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TAMARIND KERNEL POWDER (*Tamarindus Indica*) PROCESSING (REVIEWS ON ROASTING TEMPERATURE AND ROASTING DURATION)

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Abstract

Tamarind kernel is a kind of waste that is not yet used optimally. As natural hydrocolloid source, for it is containing starch and gum, the kernel can be changed in powder form to increase its utility. In powder processing, kernel shell must be separated. One manner to separate it is by roasting where problem of roasting

Research is designated to achieve combination of the best behavior of roasting temperature and roasting duration in processing of tamarind kernel as well as the calculation of production cost.

Hypothesis is made. It is estimated that the inter-relation between roasting temperature and roasting duration increases the characters of tamarind kernel powder.

Experimental method is used. Group random engineering, arranged by factorial, that is, two factors and three replications is implemented. Factor I is roasting temperature such as 140^{0}C, 150^{0}C, 160^{0}C, and Factor II is roasting duration such as 10 minutes, 15 minutes, and 20 minutes.

Analysis result of product random on tamarind kernel powder indicates that interaction between roasting temperature and roasting duration on water level, powder degree, viscosity, gel strength, rendemens and color pleasure is observed. However, interaction between roasting temperature and roasting duration in scent pleasure is not achieved.

Analysis to obtain the best alternative results in best alternative of roasting temperature treatment at 140^{0}C for 10 minutes by water level averages to 8,717% bk, starch level to 61,18% bk, viscosity 53,82 cP, gel strength 0,0097 mm/g/seconds, color and scent pleasures and rendemens to 77,17% bk, production cost in first year is Rp. 525,00 for each 1 kg.

INTRODUCTION

1. Background

Tamarind kernel is one of nature hydrocolloid source produced by plant kernel (Glicksman, 1986). Utility of tamarind kernel powder is not yet admitted in Indonesia. Fact is said that TKP (Tamarind Kernel Powder) have not been included as food supporting material in Indonesian Healing Minister Acts 722/Menkes/PER/IX/1988. The rule is talking about food supporting material, which is classifying hydrocolloid in categories of emulsifier, stabilizer, and thickener (Anonymous, 1990).

Testa separation from tamarind kernel is very important part in tamarind kernel powder processing. It is because tamarind kernel testa causes to depression and disgetion disturbance (Rao, 1983). Testa separation phase is conducted by roasting. One problem is that out of control separation causes to polysaccharide degradations resulted from heat TKP because of over roasting. The required control in roasting phase is in roasting temperature and roasting duration. Over roasting tamarind powder results in low viscosity solution (Gerard, 1980).

REVIEW OF LITERATURE

1. Tamarind Kernel

Tamarind includes in Leguminoseae family and Caesalpinioideae sub family. It has been called in several terms. For instance, it can be termed as ***tamarindo*** in Spanish, ***tamarin*** in French, ***dakar*** in Senegalian, ***tamir hindi*** in Arabian and ***imli in*** Indian (Gibbon and Pain, 1988). Indonesian has several terms for tamarind, such as ***bak mee*** in Aceh, ***mange*** in Bima, ***kenefo*** in Timor, ***kaza*** in Sumba, ***make*** in Flores, ***asam jawa*** in Sulawesi and ***asem*** in Java (Heyne, 1987).

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Tamarind plant is estimated from tropical savanna area in Afrika. The distribution of this plant is wide coming from tropical area, sub tropic, semi-arid to Monsoon arena with long dry season (Gibbon and friends, 1988). The growth is lower, particularly when it is planted from the kernel. Kernel-based plant produce fruit in 10 – 12 years period. However, vegetative kernel-based plant requires longer periods, even for 200 years to fruit. The adult can produce 180-225 kg tamarinds for each tree in a year (Hamid and Paimin, 1995).

Ripe tamarind shapes as legumes in brownish (similar to corrosion color toward iron), with thick brown pulp, and sweet in taste. The pulp covers the hard, glossy black brownish kernel (Gibbon, 1988).

Tamarind kernel has flat surface, random texture, less round, oval or dull square. The length and thickness is about 1,5 cm and 0,75 cm with rather concave and gully side (Gerard, 1980). Tamarind kernel can resistant for several months when it is saved in dry place and pest controlled area (Popenoe, 1974).

Nowadays, the kernel is often used as snacks, that is, by roasting it then pounding it in mortar to separate the shell. Winnowing is needed to select the clean kernel. It is submerged for 24 hours in salt-mixed water, and wait until the kernel is distended. When the kernel has been lifted, it is ready to boil. The boiled kernel can be prepared as snacks with or without rasped coconut. Tamarind powder functions as material in cake or bread processing. It is often mixed with wheat powder (Hamid and friends, 1995). Malayan uses tamarind powder to coagulate fruit juice, to replace starch in textile maintenance treatment, and to medicate ulcer. The latest is an indication that tamarind powder has medication benefit (Heyne, 1987). Tamarind powder can be also developed toward application in cosmetic and medicine industries (Gerard, 1980).

Hydrocolloid has specific character by the ability to relate with water which is resulting in several different functional in food products (Fardiaz, 1987).

Hydrocolloid functions in food product are vary, such as bundle material (sossis), prohibit crystallizing (ice cream, thick syrup), emulsifier (salad dressing), stabilizer (mayonnaise), thickener (sauce, broth), gel maker (jam, jelly, pudding), protector colloid (flavor emulsion), sponge stabilizer (whipped toppings), covering (confectioner), and cloud maker (wine) (Glicksman, 1982).

2. Tamarind Powder Production

Several phase are included in tamarind powder production, such as: (Whistler, 1983)

- **Sorting**

  To make the kernel in clean, specific technique is needed to discard any kinds of dirt. Cleaner machine include screen that is always trembling and aspirating to throw away small rather than large dirt (Beckett, 1994).

- **Roasting**

  The phase is very important to consider for next processing. Roasting is a means to decrease water level and to soften the shell such that shell separation from endosperm during winnowing process is easy (Ranken, 1993). Separating the shell from kernel is the hardest phase because shell (testa) is closely tied to endosperm. One separation alternative is by roasting in 150^0C for 15 minutes to make it brittle and then easy to separate by winnowing (Gerard, 1980).

  During the roasting, there is demixture of and simple form of complex compounds (Grosch, 1987), including the miss of weight and water level, and the powder color will be darker (Rao, 1983). Soluble compound will become dissoluble compounds in water, such that dissoluble compounds proportions will increase. Polysaccharide, such as starch, become water soluble, so that the gel thickness and strength from roasted material will decrease (Ranken, 1993).

  Control on roasting process is demanded, particularly when temperature and time of roasting are considered. Bias in control will result in final product that probably rejected by customer.

- **Stripping**

  Stripping is designated to eliminate the undesirable parts, or the parts that cannot be consumed (Makfoeld, 1982). Stripping phase is easy phase because tamarind shell and kernel (cotyledon) have different hardness degree where the shell is drier and more brittle (less solid) than the kernel (Rao, 1983).

- **Separating**
  Separating shell from kernel (cotyledon) is compulsory because human must not consume the shell.
  Separating tool (winnower) is designed to separate shell from the kernel and collect it separately by aspiration process. Winnower design is based on 2 conditions, that is, include the roasted kernel become dry and brittle and the shell become lighter and less solid than the kernel.
- **Grinding**
  The purpose of grinding is to obtain material with desired smooth degree. Grinder then smashes separated kernel from the shell and to change it into powder with desired smooth degree (Rao, 1983).
- **Screening**
  When tamarind powder is used as thickener, the thick liquid without clod is more desirable. It should be ensured that powder has been well separated before it is heated in liquid form (Charley, 1970). The use of powder as thickener is depending on the purity and the provision of demanding size. Whole tamarind powder should pass 60-mesh screen. Such tamarind powder by this specification will produce good result (Rao, 1983).
- **Packing**
  Tamarind powder is produced, and then packed in water resistant package. Overheat and over humidity should be avoided. Packed tamarind powder is saved in dry space such that it can be stored for long period

3. Decision Analysis

Decision analysis is logic and quantitative procedure that is not only explains about decision-making process, but also a means to take decision (Mangkusubroto and Listiani, 1987).

One method of decision analysis to produce best alternative is Multiple Attribute method, such as making comparison between quality and financial aspects from each product resulted from each treatment, determining the best alternative based on ideal value, density, and density distance among product attribute (Zeleny, 1982).

4. Production Costs

Production Costs are calculated to get Production Principal Cost (HPP). Production cost is the amount of general cost containing of raw material cost, direct labor cost, and factory overhead cost.

Production costs included in factory overhead cost are classified in some terms, such as maintenance, administration, depreciation, indirect labor, and other factory overhead that is demanding cash payment. Principal cost of raw material comprises to purchasing price in addition to purchasing cost and supporting cost that is paid during raw material preparation to be ready to process.

Labor Cost is as burden toward using of human labor. By product, labor is classified into direct labor and indirect labor. Direct labor is all employees which are directly involved in production, its merit is calculated directly from the product, and the wage is compared by product resulted. Wage of direct labor is treated as direct labor cost and directly calculated as part of production cost (Mulyadi, 1992).

PURPOSE AND INTENTIONS

1. Purpose

Research is designated to obtain the best of treatment combinations between roasting temperature and roasting duration in processing tamarind powder, and to determine the production costs.

2. Intentions

a. Give information about tamarind utility to attract interests to do further research on future potency and prospect of tamarind kernel.
b. Increase economic value of tamarind kernel as raw material of any industry, such as become the substitute material for imported

thickener so it decrease the dependability to foreign thickener.

RESEARCH METHOD

1. Time And Place Of Research

Research is conducted in Central Laboratory of Food Technology and Science and Laboratory of Industry System and Process Engineering in University of Brawijaya in Malang, from April to July 2000.

2. Research Phases

Group Random Planning (RAK) is used as Experiment plan. It is arranged based on two factors, such as roasting temperature and roasting duration, in which each factor contains three levels and involves three replications.

Factor I: roasting temperature (140^0C, 150^0C, 160^0C), while Factor II: roasting duration (10 minutes, 15 minutes, 20 minutes). Research is carried out by phase, as shown in flow diagram in Figure 1.

Random analysis indicates that there is interaction between treatment factor of roasting temperature and roasting duration. Treatment factors of roasting temperature and the length of roasting duration give real effect (p = 5%) to rendemens, water level, starch level, viscosity, and gel strength of tamarind powder.

Rendemens from tamarind powder are produced by average from 62,77% to 67,04%. Table 1 shows that the highest rendemens, water level, starch level, viscosity and gel strength resulted from roasting treatment in 140^0C for 10 minutes amount as 65,70% bk; 8,72% bk; 61,185 bk; 53,82 cP; 0,0097 mm/g/second. The lowest is observed at 160^0C for 20 minutes by similar value, that is, 61,51% bk. It is predicted that during the roasting, water level is decreased such that it becomes the reason of rendemens declination. Fellows (1990) proposed that during the roasting, water is vaporized, so that roasting will decrease water level of kernel.

Ranken (1993) suggests that water level

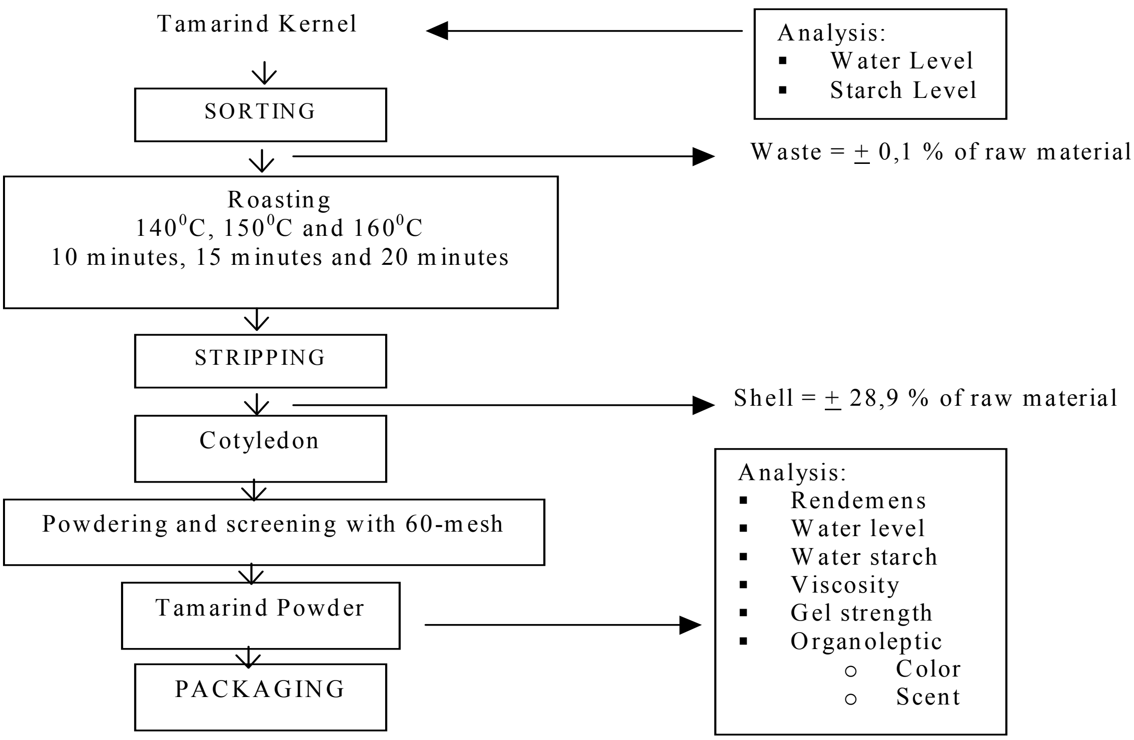

Figure 1. Flow Diagram of Tamarind Kernel Powder Processing

RESULT AND REVIEW

declination causes to weight loss during the roasting. The longer roasting and the higher roasting temperature, the larger water level is vaporized, the greater possibility of weight loss or rendemens declination.

The higher roasting temperature in same roasting duration will vaporize greater water level. The water density will decrease. In contrast, the longer roasting with similar temperature will give longer time of vaporization.

The higher roasting temperature and the longer roasting duration causes to greater starch detached from compounds link. The starch becomes simpler compounds. Ranken (1993) says that during the roasting, polysaccharide compounds, such as starch, will damage and be soluble to water. It is supported by Grosch's (1987) that during the roasting, starch is degraded into simpler compound and soluble to water.

Blanshard (1989) states that controlled amount of damaged starch in powder production are very important consideration because it affects powder quality (viscosity and gel strength). However, starch damage character is still unknown. Damaged starch influence its granular structure. By using micrograph electron scanning, starch granular is seen in disorder and physically damaged.

Ress (1991) clarifies that compound destruction during the roasting include the damage in intermolecular structure such as intermolecular hydrogen link resulted in compounds demixture and changes in chemical structure. This conditional causes to decrement of granular strength in starch, then it will decrease viscosity and gel strength.

Table 1. The average data of water content, starch content, viscosity, gel strength, and yields on various roasting temperature and time

Roasting temperature (^oC)	Roasting Time (minutes)	The Average of Water Content (% bk)	The Average of Starch Content (% bk)	Viscosity (cP)	The Average of Gel Strength (mm/g/sec)	The Average of Yields (% bk)
140	10	8,72 e	61,180 g	53,818 f	0,0097 a	77,167 e
140	15	8,43 ef	59,287 fg	52,937 f	0,0109 b	76,393 d
140	20	8,01 d	56,920 e	50,487 e	0,0124 d	75,617 c
150	10	8,31 de	57,437 ef	52,883 f	0,0116 c	76,507 d
150	15	7,63 c	54,743 de	49,727 de	0,0140 e	75,227 c
150	20	7,07 b	49,690 bc	47,640 bc	0,0146 f	73,923 b
160	10	7,23 b	52,160 cd	48,938 cd	0,0145 ef	75,233 c
160	15	6,68 a	48,467 b	46,793 b	0,0160 g	73,947 b
160	20	6,59 a	41,347 a	43,090 a	0,0177 h	72,250 a

Means within a data followed by different letters are significantly different (α = 5%) by Duncan's multiple range test.

It should be paid attention, because the higher roasting temperature results in the lower starch level in powder, so that starch level will have gelatinized when gel viscosity is low. This condition signs the lower powder solution produced. Bourne (1982) asserts that there is contra-relation between viscosity and roasting temperature, and that the higher viscosity in lower roasting temperature will be redundantly observed until the lower viscosity in higher temperature. It is summarized that the viscosity depends on roasting temperature. The opinion is supported by Gerard's (1980). He explains that during the roasting, polysaccharide is degraded. Over roasting will result in gel solution with low viscosity, and then it can be said that viscosity is decreased following the increase of temperature. Davidson (1980) states that viscosity of powder solution depends on starch concentration. Over roasting will decrease starch level as well as the viscosity. Viscosity decrement at higher temperature is related with molecular structure modification and depolimerization.

Viscosity modification is also caused by gum concentration. Davidson (1980) reports that viscosity of powder solution also depends gum concentration. Over roasting will decrease gum concentration and viscosity. Gum is composed with simpler sugars material, such as main link β-(1→4)-glukopiranosa and side link of glucose, xilose, and galaxtose.

Higher of starch level in powder will increase gel strength. It is estimated that the increment comes from starch degradation by heat air that is also the reason of viscosity and gel strength decrements. Fellows (1990) clarifies that changes in gel strength is determined by basic condition of material (water level), its composition and carbohydrate structure (starch), temperature and duration of roasting. In food material, changes in starch granular structure and dehydration factor determine the strength of the gel. Bourne (1982) agrees to the opinion by stating that temperature can affect gel strength.

The highest rate is resulted from roasting application at 140^0C for 10 minutes, while the lowest rate is at 160^0C for 20 minutes. It is likely of decrement in color pleasures value following to the increase of roasting temperature. Other inclination is decrement by the increase of roasting duration. During the roasting, Maillard non-enzymatic browning reaction is observed, for the higher roasting temperature and the longer roasting duration.

Table 2. The Sum of Panels Ranking of Colors

Roasting Temperature (°C)	Roasting Time (minute)	The Sum of Ranking
140	10	160 g
140	15	128,5 e
140	20	93,5 d
150	10	159 f
150	15	91,5 d
150	20	70 c
160	10	124,5 e
160	15	45,5 b
160	20	27,5 a

Means within a data followed by different letters are significantly different (α = 5%) by Duncan's multiple range test.

Grosch (1987) suggests similar opinion that during the roasting, brownish color is appeared by Maillard reaction. The reaction is more observable when it emerges relation between sugar reducer and amino compound, such as free amino acid, peptide, and protein or amina. Maillard reaction will be easier to occur in high temperature or in low soluble material. It is supported by Rao's (1983) that tamarind kernel, instead of composed with polysaccharide (starch), also contains with free sugar such as xilose, glucose, and galaxtose. Protein level in tamarind kernel is higher than other kernels, but it is not yet examined.

Basic color of tamarind powder (in best quality) is creamy white. The color comes from specific condition from which tannin in tamarind kernel results in enzymatic brownish in the beginning of processing. Enzyme material should be in optimal activity. Rao (1983) asserts that tamarind kernel is contained with tannin, but the molecule structure and its composition percentage have not been specified. Hui (1992) reports that enzymatic brownish is occurred because tannin is good substrate for oxidation process and reacting with sugar reducer components and protein. The condition is supported by function tannase enzyme as oxidation catalyst in browning process. Tannin browning reactivity depends on the ability of tannin to react to form complex compound with sugar reducer and protein. It is also depends on the amount of tannin in kernel. Winarno (1986) explains that tannase enzyme has optimum activity at 30^0C – 40^0C and less active in above 40^0C.

Result of assessment by panelist during the roasting shows that scent decrease in 15 minutes roasting. During the roasting, it is estimated that volatile compounds is detached, and then it results in unpleasant smell, "rotten scent". The longer roasting duration is the greater possibility for volatile compounds to vaporize and for the unpleasant smell to occur. It is supported by Pigot's (1994) that during the roasting, the scent is formed by scent components of material, and it is occurred naturally. It is also assisted by Fellows's (1990) that great amount of scent components are produced during the roasting. Scent type depends on specific combination of fat, amino acid, sugar materials, roasting temperature and roasting duration.

Rotten scent is estimated from Maillard reactions. Fellows (1990) suggests that Maillard reaction produces different smells based on the type of amino acid and sugar materials. It is supported by Pigot's (1994) that Maillard reaction gives large effect to form scent at product roasted, because hundreds of different volatile components are resulted from the reaction. Chang (1981) says that hundreds of components identified by volatile scent will be isolated.

Best Alternative Selection Analysis

Ideal value of each treatment combination, which is used as guideline for best alternative selection, is maximum or minimum value.

occurred in roasting at 160^{0}C for 20 minutes (S3L3). Ideal value of starch level is 61,180% bk (maximum) in roasting at 140^{0}C for 10 minutes (S1L1). Ideal value of viscosity is 53,817 cP (maximum) in roasting at 140^{0}C for 10 minutes (S1L1). Ideal value of gel strength is 0,00971 mm/g/second (maximum) in roasting at 140^{0}C for 10 minutes (S1L1). Ideal value of color pleasure is 7,350 (maximum) in roasting at 140^{0}C for 10 minutes (S1L1). Ideal value of scent pleasure is 6,350 (maximum) in roasting at 140^{0}C for 10 minutes (S1L1). Ideal value of production principal cost is Rp. 525,00 (minimum) in roasting at 140^{0}C for 10 minutes (S1L1).

Result calculation indicates that minimum density distance value L_1, L_2, and L~ result in S1L1 during roasting at 140^{0}C for 10 minutes, so that it is selected as best alternative.

Production capacity is calculated from rendemens amounts of each treatment by

Table 3. Alternative Analysis Consideration

ATRIBUTE	ALTERNATIVES								
	S1L1	**S1L2**	**S1L3**	**S2L1**	**S2L2**	**S2L3**	**S3L1**	**S3L2**	**S3L3**
Water content (% bk)	8,717	8,428	8,008	8,307	7,628	7,067	7,232	6,680	6,593
Starch content (% bk)	61,180	59,287	56,920	57,437	54,743	49,690	52,160	48,467	41,347
Viscosity (cP)	53,817	52,937	50,487	52,883	49,727	47,640	48,937	46,793	43,090
Gel strength (mm/g/sec)	0,0097	0,0109	0,0124	0,0116	0,0140	0,0146	0,0145	0,0160	0,0177
Color	7,350	6,600	5,500	7,300	5,500	4,800	6,550	3,900	3,250
Flavor	6,350	5,500	5,250	5,950	5,100	5,150	5,700	4,650	4,850
Yields (% bk)	77,467	76,393	75,617	76,507	75,227	73,923	75,233	73,947	72,250
Production principal cost (Rp./package)	525,33	533,34	540,52	529,48	539,79	550,59	536,24	547,13	461,02
Dk1	0,756	1,782	0,823	0,794	0,864	0,933	0,912	0,987	1,000
Dk2	1,000	0,969	0,930	0,939	0,895	0,812	0,853	0,792	0,676
Dk3	1,000	0,984	0,938	0,983	0,924	0,885	0,909	0,869	0,801
Dk4	1,000	0,891	0,786	0,835	0,694	0,663	0,670	0,608	0,550
Dk5	1,000	0,898	0,748	0,993	0,748	0,653	0,891	0,531	0,442
Dk6	1,000	0,866	0,827	0,937	0,803	0,811	0,898	0,732	0,764
Dk7	1,000	0,990	0,980	0,991	0,975	0,958	0,975	0,958	0,936
Dk8	1,000	0,985	0,972	0,992	0,973	0,954	0,980	0,960	0,936
L1	0,030	0,079	0,124	0,067	0,140	0,166	0,114	0,195	0,237
L2	0,030	0,037	0,053	0,035	0,060	0,071	0,052	0,089	0,106
$L_{unlimited}$	0,026	0,027	0,031	0,030	0,038	0,043	0,041	0,059	0,070

Table 3 shows that ideal value of rendemens is 77,167% bk (maximum) in roasting at 140^{0}C for 10 minutes (S1L1). Ideal value of water level 6,593% bk (minimum) is

assumption that production capacity for factory normal rate is 2000 kg in a day for each treatment, that production mass is 25 working hours in a month and 12 months in one year production. Product of tamarind powder for one-day production is about 1.543 kg and packed in 1 kg plastic package. Then, it is packed in cardboard containing with 30 plastic packages. Result of calculation shows that production cost for one-year production in best alternative of roasting at 140^{0}C for 10 minutes is Rp. 243.226.742,00.

Table 4. Calculation of Production Principal Cost of Treatments

Roasting Temperature (°C)	Roasting Time (minute)	Annual Cost (Rp.)	The Sum of Poduction (package)	Production Principal Cost (Rp./package)
140	10	243.226.742,00	463.000	525,00
	15	244.459.500,00	458.360	533,00
	20	245.234.140,00	453.700	540,00
150	10	243.053.980,00	459.040	529,00
	15	243.637.620,00	451.360	539,00
	20	244.208.620,00	443.540	550,00
160	10	242.058.900,00	451.400	536,00
	15	242.752.700,00	443.680	547,00
	20	243.201.660,00	433.500	561,00

Table 4 concerns about production principal cost of whole treatments. It is showed that the lowest cost is obtained from roasting treatment at 140^{0}C for 10 minutes, that is, as much as Rp. 525,00. The highest cost is achieved in roasting at 160^{0}C for 20 minutes, that is, as much as Rp. 561,00.

CONCLUSIONS AND SUGGESTIONS

1. Conclusions

a. Best treatment combination is obtained in roasting treatment by temperature at 140^{0}C and roasting time at 10 minutes with water level to 8,717% bk, starch level to 61,180% bk, viscosity to 53,817 cP, gel strength to 0,0097 mm/g/seconds, rendemens to 77, 167% bk. Color is pleasured, but scent is unpleasant.
b. Best alternative of production principal cost is obtained from roasting treatment by temperature at 140^{0}C for 10 minutes, that is, as much as Rp. 525,00 for each 1 kg package. Package for first year of production is about 463.000.

2. Suggestions

a. It is suggested that research on tamarind powder production should be conducted, particularly by using lower roasting temperature where stripping process is still well defined and where it can be supported by standardized stripping machine.
b. It is suggested that research on rotten scent elimination and on color reparation should also be conducted.

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