

## REVIEW

# Breeding a High-Lignan-Content Sesame Cultivar in the Prospect of Promoting Metabolic Functionality

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### Abstract

Sesamin and sesamol, oil-soluble lignans of sesame seeds, exhibit antioxidative activity *in vivo* and show various metabolic functions. HPLC analysis to detect the sesamin and sesamol contents was modified to easily screen hundreds of accessions. The sesamin and sesamol contents changed with seed maturity and were highest in the capsules at 30 days after flowering, showing large varietal difference at that time. The sesamin and sesamol contents are an inherited characteristic. “Gomazou” was selected from the progeny of a cross between “Toyama 016”, a large seed line from Peru and “H65”, a high-lignan-content line originating in south China. “Gomazou” stably contains roughly twice as much lignan as “Masekin”, a local Kanto-region cultivar with a good yield. A physiological activity test on fatty acid oxidation in the rat liver showed that “Gomazou” more profoundly affected lipid metabolism than the control variety, “Masekin”. A high-lignan-content sesame cultivar could promote new demand as a local speciality crop and revive domestic production in Japan.

**Discipline:** Plant breeding

**Additional key words:** component, functional property, seed, variety

### Introduction

Sesame (*Sesamum indicum* L.) is an ancient oilseed crop grown worldwide, and is considered a traditional oil crop in Japan. Domestic production is currently almost negligible, however, sesame consumption in Japan has been increasing over the last two decades because of its nutritional features and functional properties. More than 150,000 t of sesame are consumed annually in Japan, which is the largest importing country for sesame in the world<sup>1</sup>.

Sesame oil is known to be resistant to natural oxidation, attributed to the antioxidative activity of sesame lignans<sup>6</sup>, which are contained in sesame seeds as minor components. Sesamin and sesamol, oil-soluble lignans, are further reported to show remarkable antioxidative activity *in vivo*<sup>1,2,7–10,12–14</sup>, and the functional properties of sesame seeds have become interesting subjects for food scientists and human biologists.

Sesame cultivation is mostly carried out by hand and

it is therefore difficult for farmers to manage large areas of land. The usual method of sesame cultivation is currently for private consumption or on small farm holdings<sup>3</sup>.

In this context, we developed a high-lignan-content sesame variety “Gomazou” as we expect that the rising lignan content of sesame seeds will enhance the commercial value of sesame and increase domestic sesame production in Japan. In this paper, we summarize the breeding process of “Gomazou” and characterize the lipid metabolic functionality of the variety.

### Measurement of sesamin and sesamol in sesame seeds from a capsule and the accurate evaluation of accessions

To breed lignan-rich sesame varieties, simple and accurate evaluation of the selecting line is required. Sesamin and sesamol are oil-soluble lignans found in relatively high content in seeds<sup>4</sup>. Seeds from a single plant capsule were analyzed by HPLC and the protocol was

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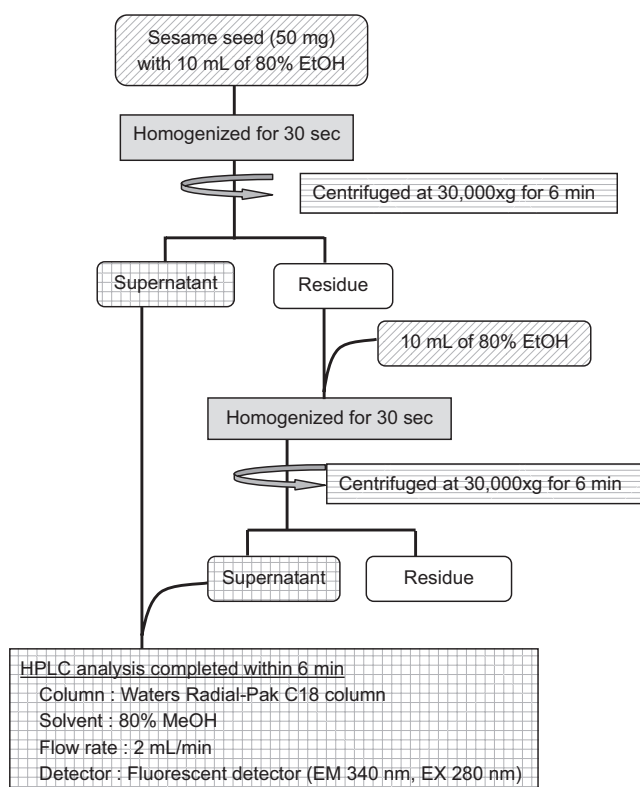
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simplified to be applied to breeding selection (Fig. 1)<sup>16</sup>.

It is difficult to sample representative capsules for measurement, as the maturity of capsule individuals are not uniform in a sesame plant, the seed size and sesamin and sesamol content of seeds vary with the capsule<sup>15,18</sup>. As shown in Fig. 2, seeds are lighter in upper capsules, which flower later, and the weight is stable in capsules more than 30–40 days after flowering. The sesamin and sesamol contents of the seeds were highest in capsules at 30 days after flowering and decreased thereafter, changing with seed maturity. It is therefore necessary to use capsules at a specific maturity stage to examine the varietal difference of the contents.

To analyze the sesamin and sesamol contents, it is necessary to use seeds from capsules that flowered and were harvested on the same dates. In particular, capsules around 30 days after flowering showed large varietal difference in the sesamin and sesamol contents of seeds. In addition, it was possible to compare samples planted on different dates if they matured during the same period (Fig. 3)<sup>20</sup>.



**Fig. 1. Standard protocol for the quantification of sesamin and sesamol in sesame seeds**

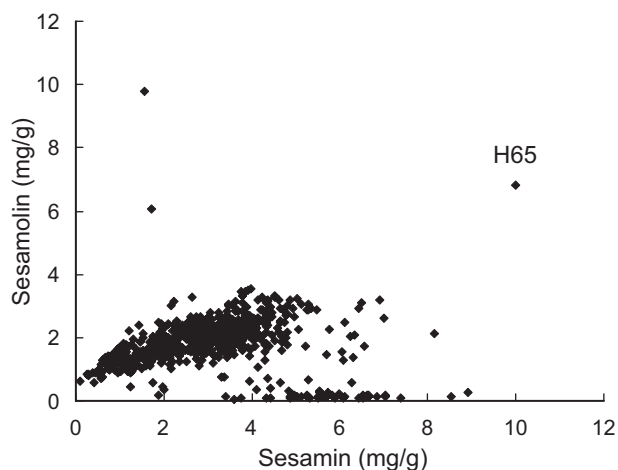
### Screening gene bank accessions for high-lignan content and inheritability of sesamin and sesamol contents of seeds

The varietal difference of the sesamin and sesamol contents of seeds has been reported<sup>5</sup>. Six hundred and fifty accessions from the MAFF gene bank were screened and the contents were analyzed using seeds harvested in Tsukuba. The sesamin content ranged from 0.1 to 10 mg/g and sesamol was from 0 to 10 mg/g (Fig. 4). Accession H65 (JP93754), whose passport data is recorded as originating in southern China, contains a high level of sesamin and sesamol in seeds.

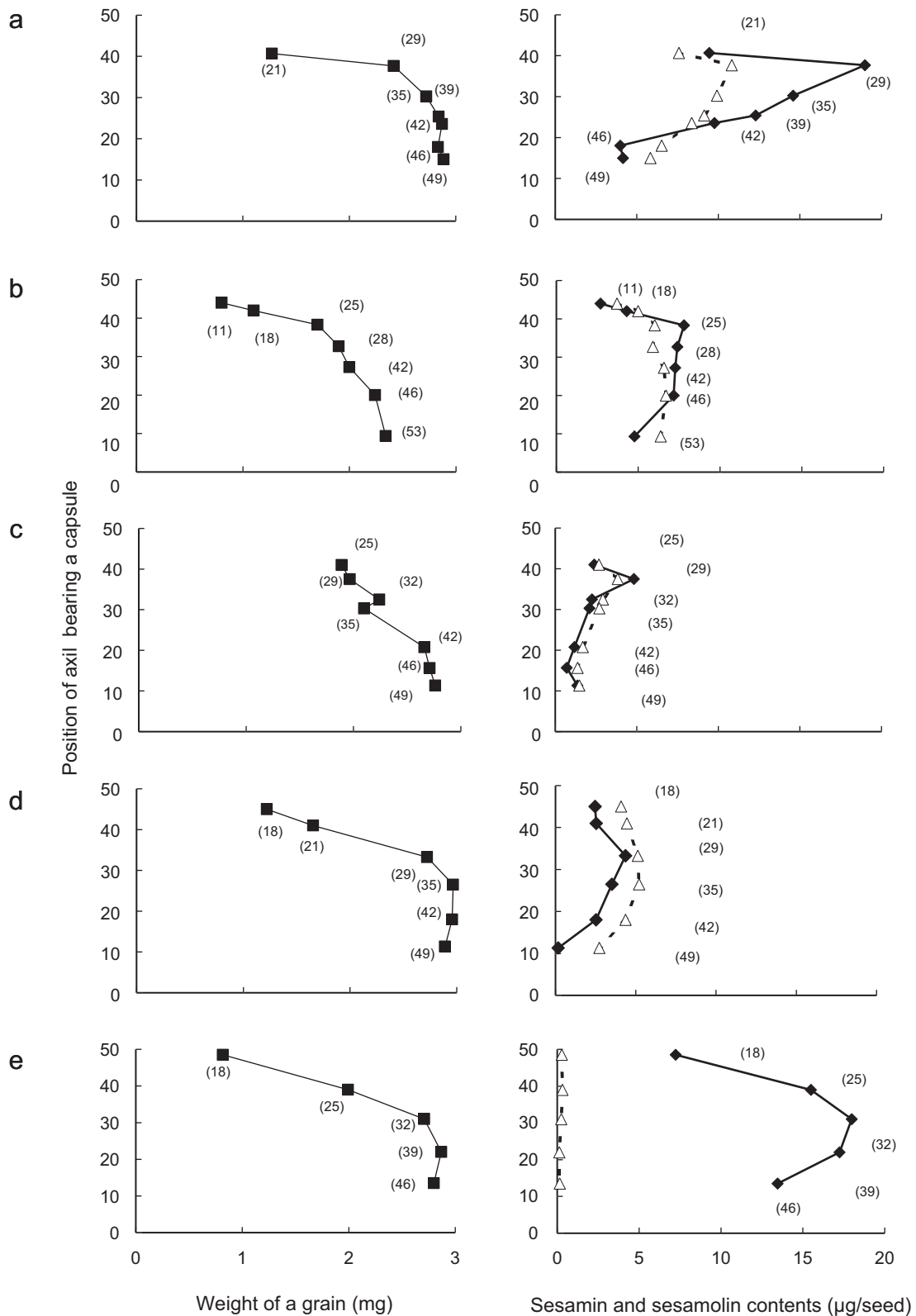
The genetic control of sesamin and sesamol content was examined. F<sub>2</sub> populations were derived from reciprocal crosses between H65 and “Aichi Shiro (JP94793)” or “Toyama 058 (JP93778)”, which have lower contents of sesamin and sesamol. F<sub>2</sub> individuals in those populations showed a continuous distribution of sesamin and sesamol contents of seeds so it is assumed to be controlled polygenically. Thirty F<sub>3</sub> lines derived from F<sub>2</sub> individuals with different levels of sesamin and sesamol contents were examined. Regression between F<sub>2</sub> and F<sub>3</sub> lines was higher for the sesamin content (r = 0.85) and significant for the sesamol content (r = 0.70) (Fig. 5). Inheritability between generations is high so it is possible to select lines based on the sesamin and sesamol contents of a plant.

### A high-lignan-content variety “Gomazou”

“H65” is a tropical-type variety and its productivity is extremely low in a temperate climate because of its



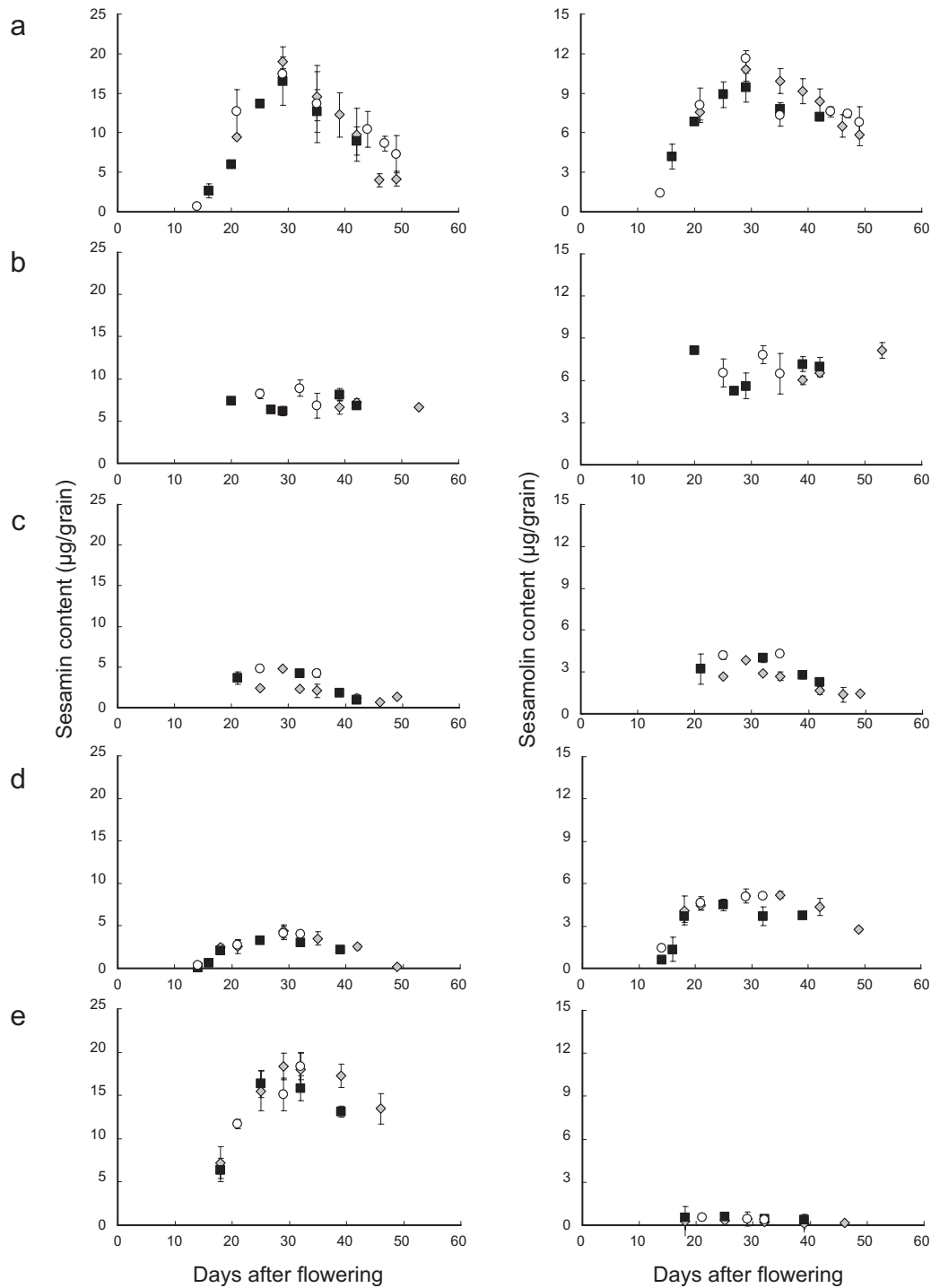
**Fig. 4. Variation in sesamin and sesamol contents of gene bank accessions**



**Fig. 2. Changes in the sesamin and sesamolin seed contents of capsules at different positions on a plant**

Numbers in parentheses show the days after flowering. a: JP33956 (white seed variety of Aichi Pref.), b: JP71503 (white seed variety of Aichi Pref.), c: JP91486 (black seed variety of Saitama Pref.), d: JP71509 (black seed variety of Ibaraki Pref.), e: JP80768 (white seed variety of Peru).

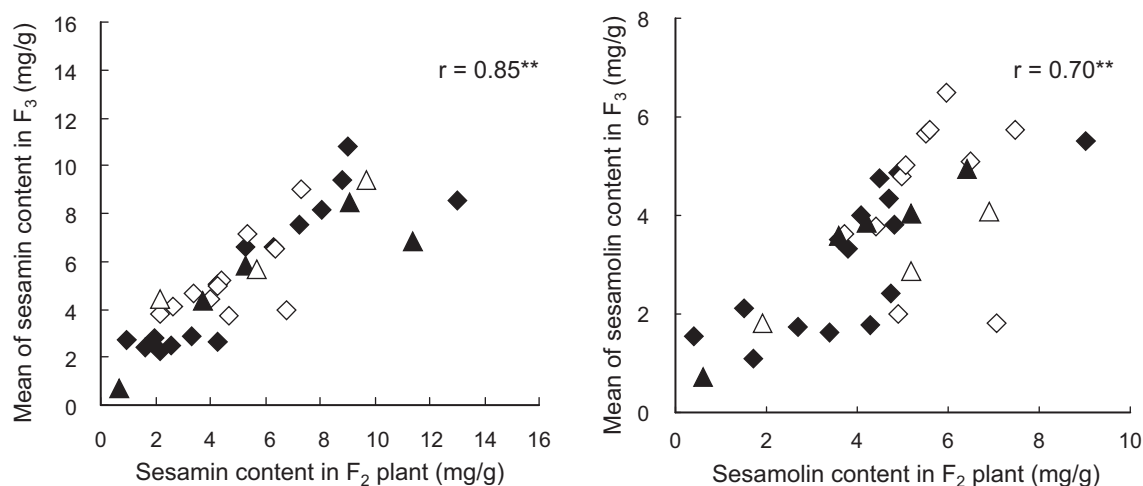
■: Grain weight, ◆: Sesamin content, △: Sesamolin content.



**Fig. 3. Days after flowering and the changes in sesamin and sesamol seed contents of capsules from plots sown on different dates**

a: JP33956 (white seed variety of Aichi Pref.), b: JP71503 (white seed variety of Aichi Pref.), c: JP91486 (black seed variety of Saitama Pref.), d: JP71509 (black seed variety of Ibaraki Pref.), e: JP80768 (white seed variety of Peru).

Capsules were sampled on September 19. Values are the mean of 5 capsules flowering on the same date in each plot. Vertical bars indicate the standard error of the mean. Plots were sown on  $\blacklozenge$ : June 14 (regular),  $\blacksquare$ : June 29 (late), and  $\circ$ : July 10 (very late), respectively.



**Fig. 5. Correlation of sesamin and sesamolin contents between  $F_2$  and the mean of  $F_3$**

◆: H65 × Aichi Shiro, ◇: Aichi Shiro × H65, ▲: H65 × Toyama 058, △: Toyama 058 × H65.  
 \*\*Significant at 1% level.

**Table 1. Agronomic and morphological characteristics of sesame varieties in field observations from 1999 to 2001**

Variety	Shape of leaves at the bottom	Date of 1st flowering	Date of maturity	Plant height (cm)	Height of the lowest capsule (cm)	No. of branches
Gomazou	Palmately cleft	Jul 21	Sep 13	165	62	3.7
(C) Masekin	Round	Jul 19	Sep 1	159	47	0.3
(P) Toyama 016	Round	Jul 20	Sep 7	177	61	3.0
(P) H65	Pedately parted	Aug 27	Oct 10	175	131	8.5

(C): Control variety, (P): Parental line.

**Table 1. cont.**

Variety	Yield (kg/a)	Type of capsule	Seed color	1,000-seed weight (g)	Sesamin (mg/g)	Sesamolin (mg/g)
Gomazou	12.3 (115)	1B	Brown	2.4	9.0 (231)	4.1 (162)
(C) Masekin	10.5 (100)	3B	Yellowish brown	2.4	3.9 (100)	2.6 (100)
(P) Toyama 016	8.5 ( 83)	1B	White	2.5	5.6 (146)	0.3 ( 11)
(P) H65	0.3 ( 3)	1B	Gray	0.9	9.5 (249)	4.4 (160)

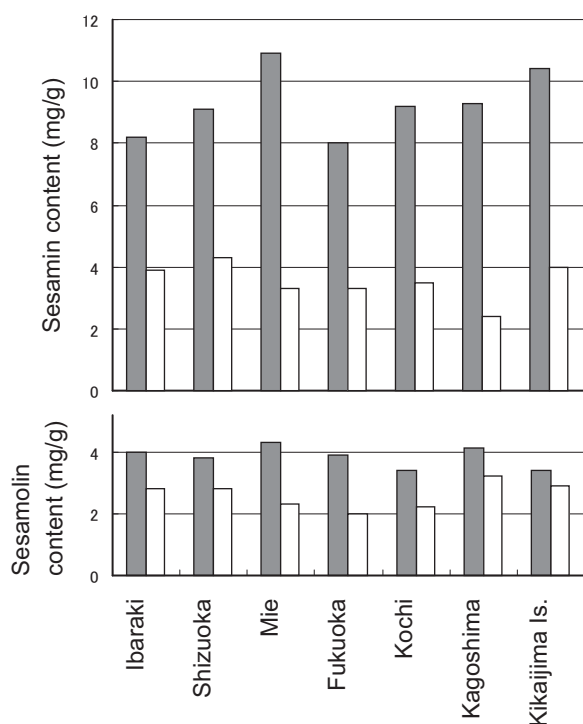
1B: Single bi-carpel capsule per axil, 3B: Three bi-carpel capsules per axil.

Values in parentheses show the relative ratio to control variety.

plant type, late maturity and small seed size. To improve its poor productivity, it was crossed with “Toyama 016”, which is characterized by large white seeds and originates in Peru. The selection of lines with a high lignan content and preferable productivity for domestic production was conducted from  $F_3$  to  $F_8$  generations, and “Gomazou”, a high-lignan-content variety, was released in 2003<sup>19</sup>.

The agronomic characteristics of “Gomazou” and a control variety “Masekin” are shown in Table 1.

“Masekin” is a local cultivar in the Tsukuba region and is popular as a high yield golden (yellowish brown) sesame variety. “Gomazou” matures slightly later than “Masekin”, however, much earlier than “H65”. The plant branches on the lower stem are taller than “Masekin”. Single bi-carpel capsules develop in axils. The seed is as large as “Masekin” and is brown. “Gomazou” has a slightly higher yield than “Masekin” and the seed contains roughly twice as much sesamin and sesamolin as “Masekin”.



**Fig. 6. Sesamin and sesamol contents of “Gomazou” and the control (local varieties) grown in different Japanese prefectures**

■: Gomazou, □: Local varieties.

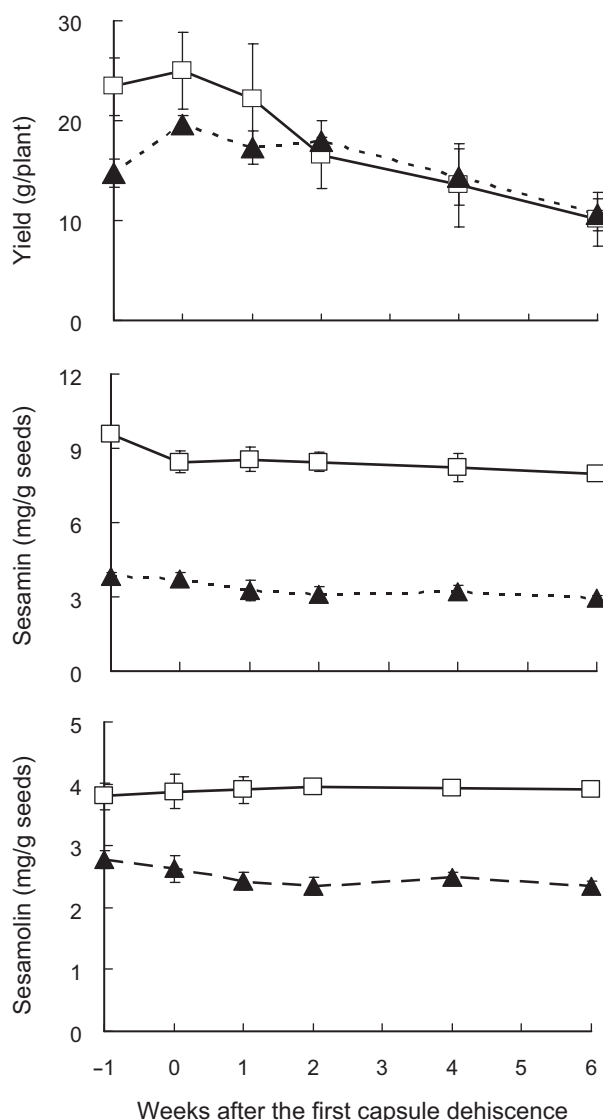
The regional trials conducted in areas west of Kanto revealed that the sesamin and sesamol contents of “Gomazou” were consistently high (Fig. 6).

### Stability of sesamin and sesamol contents in relation to the harvesting time

As mentioned earlier, the sesamin and sesamol seed contents change during maturation. To examine the yield stability and lignan content of seeds in relation to the delay of harvesting time, “Gomazou” and “Masekin” were harvested every one or two weeks from the week before the capsules began to be dehiscent. For both varieties, the yield reduced sharply in accordance with the delay of harvesting time until up to 6 weeks after dehiscence. The sesamin and sesamol seed contents were quite stable and remained higher for “Gomazou” than the local variety “Masekin” (Fig. 7).

### The functional property of “Gomazou”

The functional properties of lignan-rich sesame are reported from the viewpoints of lipid metabolism. In a physiological activity test on fatty acid oxidation in the rat liver, lignan-rich sesame lines including “Gomazou”



**Fig. 7. Changes in the yield, sesamin and sesamol contents of harvested seeds after the first capsule dehiscence**

Data show the mean value of 4 plots ±S.D.

□: Gomazou, ▲: Masekin.

more profoundly affected hepatic fatty acid oxidation and serum triacylglycerol levels than the control variety “Masekin”<sup>10,17</sup>. It was demonstrated that rising lignan content of sesame seed promoted the functional property *in vivo*. “Gomazou” is thus recognized as having highly beneficial physiological activity in altering lipid metabolism.

### Conclusion and outlook for new demand

Sesame production is currently very limited in Japan although the vendibility of domestic sesame is higher

than imported products. Sesame cultivation under contract to food companies has also started in some areas and sesame has been reconsidered as a local speciality crop. In addition, increasing the functional properties of sesame may increase its vendibility.

The sesamin and sesamolign contents of “Gomazou” were remarkably high in comparison with sesame products available on the market. “Gomazou” is a good cultivar for processing new products by emphasizing the functional properties of sesame.

“Gomazou” was registered as “Sesame Norin 1” by the Ministry of Agriculture, Forestry and Fisheries.

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