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NR Latex Particle Size and its Molecular Weight from Young and Mature Hevea *Trees*

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The age of young NR Hevea *trees has an influence on the size of latex particles. Young seedling trees aged less than 3 year had small rubber particles of sizes less than 1 μm, while mature trees showed particle sizes of up to 4 μm (from 0.04 μm to 4 μm). NR latex particles from virgin trees of clones RRIM 600, aged from 1 to 7 years showed the average particle size distribution of about 0.30 μm to 0.65 μm. The average molecular weight ($\overline{M}w$) dramatically increased from 3.3×10^5 to 12.0×10^5. The polydispersity ($\overline{M}w/\overline{M}n$) or molecular weight distribution of rubber was remarkably wide, between 3 and 10. Different clones of 25-year-old (NATAWE 208, AVROS 2037, RRIC 6, GT 1, PR 255, PR 261 and KRS 156) regularly tapped trees presented mode average particle sizes of about 1.0 μm. The average molecular weight ($\overline{M}w$) was from about 6.7×10^5 to 3.0×10^6 and the polydispersity ($\overline{M}w/\overline{M}n$) was extremely extensive between 5 and 11.*

Natural rubber tree species of *Hevea brasiliensis* produces latex which is a form of polymer in the colloidal system. Fundamental characteristics of latex are usually found in the content of rubber, particle shape, size and particle size distribution. This NR latex particle size is polydispersed. The particle diameters contains a spread of sizes although a narrow particle-size distribution was obtained. The most obvious measurement of particle frequency is the diameter of particle spheres including particle surface area and particle mass or volume. The aggregate of particles is also measured using laser diffraction particle size analysis.

The latex particle sizes and shapes are apparently not uniform. The latex from young seedling trees contains small particles with a spherical shape, while that of mature trees shows larger particle sizes, which are pear-shaped[1]. The rubber particle of 1 μm contains several thousand molecules of hydrocarbon[2].

Not all of the rubber molecules in latex particles have the same molecular weight (MW) and molecular weight distribution (MWD). Bristow[3] and Westall[4] suggest that natural rubber has a bimodal MWD. Subramaniam[5] using Gel-permeation chromatography (GPC) confirmed that the distribution is generally bimodal. Some clones of young virgin *Hevea* trees and mature regularly-tapped trees have been studied by Tanaka *et al.*[6]

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The influence of a sequence of *Hevea* tree-age on its latex particles has never been studied in any literature. Hence, this paper will study the effect of the age of the *Hevea* tree on its latex particle size. The latices were collected from RRIM 600 young virgin trees of 1 to 7 years' old, and from seven clones of regularly tapped mature trees (NATAWE 208, AVROS 2037, RRIC 6, GT 1, PR 255, PR 261 and KRS 156). Their MW and polydispersity ($\overline{Mw}/\overline{Mn}$) of rubber molecules were also analysed.

MATERIALS AND METHODS

Materials

The fresh *Hevea* latex was obtained from young and mature trees growing in Yala and Pattani provinces in southern Thailand. Five different trees of the same age grown in the same environment, from a smallholding and from an experimental plantation were tapped for assessment of latex particle distributions. A young virgin seedling tree of clone RRIM 600, aged 8 months, was subsequently tapped daily for 3 days. A sequence of trees aged between 1 and 7 years' old of RRIM 600 was tapped for the first time to observe the particle size distribution and the average particle diameter. Regular tappings of latex from 7 clones (NATAWE 208, AVROS 2037, RRIC 6, GT 1, PR 255, PR 261 and KRS 156) of 25-year-old trees, collected from a smallholder's plantation were also used to observe the particle size distributions.

After tapping, all the fresh latices were preserved with 2% sodium dodecyl sulphate and were strained with 60 mesh strainer before analysis.

Methods

Fresh NR latices from different *Hevea* tree ages and clones were diluted to 2%–5% for the measurement of particle size distribution. The latex samples were treated with an ultrasonic bath for about 1 min to avoid the formation of latex particle aggregates. A few drops of this diluted latex was subjected to a COULTER LS-230 (small volume module), and measurements taken of particle size distributions. The MWD of rubber was measured using GPC. THF was used as an eluent with a flow rate of 0.5 ml/min.

RESULTS AND DISCUSSION

Virgin-tree

Latex particles from young seedling trees (8 months of age). The latex from young virgin trees of clone RRIM 600, was successively tapped for three days to observe the particle size distribution. It was shown that the progressively tapped latex gave a very similar particle size distribution and appeared in the region of less than 1 µm. The average particle size was about 0.30 µm as shown in *Figure 1*.

Latex particles of different aged trees (1–7 years). In *Figure 2*, the NR latex particles tended to increase in diameter with tree-age. Although RRIM 600 of 1 to 7-year-old trees appeared in two groups of particle size distributions, the shifts of mode average particle diameters gradually increased with trees from 1 to 2 and 3 to 7 years' old. The latex particle size distributions from 1 to 2-year-old trees showed a narrow particle size distribution and gradually grew with the increase of tree-age. An abrupt difference in latex particle size from 2 to 3-year-old trees was suggested to be influenced by either biological factors or the plantation rubber estates.

The latex from young seedling trees, aged less than 3 years, showed the particle size distribution of less than 1 µm (in between

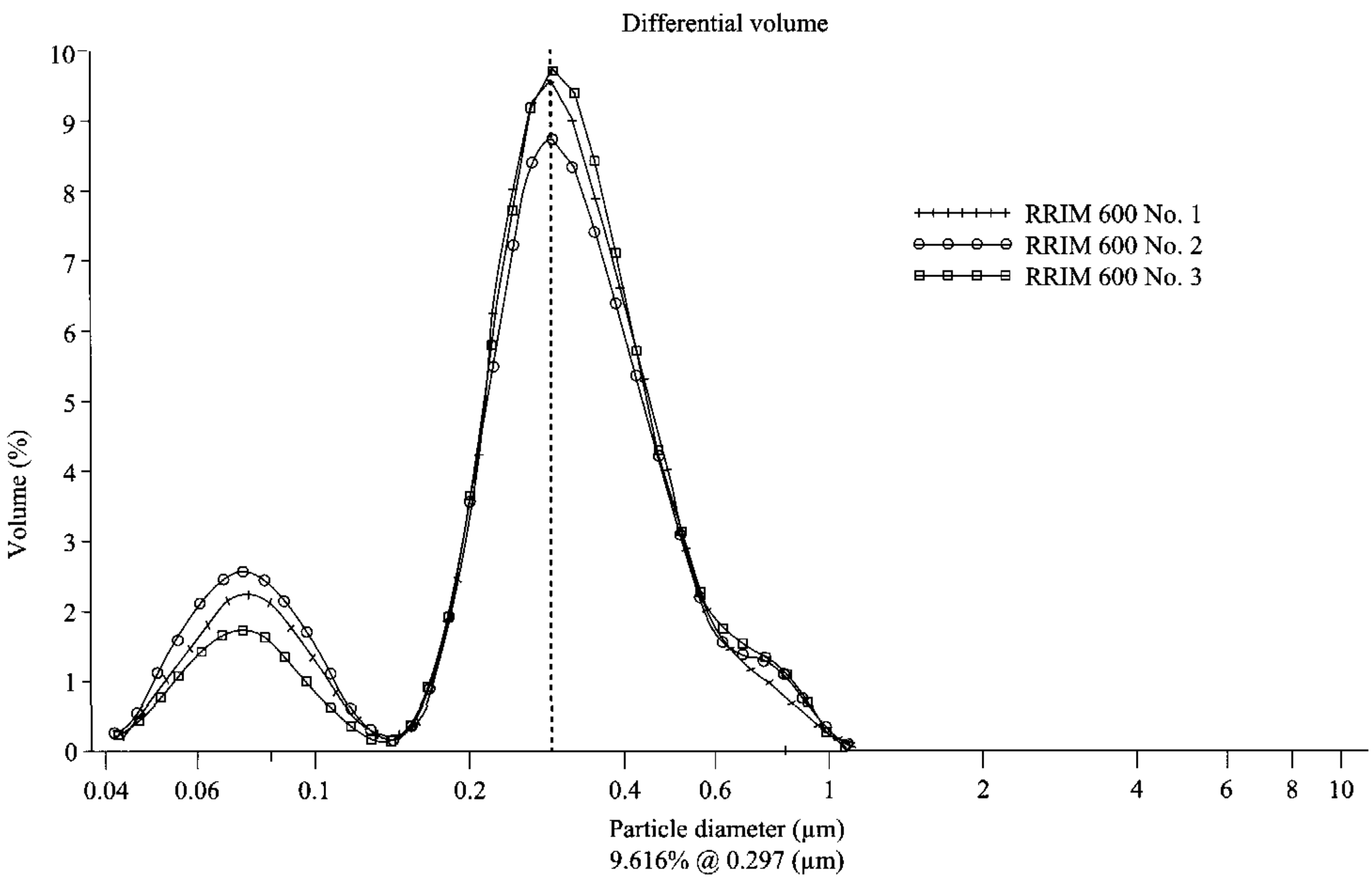

Figure 1. Particle size distribution of RRIM 600, young virgin trees of 8 months.

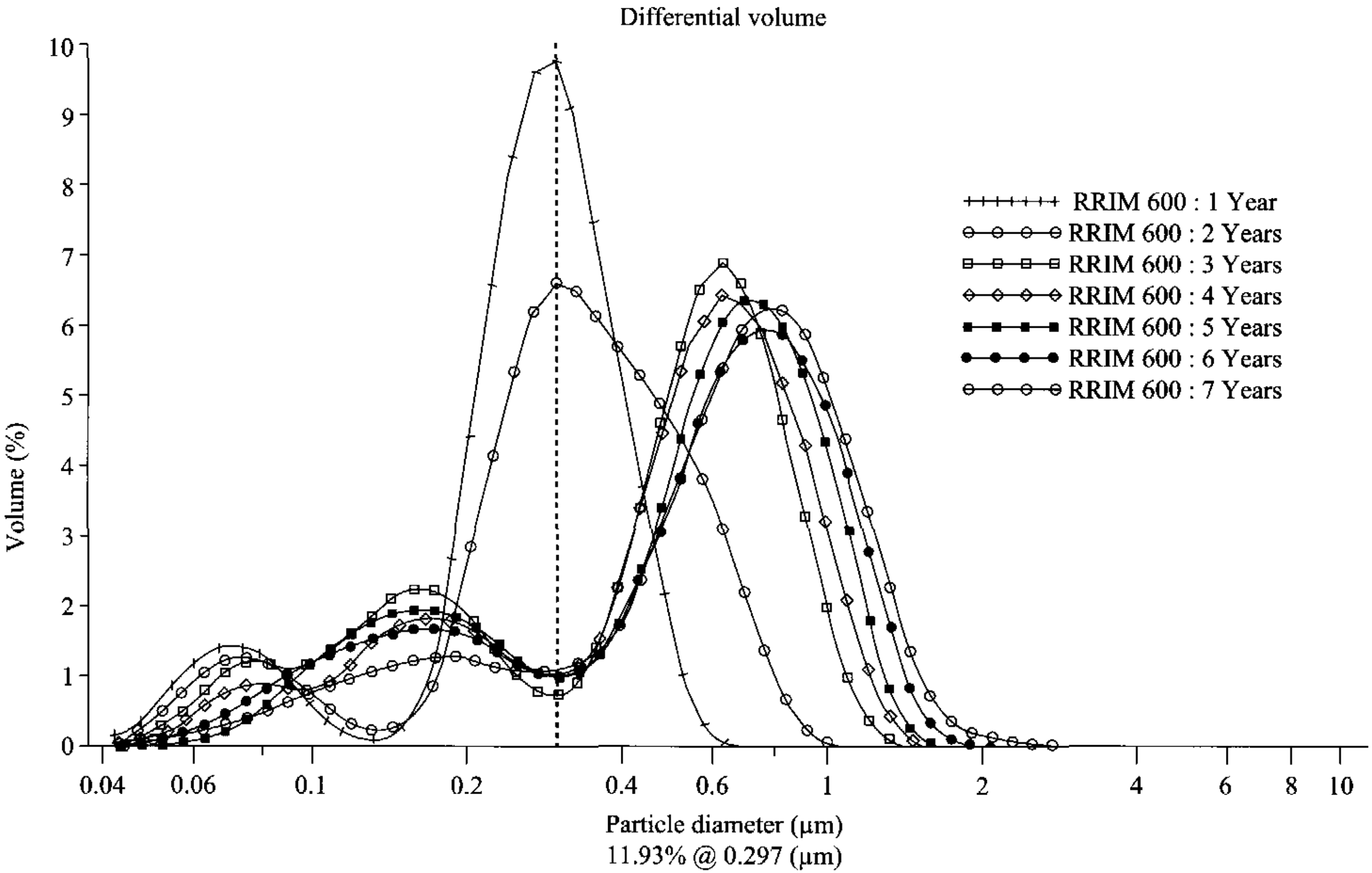

Figure 2. Particle size distribution of RRIM 600, 1 to 7 years' old.

0.04 µm and 1 µm), while those of older trees contained particles higher than 1 µm. The size of rubber particles of young trees aged 3 years was substantially in between 0.6 µm and 1.0 µm, similar to that of the grown trees aged from 4 to 7 years' old. This means that the rubber particles from NR latex trees aged 3 years' old might grow to mature as those from 4 to 7 years' old as shown in *Figure 2*. Virgin trees of RRIM 600, aged from 1 to 7 years, produced an average particle diameter of the latex ranging from 0.275 µm to 0.676 µm as shown in *Figure 3*.

Normally, rubber particles grow in the latex vessels of the bark. Whenever latex remains in the latex vessel, small rubber particles are expected to grow up if the terminal diphosphate groups hold their activities for chain elongation. Consequently, new rubber particles are also formed. However, the individual trees in the same tree-age can give a different latex particle size distribution due to fertilised soil, climate, season and weather conditions.

The $\overline{Mw}$ of RRIM 600 virgin trees dramatically increased from 3.3×10^5 to 12.0×10^5 depending on the age from 1 to 7 years, while the $\overline{Mn}$ was substantially independent of the tree's age (about 8.9×10^4 to 1.5×10^5). The polydispersity ($\overline{Mw}/\overline{Mn}$) of young to mature virgin trees was remarkably wide, ranging from 3 to 10, as shown in *Figure 4*.

The age of the *Hevea* tree influenced latex particle sizes and was also associated with the MW and MWD.

RRIM 600 virgin seedling trees, aged from 1 and 2 years showed a unimodal MWD peak, while NR latex from RRIM 600 trees aged from 3 to 7 years' old presented a slightly

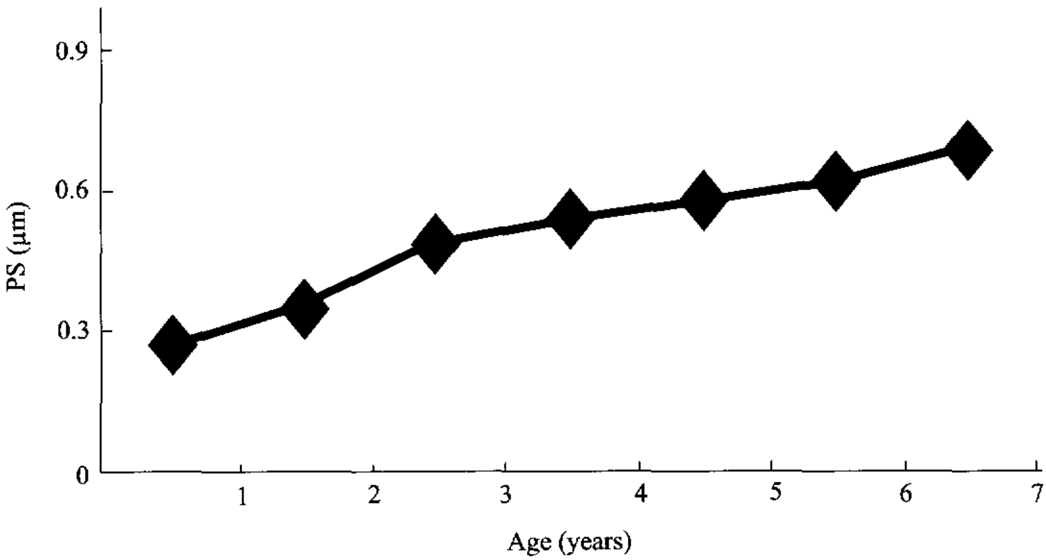

Figure 3. The mean average particle diameters of RRIM 600, 1 to 7 years' old.

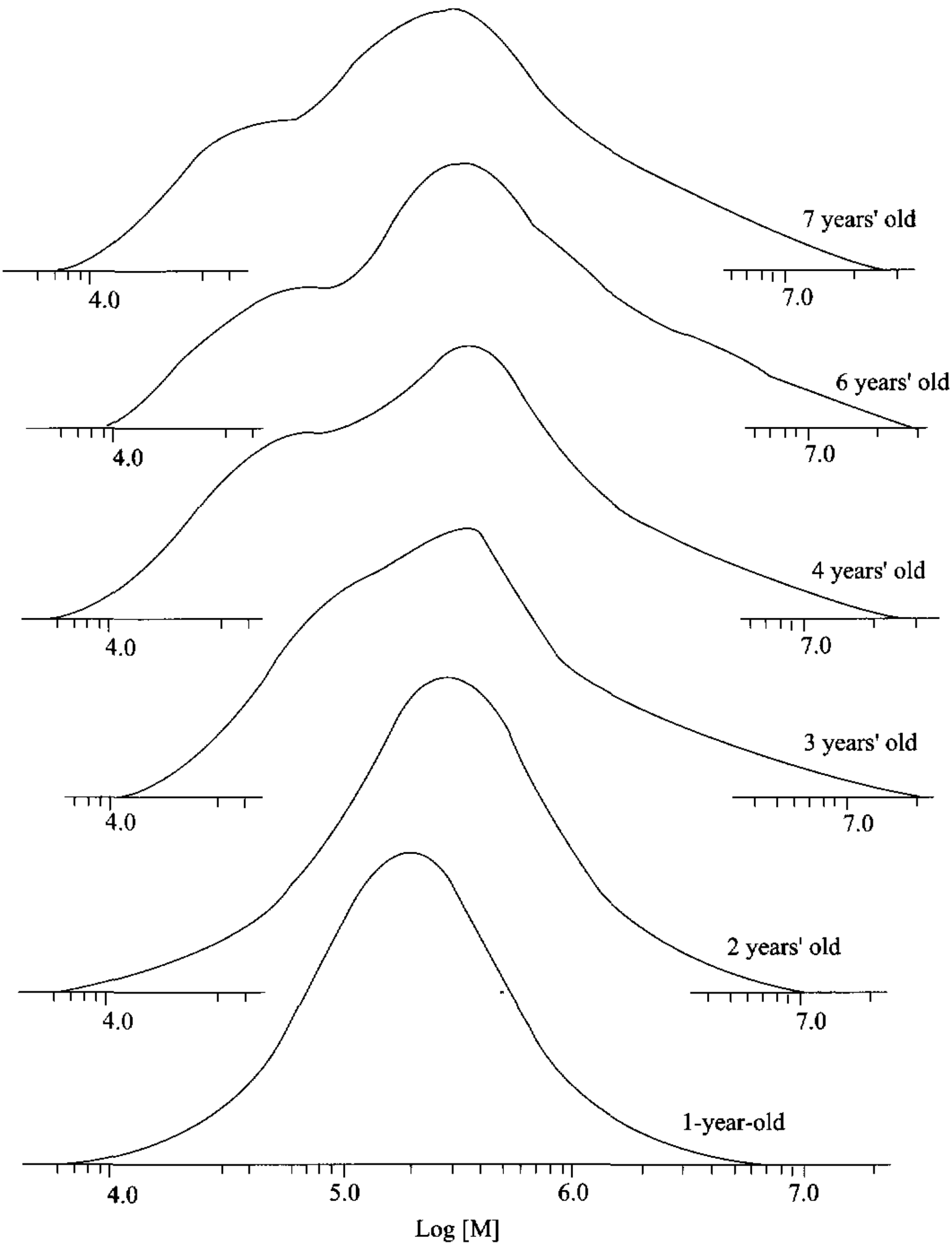

Figure 4. The molecular weight distribution of RRIM 600 of different tree-age (1 to 7 years).

bimodal distribution with small peaks. This suggests that a young tree having a small biosynthesis metabolism process in the phospholipid chain end of molecules which affects the extent of molecular weight on molecules of rubber. On the other hand, a growing tree has much more variation in biosynthesis of phopholipid chain end of molecules, that can influence the MW of rubber during growing. The $\overline{M}w$ dramatically increased from 3.3×10^5 to 12.0×10^5 depending on age from 1 to 7 years, while the $\overline{M}n$ was not substantially different (about 8.9×10^4 to 1.5×10^5). The MWD of young and mature virgin trees was remarkably wide, ranging from 3 to 10.

Regularly Tapped Trees

Latex particle from mature trees (25 years). Latices from regularly tapped seven clones (NATAWE 208, AVROS 2037, RRIC 6, GT 1, PR 255, PR 261 and KRS 156) of a mature tree, aged 25 years showed the particle size distributions between 0.04 µm and 4.0 µm as shown in *Figure 5*. A statistical analysis of two-standard deviation was automatically determined from a COULTER LS-230. The average latex particle size of these seven clones was about 1.0 µm.

The MW and MWD distribution curves of 7 mature clone trees (NATAWE 208, AVROS 2037, RRIC 6, GT 1, PR 255, PR 261 and KRS 156) aged 25 years' old are shown in *Figure 6*.

Although the shapes of the distribution curve are different, the range of molecular weights is approximately the same. The $\overline{M}w$ of these seven mature cloned trees (NATAWE 208, AVROS 2037, RRIC 6, GT 1, PR 255, PR 261 and KRS 156) aged 25 years' old showed a variation from 6.8×10^5 to 3.0×10^6, while the $\overline{M}n$ was small varying from about 1.2×10^5 to 3.0×10^5. The polydispersity ($\overline{M}w/\overline{M}n$) or MWD was remarkably wide ranging from 5 to 11.

CONCLUSIONS

The age of *Hevea* trees influenced latex particle sizes and the molecular weight of rubber. Seedling trees aged from 1 to 7 years' old gradually increased in particle size as well as the MW and MWD of rubber. Mature trees of seven different clones of NATAWE 208, AVROS 2037, RRIC 6, GT 1, PR 255, PR 261 and KRS 156, aged 25 years, showed little difference in the size of particles. The particle size distributions were between 0.04 µm and 4 µm and the mode average particle sizes were about 1 µm. The MW of rubber did not directly relate to the rubber particle size in the latex. The polydispersity ($\overline{M}w/\overline{M}n$) of rubber from young tree-age was narrow and increased with tree-age.

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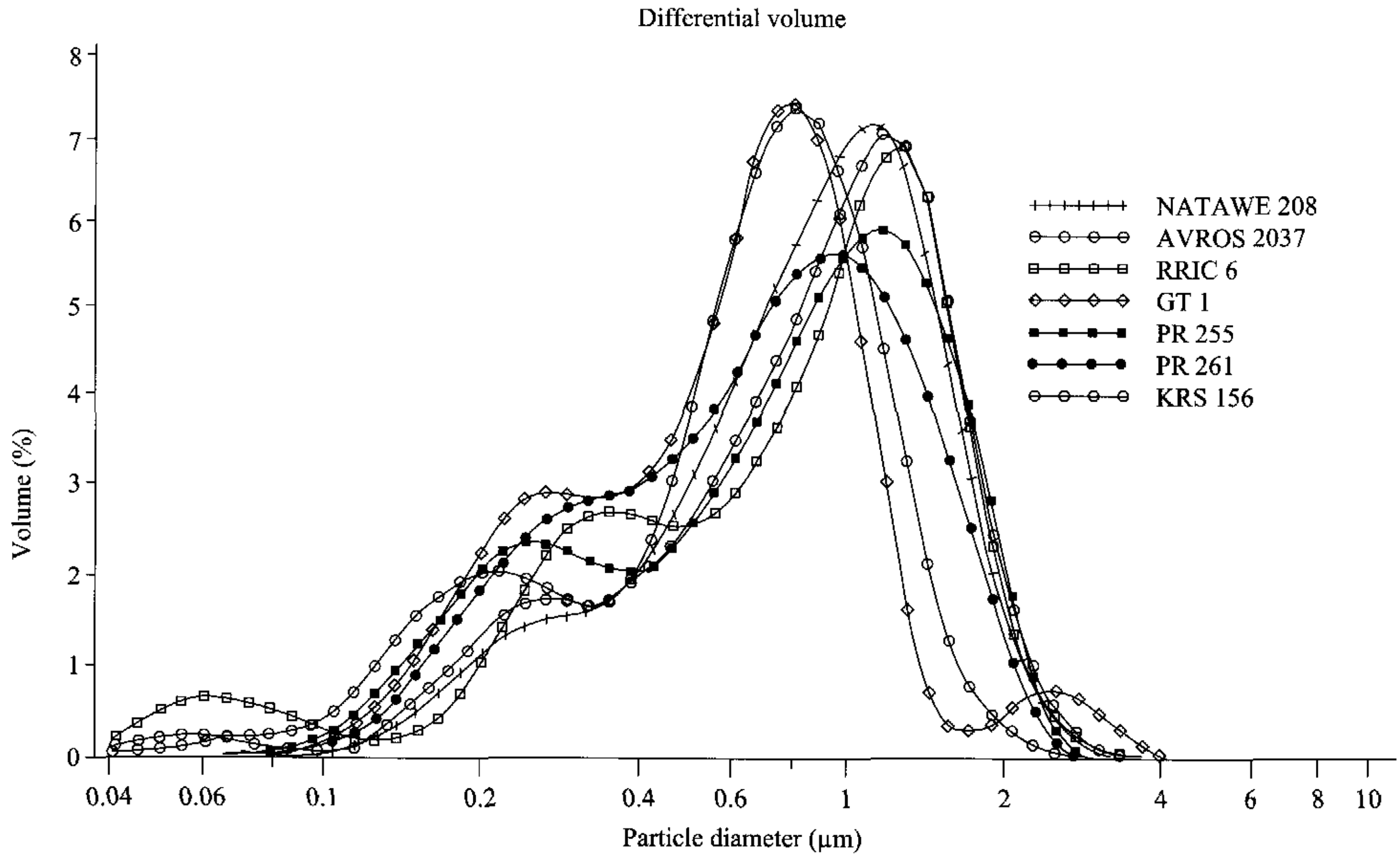

Figure 5. Particle size distrributions of 7 different clones (NATAWE 208, AVROS 2037, RRIC 6, GT 1, PR 255, PR 261 and KRS 156).

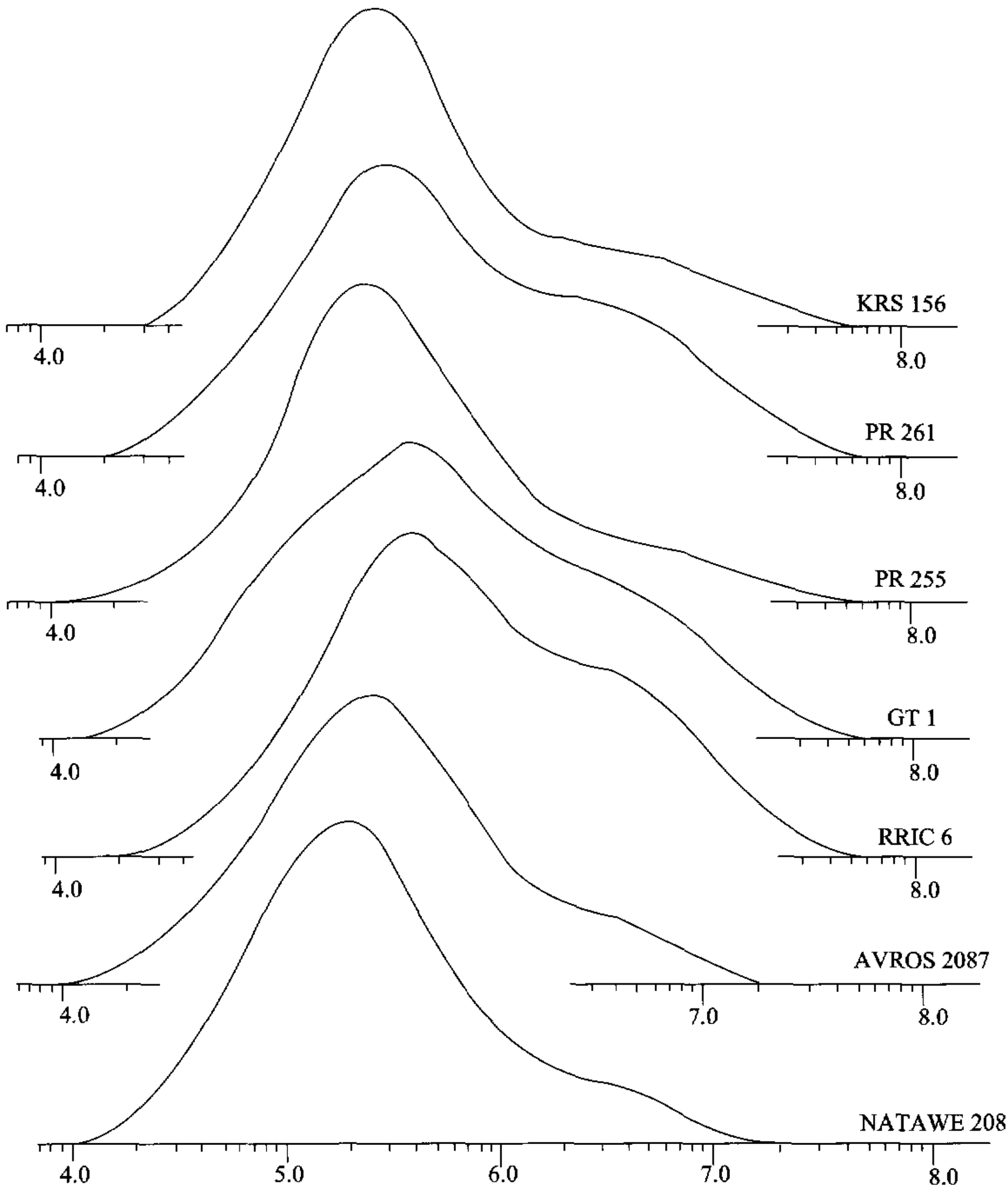

Figure 6. The molecular weight and molecular weight distribution of NR from 7 different matured clones (25 years' old).

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