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Development and oviposition characteristics of *Protaetia brevitarsis* (Coleoptera: Cetoniidae) by additional feeding Korean black raspberry marc and blueberry marc

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Abstract

The food source of white-spotted flower chafer, *Protaetia brevitarsis* is important to economical performance. The *P. brevitarsis* larva were feed by mulberry and oak fermented sawdust. The effect of additional additives, Korean black raspberry (called bokbunja) marc and blueberry marc to fermented sawdust feed on the development and oviposition characteristics were investigated. The development periods of *P. brevitarsis* was decreased from 165.7 d to 40.0 d (mulberry sawdust) and 169.3 d to 39.0 d (oak sawdust), but the survival rate of larva was not affected by the addition of Korean black raspberry marc to fermented sawdust. However, blueberry marc addition to the fermented sawdust did not significant effect on the development period and survival rate of *P. brevitarsis*. The percentage of larva weight over 2.5 g was tend to increase by addition of Korean black raspberry marc and/or blueberry marc. The number of oviposition was also tend to increase by adding additional feed to sawdust but there was no significant different.

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Introduction

Worldwide, more than 1,900 species of insects have been documented for edible purposes, with the most consumed insect Coleoptera (31%), and countries such as China, Thailand, South Africa, and Mexico are known to have the highest use of edible insects (Song *et al*., 2017). Japan has developed a full-fledged insect industry since the 80s with the formation of a pet insect market, Europe is mainly a pollinating insect, Canada and the United States are natural enemy insects, and Asia, including China and Thailand is an increasing market size of edible insects (Kim *et al*., 2015a).

In addition to the development of the insect industry in Korea, the mass breeding of insects is being carried out throughout the country. The *Protaetia brevitarsis* was registered as a food by the Ministry of Food and Drug Safety in December 2016 (Song *et al*., 2017), and the number of farmers breeding *P. brevitarsis* in the country was 1,265 in 2019, accounting for 50% of the domestic industrial insect breeding farms and the sales amount of 189 billion won, accounting for 47% of the total insect sales (MAFRA, 2020).

Although Oak sawdust is being used as a food source for the breeding of *P. brevitarsis*, there are various fields in which oak trees are used, the problem of environmental destruction

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by logging is emerging, and the feed cost of breeding 3.3 m^2 of *P. brevitarsis* is 106,000 won, accounting for 32% of the total production cost (Lee *et al*., 2018), and due to the supply and demand instability and continuous price increase of existing Oak fermented sawdust, it is necessary to improve insect productivity and develop low-cost fermented sawdust.

The planting area of Korean black raspberry (*Rubus conreanus*, called Bokbunja) and Blueberry (*Vaccinium corymbosum*) is 2,910 ha (971 ha of Bokbunja, 1,939 ha of Blueberry) in 2020, of which 650 ha (393 ha of Bokbunja and 257 ha of Blueberry) accounts for 22.3% of the national planting area (Statistics Korea, 2020).

The Bokbunja is a plant belonging to the Rosaceae family, which has been shown to prevent liver damage caused by fatigue, brighten the eyes and used it as a diuretic, or it is effective in erectile dysfunction, promoting sexual function, promoting hair growth and preventing hair from counting white (Shin *et al*., 2003). The Bokbunja is known to be rich in vitamins B or C, inorganic components and carotenes, polyphenols, and anthocyanins (Yu *et al*., 2008), antioxidant effects on Bokbunja extracts, immune enhancement (Lee *et al*., 2003) and hepatitis B inhibition (Chung, *et al*., 1997), and anti-cancer and anti-inflammatory effects (Kim *et al*., 2005; Yang *et al*., 2007)

Blueberries are shrub plants belonging to the family *Ericaceae Vaccinium*, and they are processed into jam, wine and sauces in addition to frozen raw materials, and are widely used as a confectionery raw material (Lee and Lee, 2007). Blueberry mature fruit contains a high amount of the bioactive substances anthocyanin and resveratrol, which have been shown to be excellent in antioxidant, anti-diabetic and anti-cancer properties, as well as effective in preventing various adult diseases (Jeong *et al*., 2012), and in 2002, the U.S. current affairs weekly Time ranked blueberries as one of the top 10 health foods in the world (Song *et al*., 2014).

As such, the Bokbunja and Blueberry have a high protein content compared to bananas, apples, etc., which are widely used as a food source for *P. brevitarsis* imago, and have a wide variety of functional components, so their use value in *P. brevitarsis* breeding is very high (Moon *et al*., 2018). In particular, the fruits of Bokbunja and Blueberries are distributed as raw fruits, or sold through processing such as beverages and liquor, and the fruit used for processing is left with marc after the juice is squeezed, and most of it is discarded. Therefore, it is expected that by breeding *P. brevitarsis* using Bokbunja marc and Blueberry marc, which are by-products of discarded berries, it will be possible to produce processed products with improved quality and high functionality.

In Korea, various studies have been conducted on alternative food sources and additives of edible insect *P. brevitarsis*, such as oriental medicine by-products, mushroom post-harvest medium, soybean beef, fermented aloe, mulberry pruning branches, etc., and the production cost reduction and functional effects have been reported accordingly. (Choi *et al*., 2020; Choi *et al*., 2019; Kim, 2019; Lee *et al*., 2018; Moon *et al*., 2018; Song *et al*., 2018; Song *et al*., 2017; Kang *et al*., 2012) However, it has not yet been put to practical use.

Therefore, the discarded Bokbunja marc and Blueberry marc were used as additives to Mulberry fermented sawdust and Oak fermented sawdust to compared the development properties of *P. brevitarsis* and to verify productivity.

Materials and methods

Experiment insect, feeding sources and additional material

The *P. brevitarsis* used in the experiment was purchased from an insect breeding farmhouse in Jeollabuk-do Jangsu County, and the worm was bred in the breeding room of the Sericulture and entomology experiment station(SSES) Insect Test Site (25±1°C, RH 50-60%) of the Jeollabuk-do institute of agriculture and technology, and used in the experiment. The breeding vessel used a 20ℓ living box (plastic box; 543 mm × 363 mm × 188 mm) and supplied bananas for adult feeding. Oak fermented sawdust was purchased and used by a Jangsu-gun *P. brevitarsis* breeding farm, and mulberry fermented sawdust was used in experiments by fermenting the pruning branches of mulberry grown at the SSES into sawdust using a twig crusher and grinder, and mixed with bran to ferment. The fermentation method was based on 30 kg of sawdust based on the Oak sawdust fermentation method, 3 kg of bran, 0.5 kg of sugar, and 300 ml of microbial agent (EM) were added and fermented for 90 days in a fermentation facility of a Jangsu-gun insect breeding farm. Microbial agents were purchased from the Buan county agricultural technology center. After Juicing, the remaining debris was purchased, some of which were used as food for *P. brevitarsis* adults, and some were dried for 3 days with a hot air dryer (55-60°C) and crushed into powder and stored as additives to the food of the *P. brevitarsis*

larvae. The breeding conditions were 16L:8D with an incubator set to a temperature of 25±1℃ and humidity of 60% in the breeding room.

Characteristics of the development of *P. brevitarsis* according to the addition of Bokbunja marc and Blueberry marc

The Bokbunja marc and Blueberry marc, which are by-products of Bokbunja and Blueberries, were mixed evenly in Mulberry fermented sawdust and Oak fermented sawdust in different proportions of addition, respectively, and placed in a breeding vessel for each of the freshly hatched *P. brevitarsis* larvae in 1 individual, and the development characteristics of the larvae were investigated. The addition ratio was 0, 5, and 10% of the fermented sawdust. The breeding vessel used petridish (φ100 x 40 mm) and repeated three times for each treatment of 20 larvae. The development characteristics were examined for the development period by larval stage, the pupa period and the survival rate of the larvae and the larval weight distribution ratio. The larval stage was distinguished by measuring the size of the larval head width, and the period of development and the weight of the larvae were examined by observing it once every 2-3 days. The pupa period was from the day the cocoon formed to the period during when the eclosion at the cocoon. Larval survival rates were examined for the duration of larval development and whether or not they died. The larval weight distribution ratio was divided into three steps, 2.3 to 2.5 g, and 2.5 g or more for the maximum weight before pupating up to 100 days after hatching, and the larval number was investigated, and the ratio was converted.

P. brevitarsis oviposition characteristics according to the addition of Bokbunja marc and Blueberry marc

In order to investigate the oviposition properties of the *P. brevitarsis* according to the addition of Bokbunja marc and Blueberry marc, the oviposition number was compared by adding Bokbunja marc and Blueberry marc respectively to the Banana and insect jelly, which are often used as food for adult *P. brevitarsis*. The oviposition mat used mulberry fermented sawdust filled with petridish (φ120 × 80 mm) by about 1/2, and was supplied with bananas, jelly, Bokbunja marc and Blueberry marc. The contents of the treatment were 6 treatments such as Banana + Bokbunja marc, Banana + Blueberry marc, jelly + Bokbunja marc, jelly + Blueberry marc, in contrast to the treatment supplied only with Banana and the treatment supplied only with jelly, and 1 pair per treatment was investigated in 5 repetitions.

Bokbunja marc and Blueberry marc are purchased from farmers and supplied as feeding to 1 teaspoon of non-dried marc at disposable weighing dishes (KA. WB-158, small) and it was changed of once every 1-2 days to avoid decay. Banana and jelly were also supplied in the same way. The oviposition number was examined at intervals of 7 days by placing one pair of *P. brevitarsis* adult on the first day of the eclosion, breeding in an incubator (25±1℃, photoperiod L:D=16:8), and comparing the total number of oviposition by treatment.

Characteristics of the development of *P. brevitarsis* according to the use of mixing berries marc

Three kinds of Bokbunja marc, Blueberry marc, and Mullberry marc were mixed and added to Mulberry fermented sawdust at different rates to investigate the development properties of *P. brevitarsis* larva. The mixing method was used by mixing dried Bokbunja marc, Blueberry marc, and Mullberry marc at 1: 1: 1, and the mixing ratio was 10%, 20%, and 30%, respectively, in Mulberry fermented sawdust, and the Mulberry fermented sawdust without the addition of mixing berries marc was compared with the development properties, as a contrast. The breeding vessel was filled with 2/3 of the Mulberry fermented sawdust using petridish (φ100 × 40 mm), the berries mixed marc was mixed evenly by proportion, and then one freshly hatched *P. brevitarsis* larvae was bred individually. The development characteristics were examined in the above manner for the development period and the larval survival rate by larval stage, and the larval number of more than 2.5 g during the development period from the 30th to the 95th day of the third stage was examined at intervals of 10 days.

The larval weight of 2.5 g is the weight at which the larvae have grown sufficiently on a reasonable weight basis when harvesting the *P. brevitarsis*, and the weight set forth by the Rural Development Agriculture as the breeding standard for *P. brevitarsis* is generally presented as the shipping standard for *P. brevitarsis* breeding farmers.

Statistics processing

The results obtained in the experiment were analyzed for T-test and ANOVA using the SPSS program (PASW statistic 18) and

then a Duncan's multiple range test (DMRT) was performed at the 5% level to ascertain the significance between the treatment means.

Results and Discussions

Characteristics of the development of *P. brevitarsis* according to the addition of Bokbunja marc and Blueberry marc

A. Effect of adding Bokbunja marc

As a result of breeding *P. brevitarsis* with Mulberry fermented sawdust and Oak fermented sawdust added by the addition ratio of Bokbunja marc (Table 1), the larval development period was 40.0 days with 10% addition and 44.4 days with 5% addition in the treatment of adding Bokbunja marc to the Mulberry fermented sawdust, which was shortened by more than 125 days compared to 165.7 days of treatment without addition, and the development period of 2 and 3 stage was significantly shortened rather than 1 stage. In particular, the development period of the 3rd stage was 21-25 days, so that the difference was large enough to shorten by more than 110 days compared to 135 days without treatment. The pupa period was also shortened by 11-12 days compared to 42.1 days of treatment without the addition of Bokbunja marc.

Experiments with the addition of Bokbunja marc to Oak fermented sawdust also showed a similar tendency due to the shorter development period of larvae and pupa periods. The survival rate fell slightly to 92.9% with the addition of 10% of the Bokbunja marc compared to 100% untreated in Mulberry fermented sawdust, and the addition of 5% to 52.9%. However, in the Oak fermented sawdust, it was all about 97% better in the treatment with the addition of Bokbunja marc compared to 92.5% without treatment. The reason why the survival rate in the treatment of 5% of Bokbunja marc in Mulberry fermented sawdust has dropped significantly is because a bad fungus occurred in the Mulberry fermented sawdust during the experimental process, and the damage to the mite was severe, so it is understood that there is a problem in the sawdust fermentation process or moisture management, and was not affected by the Bokbunja marc because it was dried and used as a powder.

The result that the larval developmental period was shortened was similar to the result that when Mulberry marc was added to Mulberry fermented sawdust, the larval development period was shortened by more than 117 days, the effect was good at the addition rate of 5% or more, and the mulberry marc was rich in nutrients such as protein, which shortened the larval development period (Moon *et al*., 2018).

In addition, the addition of 3-15% of aloe vera to Oak fermented sawdust reduced the larval development period by about 30 days (Kang *et al*., 2012), a report that the addition of livestock feed reduced the larval development period by more than 35 days (Song *et al*., 2018), and a report that the development period of the *P. brevitarsis* larvae according to the mushroom post-harvest medium feed was about 20% shorter than when the Oak fermented sawdust (Lee *et al*., 2018), and that the mushroom post-harvest medium had a higher protein content than Oak fermented sawdust, which also affected the nutritional content of the *P. brevitarsis* larvae (Cheong *et al*., 2012) and the like those reports, it is believed that the nutrient content of

Table 1. Developmental periods and survival rate of *P. brevitarsis* in different additional ratio of the bokbunja marc based on mulberry fermented sawdust and oak fermented sawdust(2018)

ased on fermented sawdust type	Bokbunja marc additional ratio (%)	Developmental periods of larvae(days)				Pupa periods (days)	Survival rate (%)
		1st	2nd	3rd	Total		
Mulberry	10	8.8±0.8	10.0±2.3	21.2±2.3	40.0 a	31.1±2.1	92.9
	5	8.2±0.8	10.9±3.0	25.0±2.9	44.4 a	30.0±2.0	52.9
	0	9.9±0.9	20.7±4.7	135.1±20.2	165.7 b	42.1±4.5	100
Oak	10	7.8±0.6	9.4±0.9	21.8±1.8	39.0 a	34.1±1.7	97.3
	5	8.6±1.0	11.2±1.9	21.6±1.7	41.4 a	32.1±1.8	97.1
	0	12.6±1.5	21.1±7.0	135.6±21.4	169.3 b	38.0±5.9	92.5

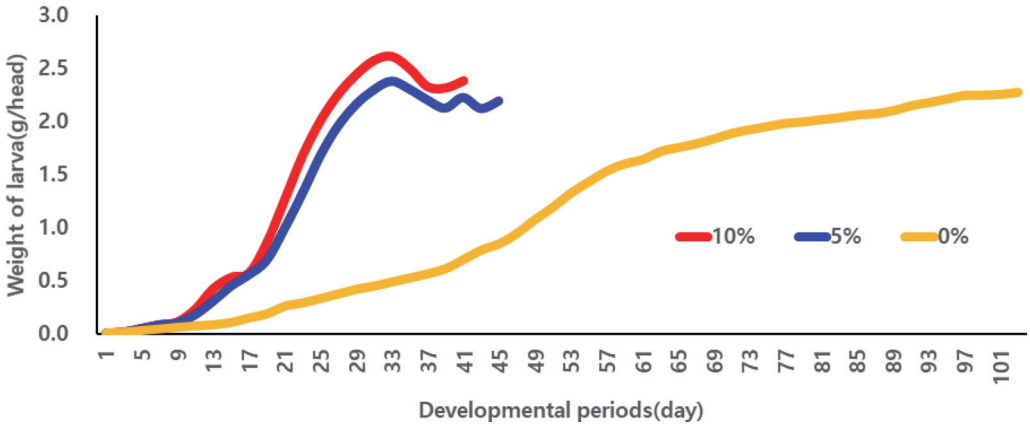

Fig 1. Change of the *P. brevitarsis* larva weights in different additional ratio of bokbunja marc based on mulberry fermented sawdust (Survey period: 10. May ~ 20. August, 2018).

the Bokbunja marc may have acted as a factor in shortening the larval development period. If the development period of the larva is shortened, the harvest period is shortened, which has the effect of increasing production and improving income. The reason for the long development period under natural conditions is that natural enemies, but natural environmental conditions such as temperature, humidity, and rainfall are unfavorable, and in indoor breeding conditions where environmental conditions are favorable, it is naturally believed that the development period will be accelerated according to the instinct of breeding, but it is judged that too fast will be a risk of causing disease, but it needs to be examined later.

However, it is believed that the management of sawdust will be very important because it affects the survival rate if the fermented sawdust is contaminated in the process of breeding *P. brevitarsis*, and if the Bokbunja marc was added raw, and was not added as a powder after dried, and it is believed that the method of adding the by-product will also need to be examined at a later date because there is a risk of decay.

The change of the *P. brevitarsis* larvae weights according to the ratio of the addition of Bokbunja marc to the Mulberry fermented sawdust was faster than that of the untreated treatment in the treatment with the addition of 10% and 5% of the bokbunja marc in the rate of weight. And the development was completed only 33 days after hatching. By the rate of addition of Bokbunja marc, the higher the addition rate, the faster the weight increase tended to be (Fig. 1).

By 100 days after hatching according to the proportion of Bokbunja marc added to Mulberry fermented sawdust, the

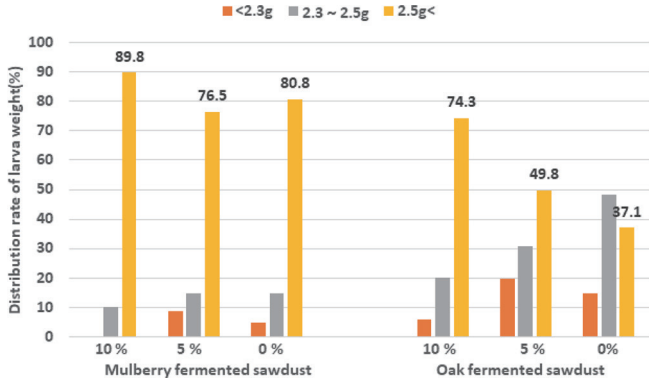

Fig 2. Distribution rate of *P. brevitarsis* larva weights in different additional ratio of bokbunja marc based on mulberry fermented sawdust and oak fermented sawdust(* Survey period: 10. May ~ 20. August, 2018).

proportion of *P. brevitarsis* larval individual weight distribution was 89.8% in the treatment with 10% added and 76.5% in the treatment with 5% added at a rate of 2.5 g or more. This result was similar or higher than that of 80.8% of the treatment without the addition of Bokbunja marc.

In addition, in the treatment in which the Bokbunja marc was added to the Oak fermented sawdust, the ratio of more than 2.5 g was 74.3% in the treatment with the addition of 10% and 49.8% in the addition of 5%. It was very high compared to the untreated 37.1%, respectively. but the distribution ratio of more than 2.5 g in the treatment added Bokbunja marc to the oak fermented sawdust was lower than in the treatment with the added to the Mulberry fermented sawdust (Fig. 2).

As a result, when the Bokbunja marc is added, the distribution

Table 2. Developmental periods and survival rate of *P. brevitarsis* in different additional ratio of blueberry marc based on mulberry fermented sawdust and oak fermented sawdust

Based on fermented sawdust type	Blueberry marc additional ratio (%)	Developmental periods of larvae(days)				Pupa periods (days)	Survival rate (%)
		1st	2nd	3rd	Total		
Mulberry	10	8.4±0.80	12.2±3.39	104.9±33.54	125.5 a	39.3±2.22	97.1
	5	8.7±0.85	18.5±4.07	98.0±72.04	125.3 a	34.8±5.56	90.0
	0	9.9±0.9	20.7±4.7	135.1±20.2	165.7 b	42.1±4.51	97.1
Oak	10	8.6±0.71	10.4±1.47	53.6±45.84	72.6 a	39.4±3.55	94.3
	5	8.6±0.65	10.2±1.90	85.5±64.59	104.3 ab	37.0±6.07	88.6
	0	12.6±1.45	21.1±6.98	135.6±21.40	169.3 b	38.0±5.89	92.5

ratio of 2.5 g or more is higher than the distribution ratio of 2.5 g or less, it can be estimated that the Bokbunja marc has the effect of shortening the development period of the *P. brevitarsis* larvae and increasing the weight by promoting development.

Mulberry fermented sawdust is known to be more effective in the development of *P. brevitarsis* larvae than Oak fermented sawdust (Jang, 2011; Moon *et al*., 2018) It is shown that the ratio of more than 2.5 g appears to be more than that of Oak fermented sawdust without the addition of Bokbunja marc, and in relatively applied sawdust, the ratio of more than 2.5 g increases significantly compared to untreated, and the higher the addition ratio, the more effective it is.

This result can be interpreted as Bokbunja marc having a similar effect to Odi Bac, as a result similar to the report (Moon *et al*., 2018) that the treatment of adding Odi bak to mulberry fermented sawdust had a higher weight of larvae and a faster time to reach the maximum weight compared to the treatment added to Oak fermented sawdust, which is manifested by a difference in the nutritional content of fermented sawdust.

In addition, in the report that the growth rate of the body length and body weight of the larva was fast and the growth rate was high when apple powder, aloe powder, etc. were added (Yoon *et al*., 2016a), and the report that the addition of soybean foil shortens the development period of the *P. brevitarsis* larvae and speeds up the period until it is sold (Song *et al*., 2017), although there is a difference depending on the type of additive and the rate of addition, the nutritional content of the additive appears to have a direct effect on insect growth, and the Bokbunja marc is considered to be an effective additive for the development of *P. brevitarsis* caterpillars. However, there is no difference in weight change when Bokbunja marc is added to silkworm artificial feed, but according to reports (Son, 2013) that weight gain was achieved in the addition of Mulberry leaf flour and red ginseng foil, it is believed that the effect of the additive may vary depending on the type of insect, physiology, and ecological characteristics. Therefore, it is judged that the development of a food source containing high nutrients is necessary, and the development of effective additives as well as a food source suitable for the development of *P. brevitarsis* is necessary.

B. Effect of adding Blueberry marc

Survey of the development characteristics of *P. brevitarsis* larva according to the proportion of Blueberry marc addition (Table 2) The larval development period for Blueberry marc added to Mulberry fermented sawdust was shortened by about 40 days from 10% addition to 125.5 days and 5% addition to 125.3 days compared to 165.7 days of treatment without Blueberry marc added, and the development period was not significantly shortened than the result of being shortened by more than 120 days in the treatment with the addition of Bokbunja marc earlier. The pupa period also tended to be shortened by 3-7 days, and the survival rate was the same as untreated at 97.1% at 10% addition, and 90% at 5% addition.

In addition, the developmental period of the *P. brevitarsis* larvae according to the proportion of Blueberry marc addition to the Oak fermented sawdust likewise was 72.6 days at the addition of 10% of the Blueberry marc and 104.3 days at the treatment with the addition of 5%, which was about 60-90 days shorter than the 169.3 days of the untreated treatment, and the higher the addition ratio, the shorter the addition. The pupa period was no different from the untreated, and the survival rate was not much different compared to the treatmentless 92.5%.

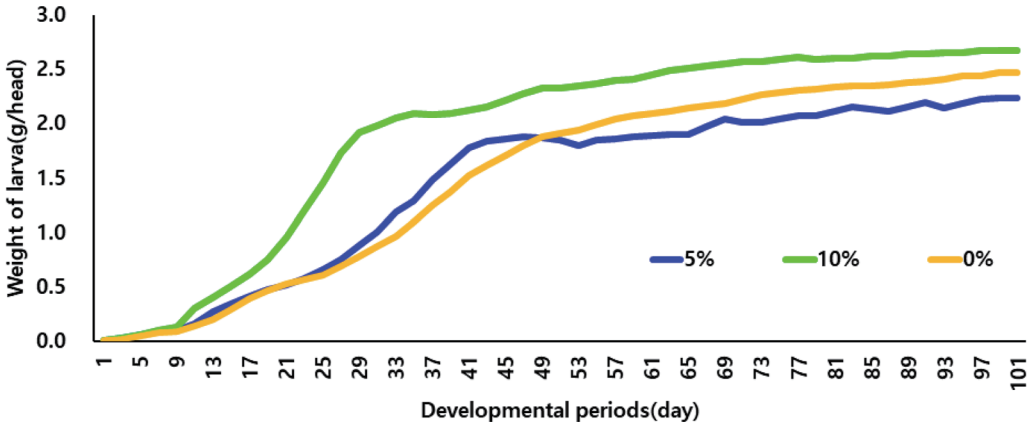

Fig. 3. Change of the *P. brevitarsis* larval weights in different additional ratio of blueberry marc based on mulberry fermented sawdust (Survey period: 9. June ~ 20. September, 2019).

This is due to the effect of shortening the development period, although the effect of Blueberry marc is somewhat less than that of the aforementioned Bokbunja marc, it is clear that it is effective in the development of *P. brevitarsis* larvae, and it is considered stable because there is no difference in the survival rate due to the addition of Blueberry marc. However, depending on the type of auxiliary feed such as Sweet pumpkin, sweet persimmon, banana, aloe, etc., the results of estimating that the weight change of the *P. brevitarsis* larvae and that the mortality rate is different. and that the breeding environment changes according to the method and form of auxiliary feed feeding. And also that changes in the crude protein, crude fat and inorganic components of the *P. brevitarsis* larvae are caused according to the type of auxiliary feed (Yoon, 2017; Yoon *et al*., 2016b). Therefore it will need to examine the methods and forms of supplemental feed feeding in the future, as well as the nutritional content of the *P. brevitarsis* larvae that feed the Bokbunja marc and Blueberry marc.

The change in the weight of the *P. brevitarsis* larvae according to the ratio of Blueberry marc addition to the Mulberry fermented sawdust was the fastest in the treatment with the addition of 10% of the Blueberry marc, and the development was completed only 33 days after hatching, but remained in the 3-stage until 100 days or turned into a pupa in the middle. The treatment with the addition of 5% was similar to the weight gain rate of the untreated (Fig. 3).

The proportion of *P. brevitarsis* larval individual weight distribution according to the proportion of Blueberry marc added to Mulberry fermented sawdust was 76.2% in the treatment with 10% added and 57.1% in the treatment with 5% added at a rate

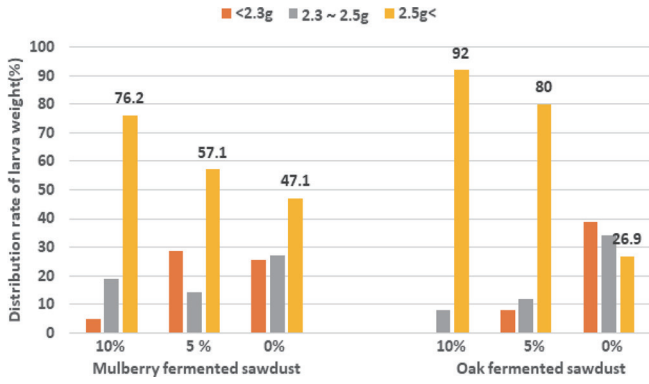

Fig. 4. Distribution rate of *P. brevitarsis* larval weights in different additional ratio of blueberry marc based on mulberry fermented sawdust and oak fermented sawdust(* Survey period: 9. June ~ 20. September, 2019).

of 2.5 g or more, which was a higher proportion of 2.5 g than the untreated 47.1%,. And the higher the addition rate, the higher the tendency to be. the proportion of *P. brevitarsis* larval individual weight distribution according to the proportion of Blueberry marc added to Oak fermented sawdust was also 92% and 80% with 10%, 5% of the treatment with the addition of Blueberry marc, the proportion of more than 2.5 g was higher than that of the untreated 26.9% (Fig. 4).

This is the result of the addition of Blueberry marc, as is the result of the addition of the Bokbunja marc earlier, which is effective in the development of *P. brevitarsis* larvae. However, in the experiment in which Blueberry marc was added to Oak fermented sawdust, the proportion of more than 2.5 g was higher than in the experiment in which Blueberry marc was added to the Mulberry fermented sawdust, and there was a slight difference,

Table 3. Ovipositional number of *P. brevitarsis* adults by additional of different feeding sources based on mulberry fermented sawdust

Contents (Years of experiment)	No. of eggs/female adult			
	Banana	Banana+marc	Insect Jelly	Insect Jelly+marc
Bokbunja marc (2018)	131.3±62.12 a	139.0±49.95 a	100.8±30.63 b	109.1±18.32 b
Blueberry marc (2019)	161.4±19.26 a	173.2±25.24 a	62.7±16.21 c	92.8±21.97 b

which is believed to be the result of the difference in the nutritional content and content of Blueberry marc and Bokbunja marc depending on the origin and variety of Blueberries (Song *et al*., 2014), but it is also believed that there may be an effect due to the feeding preference of the *P. brevitarsis* larvae and the differences in the growing environment between individuals, It needs to be reviewed later.

P. brevitarsis oviposition characteristics according to the addition of Bokbunja marc and Blueberry marc

Survey of the oviposition number of *P. brevitarsis* according to the addition of Bokbunja marc and Blueberry marc (Table 3), When bananas and insect jelly were fed in 2018, the number of oviposition was 131.3 and 100.8, respectively, which was higher when feeding bananas were than feeding jelly, and when the Bokbunja marc was upgraded to bananas and jelly, there was a slight increase 139 and 109.1, respectively from when only bananas and jelly were feeding, But significant differences were not recognized due to the large deviation between individuals.

In 2019, the difference was 161.4 and 62.7 respectively when bananas and jelly were feeding, and the number of oviposition was high, as in 2018, when bananas were feeding. When blueberry marc was added to bananas and insect jelly, the number of oviposition was 173.2 and 92.8, respectively, which tended to increase the number of oviposition rather than feeding bananas and insect jelly alone. Therefore, it is clear that bananas have more oviposition numbers than insect jelly, and it is estimated that the addition of Bokbunja marc and Blueberry marc to bananas and insect jelly has a positive effect on the increase in oviposition number, if not a significant effect. This is due to the impact of on the protein and carbohydrate dietary ratio. Kim *et al*.(2021) was the longevity is long, the number of oviposition is the highest, and the rate of decline in fertility is slowed down at a protein to carbohydrate ratio of 3:7, while consuming only protein leads to shorter lifespans, and decreases the number of oviposition in report of the impact of dietary protain : carbohydrate balance on lifespan and reproduction in *P. brevitarsis*. Which is due to the addition of protein and carbohydrate content contained in Bokbunja marc and Blueberry marc, and needs further review.

However, overall, there was a significant variation in the number of oviposition numbers, which is due to reports that the spawning rate of *P. brevitarsis* decreases when passage breeding under constant temperature breeding conditions, and that the oviposition rate can be increased by low temperature treatment of larva, and that the feeding and temperature affect the number of oviposition (Jang, 2011; Choi *et al*., 2020). It was predictable that the number of oviposition will be affected depending on the feeding conditions, but the results of the significant drop in the number of oviposition in insect jelly in 2019 compared to 2018 are believed to be a large variation depending on the difference in oviposition ability among the test adult individuals or the conditions of the breeding environment.

Characteristics of the development of *P. brevitarsis* according to the use of berry marc mixing

The larval development period (individual breeding) by the ratio of the addition of berry mixed marc to the mulberry fermented sawdust is about 10~30 days shorter than the treatment 131.1 days without the addition of berry mixed marc. And the higher the addition rate is 121.4 days with 10% addition by the addition ratio, 20% 118.8 days, and 30% 101.3 days, the shorter the development period. The survival rate was 97~98%, and there was no difference in the addition rate, and there was no difference in the untreatment survival rate (Table 4).

This did not significantly shorten the development period than the result of the addition of the Bokbunja marc and Blueberry marc without mixing at the above, but it had the effect of shortening the development period rather than the treatment without the addition of the additive. Kim *et al*. (2015b) was

Table 4. Developmental periods and survival rates of *P. brevitarsis* larvae by additional ratio of mixed berries marc based on mulberry fermented sawdust

Additional ratio (%)		Developmental periods of larvae (days)				Survival rate (%)
		1st	2nd	3rd	Total	
mulberry fermented sawdust + mulberry mixture marc	10	13.3	24.2	84.0	121.4 bc	97.0
	20	12.5	21.2	85.1	118.8 b	97.8
	30	11.0	16.9	79.9	101.3 a	98.4
	0	12.7	29.7	88.5	131.1 c	97.8

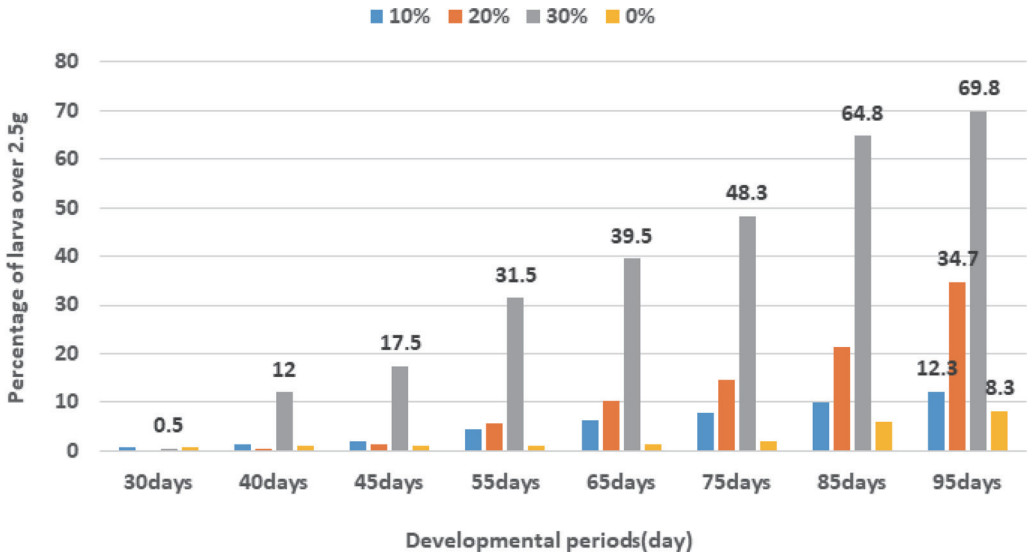

Fig. 5. Percentages of larvae over 2.5g of *P. brevitarsis* by additional ratio of mixed berries marc in developmental periods.

similar to this result because it was more effective in mixed supplied than when supplied rice chaff and soybean cake respectively, as food in the test of the effect of different diets and temperatures on larval growth of the white-spotted flower *P. brevitarsis*. Therefore, even if the berry marc is used in combination, it is judged to be effective in the development of *P. brevitarsis*. larvae. In addition, in view of the survival rate, the addition of mixed marc to the breeding of larvae is considered safe because there is no significant difference from the untreated, and it is judged that the shipment period due to the shortening of the larval development period is accelerated and is economical.

In group breeding, the proportion of larval over 2.5 g according to the development period tends to appear faster than in the treatment without the addition of berry mixed marc to the Mulberry fermented sawdust, and the larval rates of more than 2.5 g in the treatment of 30% of the berry mixed marc is 69.8% at the 85th day, while in the treatment without addition, it is within 10% at the 95th day, and in the addition of 10% and 20%, it is slower than the addition of 30%, but it appears faster than the untreated, and the higher the addition rate (Fig. 5).

This was consistent with the results that the accumulation rate of more than 2.5 g in Oak fermented sawdust with the addition of Odi bac was slower than the result of 67% at day 45 and 86% at day 55 (Moon *et al*., 2019), but the addition of berry mixed marc was faster to develop than untreated. It is also consistent with reports that secondary or alternative feed feeds have a distinct and significant effect on development rate (Yoon, 2017). Therefore, as mentioned earlier, it is believed that there will be various differences depending on the type and form of auxiliary feed, and further research is needed on this.

In the above results, both Bokbunja marc and Blueberry marc can be added as a food source to the breeding of *P. brevitarsis*, and it is judged that it has the effect of promoting the development of larvae when breeding by adding about 5-10% to Mulberry fermented sawdust or Oak fermented sawdust.

In addition, when the berry by-products Bokbunja marc,

Blueberry marc, and Odi bak are mixed and added to Mulberry fermented sawdust or Oak fermented sawdust, it has a positive effect on the development of *P. brevitarsis* larva, and generally shortens the development period of *P. brevitarsis* larva, increases the amount of larval weight gain, and the higher the addition rate, the shorter the development period.

In addition, since it is judged to have a positive effect on the increase in the number of oviposioning of *P. brevitarsis* adult, it is expected that the addition of berry by-products will improve the quality and productivity of the *P. brevitarsis*, and it is believed that it can become a new source of income through the recycling of discarded berry by-products. And it is believed that the effect on nutritional and antioxidant components and functional components such as ABTS and DPPH radical erasure activity according to various feeds of *P. brevitarsis* will also need to be examined at a later date.

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