<td>29.1 ± 1.3</td>
<td>7.91 ± 0.87</td>
</tr>
<tr>
<td>BEC</td>
<td>456 ± 19</td>
<td>490 ± 21</td>
<td>29.4 ± 1.3</td>
<td>7.15 ± 0.65</td>
</tr>
</tbody>
</table>

Data represent the mean ± standard error (SE) for 16 subjects. †indicates significance at p<0.1. *Performance rate is a percent of questions answered (right or wrong) to the total number (1,600) on the test.

Fig. 3 Error rate for the mental arithmetic test (MAT). Mean error rates of all trials of 16 subjects were calculated. The solid bar represents the data of the BEC intake condition, the lighter bar represents the data of the placebo intake condition. Data are means ± SE. Statistical significance between conditions: †p<0.1.

Fig. 2 Recovery of serum cortisol level. Mean changes of serum cortisol level were calculated on the basis of the values of the pre-workload condition. Cortisol levels at the pre-workload condition were 14.60 ± 1.20 (µg/100 ml) in the BEC intake condition, and 12.83 ± 0.70 (µg/100 ml) in the placebo intake condition. Open squares represent the data from the placebo intake condition, closed square represent data from the BEC intake condition. Data points are mean ± standard error (SE). Statistical significance between conditions: *p<.05, **p<.01.

Fig. 4 Error rate for the short term memory test (SMT). Mean error rates of first and second half sessions of the 16 subjects were calculated. Dark bars represent the data of the BEC intake condition, the lighter bars represent the data of the placebo intake condition. Data are means ± SE.
Fig. 5 Results of profile of mood state (POMS). The mean score changes of 7 mood factors (Tension, Depression, Anger, Vigor, Fatigue, Confusion, Friendliness) were calculated on the basis of a pre-workload session: (A) post-MAT session, (B) post-SMT session. Dark bars represent the data of the BEC intake condition; the lighter bars represent the data of the placebo intake condition. Data are means ± SE. Statistical significance between conditions: *p<.05.

Differences were not obtained, the recall error rate (in particular, that in the earlier session before the establishment of an habituation to the task) was 25.8% for BEC condition and 32.2% for Placebo condition, indicating a slight improvement of memory with BEC.

Subjective mood state

Using the POMS questionnaire, mean score changes of each factor (tension, depression, anger, vigor, fatigue, confusion and friendliness) were calculated and compared with the pre-workload condition (Fig. 5). After MAT, the score for “anger” increased in BEC condition, but decreased in placebo condition (t (15)=2.189, p<.05). The score of “fatigue” increased in subjects on the Placebo condition, but remained unchanged in BEC condition (t (15)=2.576, p<.05). After SMT, the score for “tension” remained at a high level in BEC condition compared with Placebo condition (t (15)=2.812, p<.05), and the score for “vigor” showed a less decrease in BEC condition (t (15)=2.625, p<.05). These results suggested that the subjects felt more active but less fatigued during the workload task when they took BEC.

Discussion

Stress-related substances in blood

From the results of cortisol concentration in serum, it is evident that the mean levels were highest immediately before MAT, i.e., 14.60 µg/100 ml and 12.83 µg/100 ml, for BEC and Placebo conditions, respectively. This may be attributed to the elevated release of stress-related compounds (represented by cortisol) due to the stress caused by anxiety or tension before starting a test. These levels were significantly higher than the serum cortisol levels at rest condition, i.e., 5.0-10.0 µg/100 ml. Since the serum cortisol concentration was reduced to the normal level more clearly and quickly after taking BEC than after taking placebo, it may be suggested that BEC contains a factor which accelerates the metabolism of cortisol.

Generally speaking, the stress-related compounds such as cortisol are released as an alerting signal. If, however, they remain in the blood for a long period, they may cause various psychosomatic symptoms through the reduction of immune and other protective functions. It is conjectured, therefore, that restoring the level of released stress-related compounds to normal levels quickly allows a release of mental stress symptoms. Among the ingredients in BEC used in the present experiment are CAR and ANS. 140 ml of BEC contains several hundred milligram of CAR and ANS, which are regarded as candidates for the cortisol metabolism accelerator. These substances may enhance metabolic enzyme activity in the liver (Nagai K et al., 1990).
Task performance on mental workload test

Task performance and work efficiency were examined by MAT and SMT after BEC and placebo administration. The MAT was a task demanding "accuracy" and "speed" in the mental work, requiring the subjects to perform a series of 1,600 simple calculations in 40 minutes. As shown in Table 1, the performance rate was about 30% after consumption of BEC or placebo, and there was no difference between conditions. The error rate after the administration of BEC was, however, 11% lower than that following consumption of placebo. This difference was significant at the 10% level.

It may be concluded, therefore, that BEC is effective for enhancing "concentration" by reducing the calculation errors while keeping work efficiency at a fixed level. In one of our earlier studies, the subjects were asked to evaluate an odorous substance for which stress-relieving effects had been demonstrated in an animal experiment (Nagai H et al., 1990; Nakagawa et al., 1992). Since the efficacy was defined in terms of physiological parameters, but not in terms of task performance in the authors' previous study, it is of significance that the efficacy should be assessed in terms of behavioral parameters as in the present experiment.

For SMT, as a result of Fig. 4, the major effect for "time", revealed as a lowered recall error rate, may be attributed to the habituation to trials within a session. In the present memory task, the number series was recalled immediately after memorizing. It may be necessary to confirm the effect of BEC administration upon retention of memory on BEC administration, for instance, by changing the task difficulty through the inclusion of an elimination process prior to recitation phase of the memory recall.

Subjective mood state

Nakagawa and Nagai (1991) found using the POMS that typical changes in the subjects' mood state generally observed in a mental stressful task were increased "fatigue", lowered "vigor" and augmented "confusion". In the present study, the same pattern of mood change was seen in the placebo-subjects, thus indicating that MAT and SMT given to them evoked a stress-related mood. On the other hand, when BEC was taken, "fatigue" increased very little immediately after MAT (Fig. 5). MAT involved successive efforts of calculation for 40 minutes, and this significant decrease in fatigue may have been partly responsible for the smaller calculation error rate seen in MAT (Table 1). Another feature we observed in the BEC-subjects was a significant increase in the "anger" factor following MAT. This increase in "anger", one of the seven factors of the POMS, is generally explained as a negative change in subjective mood state, and is not bound in such a simple task loading test as used in the present study. However, based on subjects' comments reported in interviews following the test, it became obvious that many of the subjects had misinterpreted the term "anger". As a result from these interviews, it is concluded the changes in the "anger" factor revealed in the present experiment may be interpreted as positive feelings in the subjective mood state, such as "willingness" or "aggressiveness", rather than increased "irritation" induced by the consumption of BEC. Moreover, "aggressiveness" may be increased through an augmentation of metabolic rate (thermic response) after intake of BEC (Geissler and Boroumand-Naini, 1989). It should be noted that a circadian rhythm in body temperature correlates with a human mental activity (Stephan, 1985). He observed that during the day, a period of high body temperature insured a higher performance of mental work.

On the other hand, the subjective mood state as measured by the POMS immediately after SMT revealed a suppression of "vigor" and augmentation of "tension" in BEC-subjects compared with those consuming placebo (Fig. 5). The mental workload produced by a test such as SMT, where a series of memory task is required needs a sustained level of concentration. Such a task is directly linked to a reduction in "vigor", as in both groups (Fig. 5). However, in the BEC-subjects, the "tension" response factor increased significantly above that of the placebo-subjects (Fig. 5B). Such an augmentation of "tension" may tend to raise a level of awareness and enhances concentration, both activities would tend to prevent a marked decrease in "vigor".

Active components

These benefits of BEC may be attributable to some of its ingredients: CAR, ANS, various amino acids, peptides and proteins (Geissler and Borouman-Naini, 1989). Recent reports claim that intake of amino acid from food affects the concentration of cerebral neurotransmitters synthesized from them (Beverly et al., 1991; Park et al., 1976), and that the quantity and quality of protein in food affects protein synthesis in some brain areas, e.g., the hippocampus and the brainstem (Yokogoshi et al., 1992). In the present experiment, a gelatin solution of protein composition similar to meat extract was used as a placebo control. Thus the effects of BEC are inferred as being due to the action of ingredients other than amino acids on particular parts of the central nervous system. One report described a pre-administration of glucose increased a subjective feeling of "concentration" while driving a car, but both BEC and the placebo used here contained negligible carbohydrate (Keul et al., 1982). Another investigator reported that a choline supplement in food improved the memory of mice (Bartus et al., 1980). 140 ml of BEC contains 50 mg of phosphatidylcholine. It is, however, difficult to regard such an ingredient as the sole active component.
Conclusion

We have described the effects of a week-long consumption of BEC on the efficiency of mental workload tasks. In summary the effects of BEC were (A) an acceleration of metabolism of stress-related substances in the blood, (B) an improvement of subjective mood state, and (C) a facilitation of work performance. Nevertheless, it is necessary in future studies to identify the effective ingredients in BEC and clarify their mode of action. In addition, it is hoped to determine whether BEC can only exert its effect after a week of consumption or if shorter times, down to a single load, can result in augmented mental performance.

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References


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