Low Sodium Healthy Salt by Dry Methods

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Abstract. Table salt that meets Indonesian National Standards (SNI) have a high sodium content of around 60% so that it is not suitable for consumption by people with hypertension. The reduction in the size of NaCl and KCl salts is carried out in a range of 30; 40; 50; 60 Mesh and the mass ratio of NaCl and KCl is provided at 1: 3; 1: 2; 1: 1; 2: 1; 3: 1. The results showed that there was a decrease in Na concentration in table salt products. The product composition is carried out with AAS and XRF analysis. Products that approach SNI 2016 salt diet is at a particle size of 40 mesh with a mass ratio of 1: 3 where the NaCl content is 54.40 % and the KCl content is 40.33 %.

Keyword: hypertension, potassium, sodium chloride, table salt

1. Introduction
Consumption salt in commercially available products is generally made through several technologies [1-7], but it cannot be separated from the process of sea water evaporation [5,6]. The higher the level of purity of salt, the higher the sodium (Na+) and chloride(Cl-) ion content in salt. While it has been widely reported that NaCl salt is one of the causes of hypertension. Hypertension is a disease that can affect everyone. Consuming too much food containing sodium or artificial sweeteners can cause hypertension [7,8]. Many cases show excessive salt intake in Indonesian society, indicating that many people are less concerned about the negative effects of excessive salt consumption. One of the negative effects of excessive salt consumption is the increased risk of suffering from hypertension or in the pathogenesis of hypertension [9-11]. Decreasing the molar Na / K ratio of urine from 3.09 to 1.00 resulted in a decrease in population of systolic blood pressure of around 3.36 mmHg. The high potassium reduces the impact of high sodium (Na) on blood pressure, thereby reducing the risk of cardiovascular disease [11-16]. Actually NaCl salt is not the cause of increased blood pressure but sodium content in salt (NaCl) which causes hypertension. Potassium chloride (KCl) based salt substitutes are the most important class of all salt substitutes. KCl is generally similar to the common salt (NaCl), but is characterized by slightly less intensive salty taste with a certain degree of bitterness and acrid and metallic off tastes [17-18].

Rood [19] reported the manufacture of salts with compositions consisting of 40-50% by weight of sodium chloride, 25-35% by weight of potassium chloride, 15-25% by weight of magnesium salts which included magnesium sulfate or magnesium chloride. Because the salt is dry and has a crystalline structure, mixing the two types of salt (NaCl and KCl) [20] can be done using a dry method, namely grinding the salt raw material until a uniform and suitable size is obtained, then the two fine salts are mixed dry or may be put together in a tool milling. The purpose of this study was to find out the influence...
of particle size and mass ratio of materials in the manufacture of low sodium healthy salts using the dry method.

2. Materials and Methods

2.1. Materials
The raw material consists of two types of salt, namely sodium chloride (NaCl) which is the SNI standard and potassium chloride (KCl). The results of the AAS analysis of two raw materials obtained NaCl concentration of 95% and KCl with a concentration of 63%.

2.2. Methods
The stages of the study began with the grinding of raw materials for salt followed by sieving with sizes of 30; 40; 50; and 60 mesh. Each salt of a certain size is mixed following the weight ratio of NaCl to KCl, which is 1: 3; 1: 2; 1: 1; 2: 1; 3: 1. The salt mixing process is carried out in a stirred reactor to produce low sodium table salt. Mixing the two types of salt was carried out for 15 minutes with a stirring speed of 24 rpm to obtain a homogeneous mixture.

The concentration of Na and K in table salt products is analysis by AAS and X-ray fluorescence.

3. Results and Discussion

3.1. Effect of particle size on the concentration of NaCl and KCl in the product.
The low sodium salt composition can be formulated by carefully mixing ingredients from 40-50% NaCl, 25-35% KCl, and 15-25% magnesium salts, because of the relatively dry and crystalline properties of the salt. Mixing itself can be done with a dry method to smooth the material to get a uniform and appropriate size. Then all the ingredients are mixed dry, or maybe put together in a grinder.

| Particle size (mesh) | Ratio NaCl:KCl (%w) | Na (%) | K (%) |
|----------------------|---------------------|--------|-------|
| 30                   | 1:3                 | 62.63  | 36.55 |
|                      | 1:2                 | 47.71  | 46.04 |
|                      | 1:1                 | 66.70  | 26.82 |
|                      | 2:1                 | 77.87  | 13.95 |
|                      | 3:1                 | 82.99  | 10.31 |
|                      | 1:3                 | 54.40  | 40.32 |
|                      | 1:2                 | 63.71  | 30.20 |
|                      | 1:1                 | 84.56  | 6.46  |
|                      | 2:1                 | 80.93  | 16.34 |
|                      | 3:1                 | 80.07  | 16.49 |
|                      | 1:3                 | 64.10  | 31.84 |
|                      | 1:2                 | 67.95  | 23.94 |
|                      | 1:1                 | 77.91  | 15.12 |
|                      | 2:1                 | 80.70  | 18.41 |
|                      | 3:1                 | 87.81  | 7.39  |
|                      | 1:3                 | 64.73  | 24.46 |
|                      | 1:2                 | 66.11  | 24.29 |
|                      | 1:1                 | 61.54  | 31.34 |
|                      | 2:1                 | 89.73  | 9.39  |
|                      | 3:1                 | 83.35  | 14.12 |
As stated in Table 1 and related to Figure 1 and Figure 2 showed the results of table salt products at various particle sizes. In general, particle size does not affect the results of Na and K concentration on products. The larger the particle size, the level of Na and K do not show results in accordance with the literature, the smaller the particle size of the material, the easier the movement between particles and the mixing process will be better. The smaller the difference in particle size between materials it will facilitate the mixing process so that the resulting product becomes homogeneous.

**Figure 1.** Effect of particle size on Na and K concentrations prepared at raw ratio 1:2

| Particle size (mesh) | Concentration (%) |
|----------------------|-------------------|
| 30                   | 25                |
| 35                   | 30                |
| 40                   | 35                |
| 45                   | 40                |
| 50                   | 45                |
| 55                   | 50                |
| 60                   | 55                |
| 65                   | 60                |

**Figure 2.** Effect of particle size on Na and K concentrations prepared at raw ratio 1:3

| Particle size (mesh) | Concentration (%) |
|----------------------|-------------------|
| 30                   | 20                |
| 35                   | 30                |
| 40                   | 40                |
| 45                   | 50                |
| 50                   | 60                |
| 55                   | 70                |
| 60                   | 80                |

3.2. Effect of the raw ratio of NaCl / KCl mass on NaCl and KCl concentrations in table salt products.
Figure 3 and Figure 4 showed the effect of the raw ratio of NaCl to KCl on concentration of Na and K in table salt products. The Na concentration tends to rise along with the decrease in K in the range of changes in the raw material ratio from 1: 3 to 3: 1. As in the 40 mesh particle size data, the results of the analysis of Na levels which decreased according to the mass ratio of the material were 1: 3, 1: 2, 1: 1, respectively 54.40; 63.71 and 84.56%. This result is in accordance with the hypothesis that the greater the mass ratio of Na material the greater the level obtained from the results of dry mixing. While the results of the analysis of K levels decreased according to the corresponding mass ratio of the material, namely 1: 3, 1: 2, 1: 1, respectively by 40.32%; 30.20% and 6.46%. This result is in accordance with the hypothesis and literature, namely the smaller the mass ratio of KCl material, the smaller the level obtained from the results of dry mixing.
The results of the analysis of the obtained Na levels decreased so that it was not in accordance with the mass ratio of the material, namely 1:1, 2:1, 3:1, respectively at 84.56%; 80.93%; 80.07%. This result is not in accordance with the hypothesis or literature, namely the greater the mass ratio of NaCl material the greater the level obtained from the results of dry mixing. While the results of the analysis of K levels have increased which is not in accordance with the mass ratio of the material namely 1:1, 2:1, 3:1 in a row of 6.46; 16.34, and 16.49%. This result is not in accordance with the hypothesis or literature, namely the smaller the mass ratio of KCl material, the smaller the level obtained from the results of dry mixing. Both of these are due to various factors that influence one of them such as mixing the two materials that are not homogeneous.

**Figure 3.** Effect of raw ratio NaCl:KCl on concentrations Na in products.

**Figure 4.** Effect of raw ratio NaCl:KCl on concentrations K in products.

**Figure 5.** Effect of raw ratio NaCl:KCl on concentrations of Na and K prepared at 30 mesh particle size.

**Figure 6.** Effect of raw ratio NaCl:KCl on concentrations of Na and K prepared at 40 mesh particle size.
Figure 5 and Figure 6 showed the effect of raw ratio NaCl:KCl on concentrations of Na and K prepared at 30 and 40 mesh particle size respectively. If based on the electronegativity value of sodium has a value of 0.93 and potassium has a value of 0.82, it indicates that the electronegativity of potassium is smaller than sodium. The smaller the electronegativity of an atom, the stronger the force of the nucleus is weakened and tends to release electrons. So potassium has a tendency to release electrons that are larger than sodium. Whereas chloride is the third largest element of electronegativity, so the possibility of attracting electrons is very large. It can be concluded that chloride is more likely to attract electrons than potassium than sodium which can lead to more binding of KCl compounds than NaCl compounds.

4. Conclusions
The results of this study which most closely approach the 2016 Salt Diet SNI is at a particle size of 40 mesh with a mass ratio of 1:3 resulting in 54.40 % NaCl and 40.32 % KCl concentration. Concentration of K in table salt product is very influential on decreasing Na concentration, the higher the purity of KCl concentration added in NaCl, the results obtained will be in accordance with the mass ratio of the material. And the smaller the electronegativity of an atom, the stronger the force of the core weakens and tends to release electrons. While the particle size does not have much effect on the results of K and Na concentration obtained after the mixing process.

5. References
[1] Y. Mogheir, A. Qarroot, (2017) Treatment of Desalination Brine Using an Experimental Solar Pond, J Eng. Res. Tech., 4 (1) 5-15
[2] T. Shakouchi (2018) Desalination of Seawater by Liquid Columns and Decompression Boiling (Recovery of Condensation Latent Heat), J. Water Resource and Protection, 10, 809-816
[3] Widayat, (2009), “Production of Industry Salt With Sedimentation-Microfiltration Process : Optimization of Temperature and Concentration By Using Surface Response Methodology”, J. Teknik, 30, 1,11-18.
[4] M. Apriani, W Hadi dan A Masduqi, (2018) Physicochemical Properties of Sea Water and Bittern in Indonesia: Quality Improvement and Potential Resources Utilization for Marine Environmental Sustainability, J. Ecol. Eng. 19(3):1–10
[5] G Guntur, A A Jaziri, A A Prihanto, D M Arisandi, A Kurniawan (2018) Development of salt production technology using prism greenhouse method, IOP Conf. Series: Earth and Environmental Science 106, 012082
[6] F. Wang, S. Wang, J. Li, D. Xia and J. Liu (2017) Seawater Desalination with Solar-energyintegrated Vacuum Membrane Distillation System, J. Water Reuse and Desalination 7 (1), 16-24.
[8] Bussemaker E, Hillebrand, U, Hausberg M, Ravenstadt H, and Oberleithner H 2010 Pathogenesis of hypertension: interactions among sodium, potassium, and aldosterone. A. J. Kid. Dis. 55 1111-1120
[9] World Health Organization . Guideline: Potassium Intake for Adults and Children. WHO Document Production Services; Geneva, Switzerland: 2012.
[10] Nierenberg JL, Li C, He J, Gu D, Chen J, Lu X, Li J, Wu X, Gu CC, Hixson JE, Rao DC, and Kelly TN 2017 Hypertension 70 1106-1112
[11] Adрогue HJ and Madias NE 2007 Sodium and potassium in the pathogenesis of hypertension. N. Engl. J. Med. 356 1966–1978.
[12] Van Mierlo, L. A., Greyling, A., Zock, P. L., Kok, F. J. and Geleijnse, J. M. 2010. Suboptimal potassium intake and potential impact on population blood pressure. Archives of Internal Medicine 170(16): 1501-1502.
[13] Munteanu, C. and Iliuţi, A. 2011. The role of sodium in the body. Balneo-Res. J. 2 (1)70-74
[14] Inês L M, Nuno L, Gabriela A, Marcello G, Susana C, et al., 2018 The Sodium and Potassium Content of the Most Commonly Available Street Foods in Tajikistan and Kyrgyzstan in the Context of the FEEDCities Project Nutrients 2018, 10, 98
[15] Sarkkinen ES, Kastarinen MJ, Niskanen TH, Karjalainen PH, Venäläinen TM, Udani JK, Niskanen LK 2011 *Nutrients* **10** 88
[16] Tan W L Azlan A and Noh M F M 2016 Sodium and potassium contents in selected salts and sauces *Inter. Food Res.J* **23** 2181-2186
[17] Thaker, A. and Barton, A. 2012. Multicultural handbook of food, nutrition and dietetics, p. 410. Oxford: WileyBlackwell.
[18] Toshiyuki I, Katsuyuki M , and Hirotsugu U 2017 Time to Consider Use of the Sodium-to-Potassium Ratio for Practical Sodium Reduction and Potassium Increase *Nutrients* **9** 700
[19] Rood RP and Sarko M Tilkian 1982 Low-sodium salt substitute US4473595
[20] Ryberg P 2006 Salt mixture with low sodium content for human. US Patent 2010247709A1.

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