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Application of response surface methodology for the optimization of process variables on the wet extraction of inulin from sisal boles

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Abstract

In sisal industry, only four percent of the leaves weight is used for production of sisal fibers. The leaves are only 2% of the whole plant meaning that the rest 98%, is discarded as waste. This study focuses on investigating the potential to produce inulin from sisal boles. In this investigation, a 2-factors 3 - levels Response Surface Methodology (RSM) with Central Composite Design (CCD) in Minitab statistical software was applied to evaluate the main effects and interactions of temperature and time on the inulin yield during extraction. The developed Second Order Quadratic mathematical regression model was used to analyze the main and interaction effects of the process variables on the inulin yield and optimizing the parameters. The inulin concentration was analyzed using HPLC with C-18 carbohydrate (4.6×45 mm) column and an RID detector. The optimal extraction conditions for inulin were obtained at a temperature of 70°C and reaction time of 86.67 minutes in which the optimum yield was 35.20%. The physicochemical properties of the produced inulin had a moisture content of 6.104 ± 0.104%, water-solubility of 124.92 ± 1.76 g/L and pH of 6.62 ± 0.38 indicating that this study's inulin exhibited close similarities with the commercial ones. This study has revealed that Sisal bole has a relatively good potency of producing inulin nearing to the leading biomass sources like chicory and Jerusalem artichoke roots.

Key words: *inulin; inulin yield; physicochemical properties; sisal bole; wet extraction*

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Introduction

Inulin is a naturally soluble dietary fiber, a reserve biopolysaccharide in plants (Afoakwah, 2022). Chemically, inulin-type fructans are linear polydisperse carbohydrate material consisting mainly of a distinctive β-(2-1)- fructosyl-fructose glycosidic bond linkages structure and terminated either with β-D-fructose or α-D- glucose molecule, linked to D-fructose by one α-(1→2) linkage, which renders it an indigestible fructan carbohydrate that possesses prebiotic properties (Franck, 2002; de Almeida Gualtieri *et al*., 2011; Du *et al*., 2023; Qin *et al.,* 2023; Wang *et al.* 2024). According to Verma *et al.* (2021), inulin and fructooligosaccharides (FOS) are among the fructans which are fructose polymers synthesized from sucrose as the precursor and constitutes a carbon reserve to plants. Inulin oligosaccharides, fructooligosaccharides (FOS), galacto-oligosaccharides (GOS) and lactulose are among the compounds considered to have prebiotic properties for their non-digestible carbohydrate which are often found in many vegetables, fruits and cereals (de Almeida Gualtieri *et al*., 2011). The degree of polymerization (d.p.) for standard inulin is estimated between 2-60 (Zimeri and Kokini, 2002).

There is a growing demand for inulin due to its extensive use as an antioxidant, anticancer, anti-aging, hepatoprotective, hypoglycemic, and gastrointestinal protective activities and regulating intestinal flora activities (Melilli *et al.,* 2024; Wang *et al.,* 2024). Inulin also has health benefits in regulating lipid metabolism, weight loss, lowering blood sugar, inhibiting the expression of inflammatory factors, reducing the risk of colon cancer, enhancing mineral absorption, improving constipation, relieving depression and reducing risk of atherosclerotic changes in the cardiovascular system (Qin *et al.,* 2023). Inulin is also widely used as ingredient in functional foods (de Almeida Gualtieri *et al*., 2011). Inulin market was estimated at USD 1.75 billion in 2023, with projections indicating a growth trajectory to USD 2.40 billion by 2028 (Kardamanidis *et al.,* 2024). The average estimated consumptions of inulin in various region shows that Europe have relative high rate of consumption of 3 and 11 g as compared to the USA with an average between 1 and 4 g (de Almeida Gualtieri *et al*., 2011).

Inulin occurs as a starch like carbohydrate in various plant roots. Unlike others starches which are polymers of glucose and fructose, inulin is a fructose polymer found in many species of plants, including agave, wheat, onion, bananas, garlic, asparagus, Jerusalem artichoke (*Helianthus tuberosus*), chicory, dahlia, elecampane, burdock, yacon tubers and dandelion roots whereby it is used an energy reserve (Niness, 1999 and Kalyani, *et. al., 2010*). Historically, inulin has been produced since the 19th century. Industrially inulin is currently derived from Jerusalem artichoke tubers (Terkmane *et al.,* 2016; Rubel *et al.,* 2018; Petkova, *et. al.,* 2018; Zhang *et al.,* 2022) and chicory roots (*Cichorium intybus*) (Kardamanidis *et al.,* 2024; Kumar and Uppuluri, 2024; Sağcan *et al.,* 2024). Inulin has also been produced from dahlia tubers which has an estimated inulin content of 15-20%. According to Mariano *et al.* (2023), inulin is produced largely by water diffusion followed by ethanol precipitation and drying. Generally, inulin can be produced by both cold extraction technologies and hot extraction technologies. Thermal extraction methods are among the conventional methods used for inulin extraction; however these methods have a disadvantage of heating of raw material up to 80ºC, which could lead to partial hydrolysis of inulin into oligofructose and fructose (Yankevich *et. al.,* 2022). Various technologies have been applied in inulin extraction including microwave and ultrasound-assisted extractions (Kosasih *et al.* 2015; Petkova *et. al.*, 2018; Mariano *et al.*, 2023).

Sisal bole is an intermediate part between the roots and stem of the sisal plant where the leaves are attached. Despite the fact that the sisal bole is composed of 30% (w/v) of total sugars in juice extract (Msuya *et al.,* 2018) it is among the parts of the discarded waste in sisal industry after fiber production. Sisal fiber makes up only 4% of the leaf weight (Virgin *et al.,* 2022) and accounts for only 2% of the sisal plant, leaving 98% (leaves stubs, sisal bole, and sisal pole) as waste (Elisante and Msemwa, 2010) indicating a need for increased variolization of the plant. Tanzania ranked second in the world for sisal fiber production in 2018, with 33,766 tones (15%), after Brazil, and it is estimated that by 2025 at least 100,000 tons of fibre will be needed in Tanzania alone (Colley *et al.,* 2021; Beleko and Urassa, 2022). According to Virgin *et al.* (2022), the amount of sisal bole residue that is sustainably available for further value addition is 240,000 tonnes, presenting a remarkable biomass reserve. These boles are currently burnt or broken down and ploughed under (Virgin *et al.,* 2022). Efforts to utilize fructan-derived sugars from sisal boles has been done, including production of citric acid (Ngonyani, 2010), feedstock for ethanol (Elisante and Msemwa, 2010) and in the production of Lactic acid a precursor for Polylactic acid (PLA) (Msuya *et al.,* 2022).

Sisal boles present potential bio-resources that could be used to produce valuable products including inulin (Mshandete *et al.,* 2013; Msuya *et al.,* 2018). Despite its potential, only few studies on inulin production from sisal bole have been conducted, with emphasis on yield. The study by Elisante and Msemwa (2010) employed a dry process of extracting inulin from sisal bole as a feedstock for ethanol production and the optimal yield of 16% was found at 70°C and particle size of 250 µm. Akram and Garud (2020) found that spray drying technique under optimized conditions improved the inulin yield to 11.96% as compared to other drying methods applied to inulin extraction from chicory. In another study by Majaliwa *et al.* (2023), the ultrasonic extractor in a wet extraction to produce inulin was employed and the result showed an optimal yield of 18% at 80°C and 90 minutes. When comparing the two methods, the wet extraction appears to produce slightly more inulin than the dry method, thus prompting more research on the wet extraction method. Low yields in the dry process can be attributed to the use of heat during material preparation, which reduces the quality and quantity of inulin. Despite all these efforts, still remains a need to explore more studies on the influence of operating parameters on yield and other physicochemical parameters with respect to sisal bole biomass.

This study focused on a systematic investigation on the effect of operating variables, namely temperature and time on the inulin yield and the physicochemical parameters during wet extraction of inulin from sisal boles. To accomplish this, statistical methods using Design of experiment and Response surface modeling (RSM) with Central Composite design (CCD) was employed. Application of Response surface optimization enables to optimize the process variables with a minimum number of experiments by statistically determining the best combination for a single response or multiple variables and can be used to analyze effects and interactions between variables parameters (Behera *et al*., 2018; Bezerra *et al*., 2019).

Materials and Methods

Materials Collection and Preparation

The material used for extraction of inulin was sisal boles collected from Highland Sisal Estate, Ubena Zomozi in Chalinze, Pwani Region. The average weight of the sisal boles with leaf stubs ranges from 26 to 55 kg. After the removal of leaf stubs, the weight of the sisal bole ranges from 4.6 kg to 12 kg. This shows that the leaf stubs cover approximately more that 65% of the whole sisal bole Stalks of dried leaves on the boles were removed by machetes and other impurities were removed by gentle scrubbing. The remaining sisal boles were then washed several times using tap water to remove dust and other remained impurities. The cleaned sisal boles were stored at -18°C in sealed bags to reduce microbial activities before extraction and analysis.

Wet Extraction of Inulin

To increase the surface area for extraction, the cleaned sisal boles were first chopped into small pieces about 3 mm using an axe, panga and laboratory knife. The inulin extraction was conducted by adopting the method by Andrianto *et al*. (2022) with slight modification on the solid pulp consistency. In this method, the chopped sisal bole pieces were mixed with four times the volume of distilled water and then homogenized using commercial electric blender (DW DIGIWAVE, CHINA). Three drops of 0.1 M NaOH was then added to adjust the pH to 7 and inulin was then extracted in Erlenmeyer flask placed in the Shaking water bath (GT SONIC -D9 model, China) on varying temperature ranging from 70°C to 100°C and time ranging from 60 minutes to 120 minutes.

Purification of Inulin

During the purification process, the extracted slurry was filtered by 11 μm Whatman filter paper to remove fibers and then centrifuged at 3000 rpm for 20 minutes to remove the insoluble fractions. The supernatant was precipitated with 1:5 volume acetones at 4°C for 24 hours to obtain inulin. The inulin syrup was then oven dried at 50°C for 3 hours to remove the residual acetone. The dried inulin syrup was broken down using mortar and pestle then sieved using a 90-mesh sieve to get the inulin powder.

Experimental Design and Model development

In this study, a Response Surface Methodology (RSM) with a two-factor, three-level Central Composite Design (CCD) of Experiment and one replicate at the centre was used to evaluate the main effects, interaction and optimizing the independent variables, namely temperature and time, on the dependent variable (inulin yield) response parameter during extraction using Minitab software (Minitab version 21 from Minitab, LLC,). The CCD for this study comprised of a total of 13 experiments in which 4 were cube or factorial points, 4 were axial/star points and 5 were centre points in the cube (replicates). The central point was replicated to determine experimental error. The experimental runs were carried out random to minimize unexpected errors in the response arising due to the extraneous factors. The actual levels of temperature were 70^{o}C, 85 ^{o}C and 100 ^{o}C represented by coded levels of -1, 0, and +1, respectively, while the reaction time actual levels were 60 minutes, 90 minutes and 120 minutes represented by coded levels of -1, 0, and +1, respectively.

The Second Order Quadratic mathematical model with linear regression analysis used to analyze the effects and interaction of temperature and time on the inulin yield is shown in Equation 1.

$$Y = \beta o + \beta_1X_1 + \beta_2X_2 + \beta_{11}X_1^2 + \beta_{22}X_2^2 + \beta_{12}X_1X_2 +...+ \varepsilon \quad (1)$$

Where βo is the constant; β_1, β_2 are linear coefficients for the coded variables X_1 and X_2, respectively; β_{12} represents the interaction effect between variables, β_{22} is the coefficients for quadratic (square) term, Y is the predicted response factor and ε is the residual or error term. The optimum inulin yield was determined by the optimization function embedded in Minitab software, version 21.

Physicochemical Characterization of Inulin

HPLC-RID analysis of Inulin Content in Sisal bole extracts

The analysis method by Başaran *et al.* (2018) was adopted to perfrom Chromatographic separations and determine the inulin content in sisal bole extract, with some modifications on the temperature of the detector, injection volume and the concentrations used for preparation of standard curve. The separation of inulin was done with High-performance liquid chromatography (HPLC) (Agilent Technologies, GERMNY, Series 1260, infinity II) with an isocratic pump (G7111A Series DEAEX01679) and auto sampler (G7129A Series DEAEQ21126) on a C-18 carbohydrate (4.6×45 mm) column and Refractive Index Detection (RID) detector (G7114A Series DEACX10455). The HPLC conditions were set isocratic at 80°C (column) and 40°C (detector) with the flow rate of 1.0 mL min-1 and injection volume of 10 microliter using distilled water as a mobile phase, the total retention time was 16 minutes prior to injection, the column was equilibrated with the mobile phase flowing through the system for 30 minutes. A 100 g/L stock solution of inulin standard was prepared in hot water. A series of standards containing 10.0, 20.0, 40.0, 60.0, 80.0 and 100.0 g/L were also prepared from the stock solution. The inulin content was determined by comparing the peak area of inulin standards and the sample. The inulin yield was then calculated using equation 2.

$$inulin\ yield\ (\%) = \frac{\text{inulin produced (g)}}{sisal\ bole\ weight\ (g)} \quad (2)$$

where PWI (g) is the mass of powdered inulin obtained from the sisal bole extract and MSB is the weight (g) of charged sisal bole in the extractor to obtain the extract.

Water- Solubility analysis of produced inulin

The water-solubility determination of inulin was carried out by adopting the method applied by Bouaziz *et. al.* (2014). In this method, the solubility was determined at 25°C by slow addition of inulin into 10 mL of water and stirring until no more inulin dissolved, indicating a saturation point. Then the solution was filtered to remove undissolved inulin, the amount of inulin dissolved in the solution was weighed using analytical balance by measuring mass of solution and subtracting with the original mass and the solubility was then calculated using equation 3.

$$solubility = \frac{\text{mass of inulin dissolved}}{\text{volume of solution}} \quad (3)$$

pH and Moisture content measurement

The pH was measured by using pH meter, where 1g of inulin sample were dissolved in 5 mL of distilled water to form a solution and the electrode was dipped to measure the pH. Moisture content measurement was measured by adopting the method by Andrianto *et al.*, (2022). According to this method, 2 g of the sample was placed in a Petri dish and dried in oven (WTB binder Temp. Schutz DIN 12880) for 1 hours at a temperature of 105°C, the dish then removed from the oven, covered and cooled to a room temperature in a desiccator and weighed, the heating was repeated until a constant weight. The moisture content was then calculated using equation 4.

$$moisture\ content\ (\%) = \frac{\text{W1 - W2}}{\text{W1}} \quad (4)$$

Where W1 is an initial weight of the sample (g) and W2 is a final weight of the sample (g).

Results

Determination of Inulin yield

The yield of extracted inulin obtained from the conducted experiments under various conditions varied from 22.84 to 35.78% as indicated in Table 1. In this extraction, the lowest inulin yield of 22.84% was recorded at temperature of 100°C for 120 minutes. The predicted optimum extraction yield of inulin from the developed model was 35.20% obtained at optimum extraction of temperature and time of 70°C and 86.67 minutes respectively (Figure 2).

Table 1

Central Composite Design matrix and measured responses for inulin production

StdOrder	RunOrder	PtType	Blocks	Independent variables		Response variable
				Temperature (°C)	Time (min)	Inulin Yield (%)
8	1	-1	1	85	120	29.22
4	2	1	1	100	120	22.84
12	3	0	1	85	90	30.57
6	4	-1	1	100	90	28.45
9	5	0	1	85	90	30.62
3	6	1	1	70	120	32.50
1	7	1	1	70	60	34.02
2	8	1	1	100	60	29.82
10	9	0	1	85	90	29.35
5	10	-1	1	70	90	35.78
7	11	-1	1	85	60	30.94
11	12	0	1	85	90	31.95
13	13	0	1	85	90	32.87

Model fiting, Evaluation and Optimization The findings shown in Table 1were used to fit the model using regression. The developed empirical model in Equation 5 was tested using model quality indicators and Analysis of Variance (ANOVA) as shown in Table 2.

Table 2

Response surface quadratic model of inulin extraction from sisal bole at different extraction temperatures and time

Source	Coeff.	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression (Model)		5	107.120	90.81%	107.120	21.4241	13.84	0.002
Constant	31.4							0.245
Linear								
Temperature (^oC)	-0.265	1	74.794	63.41%	0.323	0.3228	0.21	0.662
Time (min)	0.527	1	17.390	14.74%	11.768	11.7682	7.60	0.028
Square								
Temperature (^oC)*Temperature (^oC)	0.00178	1	0.157	0.13%	0.443	0.4426	0.29	0.609
Time (min)*Time (min)	-0.001810	1	7.331	6.21%	7.331	7.3306	4.74	0.066
2-Way Interaction								
Temperature (^oC)*Time (min)	-0.00303	1	7.450	6.32%	7.450	7.4496	4.81	0.064
Error		7	10.836	9.19%	10.836	1.5481		
Lack-of-Fit		3	3.406	2.89%	3.406	1.1354	0.61	0.643
Pure Error		4	7.430	6.30%	7.430	1.8575		
Total		12	117.957	100.00%				

DF, degrees of freedom; F, test statistic; MS, mean squares; SS, sums of squares

The regression equation in uncoded units used to predict the inulin yield (%) from sisal bole (Equation 5) showed an adequacy of fit with R-sq and R-sq(adj) values of 90.81% and 84.25% respectively and the mean of squares residual of 1.244 (Montgomery, 2009).

$$Yield\ (\%) = 31.4 - 0.265\ X_1 + 0.527\ X_2 + 0.00178\ X_1 * X_1 - 0.001810\ X_2 * X_2 - 0.00303\ X_1 * X_2 \quad (5)$$

Where X_1 is extraction temperature and X_2 extraction time all represented in coded values.

Normal probability plot for standardized residuals in Figure 1 was used to check the normality of the errors in the empirical data in terms of the standardized residuals and the response optimization plot in Figure 2 was used to predicted the inulin yield from the model.

Figure 1

The Normal probability plot for standardized residuals for Inulin yield

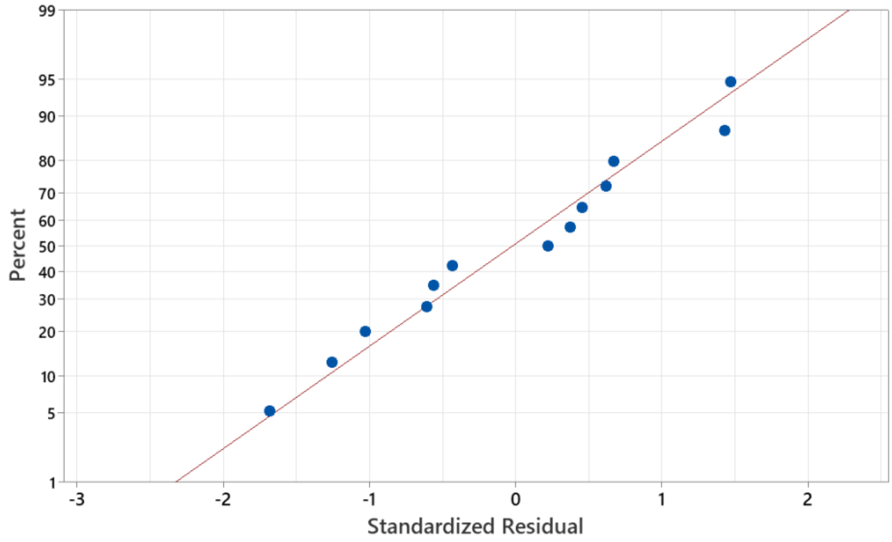
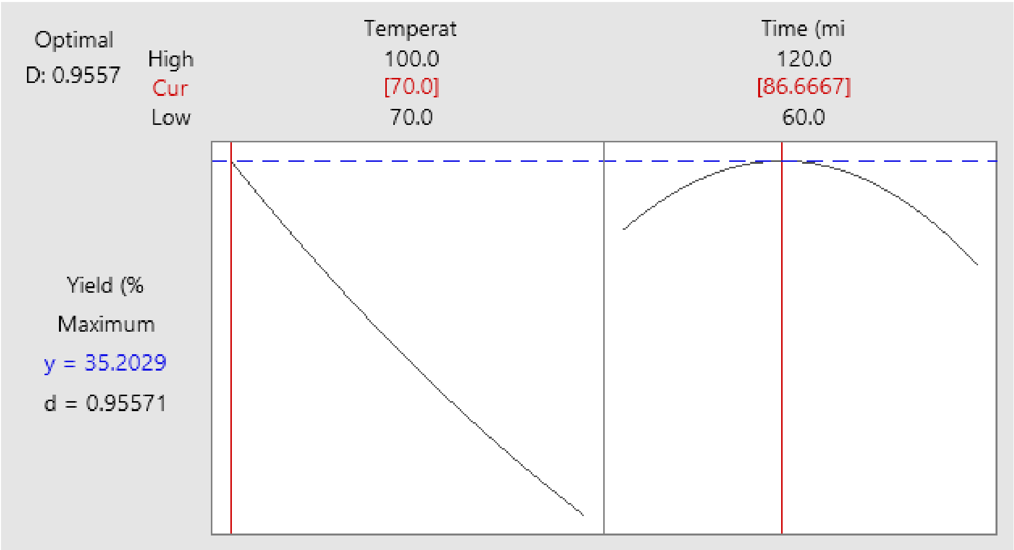


Figure 2

Response optimization plot for predicted inulin yield

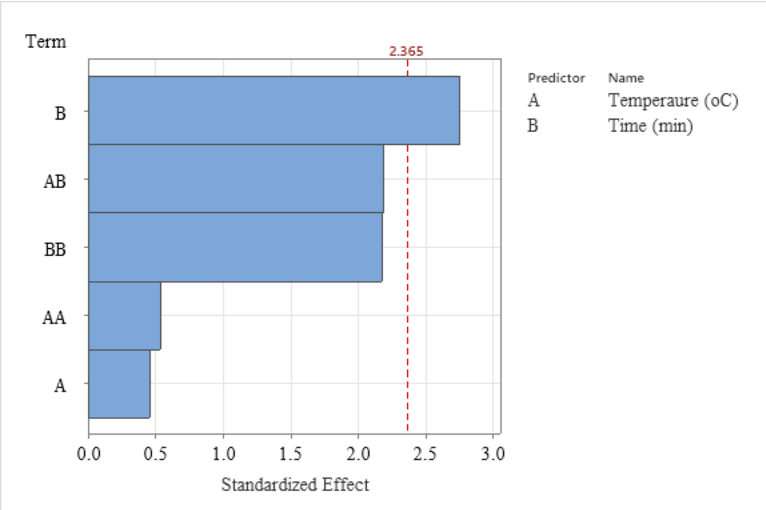


Interactive Influence of the extraction temperature and time on the inulin yield

The influence of the independent variables on the dependent variable were evaluated using the Standardized Pareto chart shown in Figure 3. According to Antony (2023), Pareto chart illustrates the absolute values of the effects of main parameters and the effects of interaction of factors on the response, and is usually depicted in terms of horizontal bars. The bar extending beyond the reference line indicate the potentially important factors and corresponds to the factors that is statistically significant at the confidence level of 95% and significance level (α) of 0.05.

Figure 3

Pareto chart for standardized effect (Response is Yield (%), a=0.05)

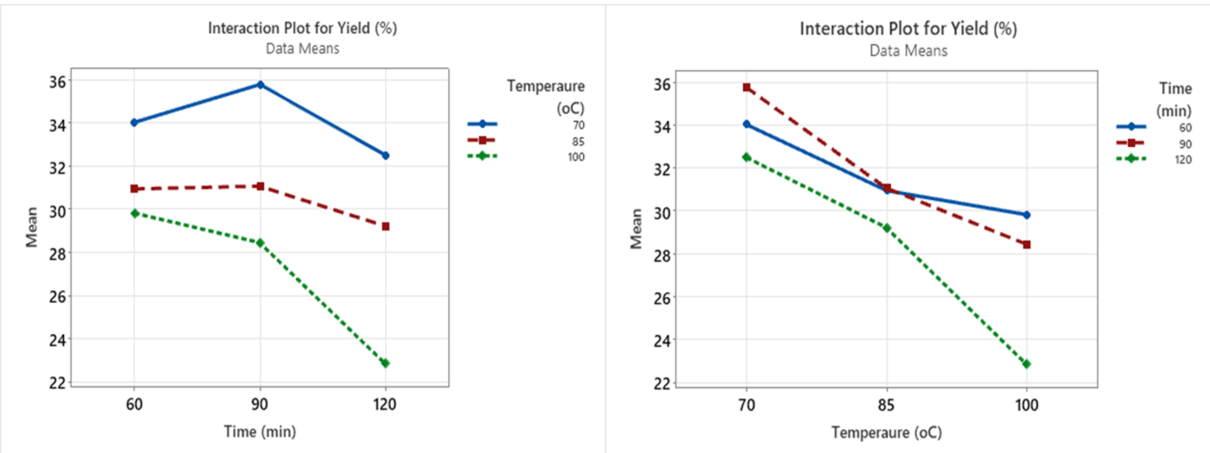


The the two-way interaction effects plot for inulin yield from sisal bole is shown in Figure 4(a) and 4(b). The interaction plot shows the mean inulin yields versus reaction time (Fig. 4(a)) for each of the three investigated temperature levels and temeperature (Fig. 4(b)) each of the three investigated reaction times. The non-parallel lines on both interaction plots indicate interaction effects between reaction time and temperature on the inulin yield. The interactions shown in Figure 4 justify the correlation between inulin yield and reaction time is significantly affected by the reaction temperature and vise versa.

The interactions and combined effects of the operating variables on the response extraction yield are also distinctly demonstrated in a 3D response surface contour plot revealed in Figure 5. Though the interaction effects are shown on the interaction and contour plots, their statistical significance are evaluated more on the ANOVA Table 2 (Antony 2023).

Figure 4

Interactions plot for the effect of time (a) and temperature (b) on inulin yield

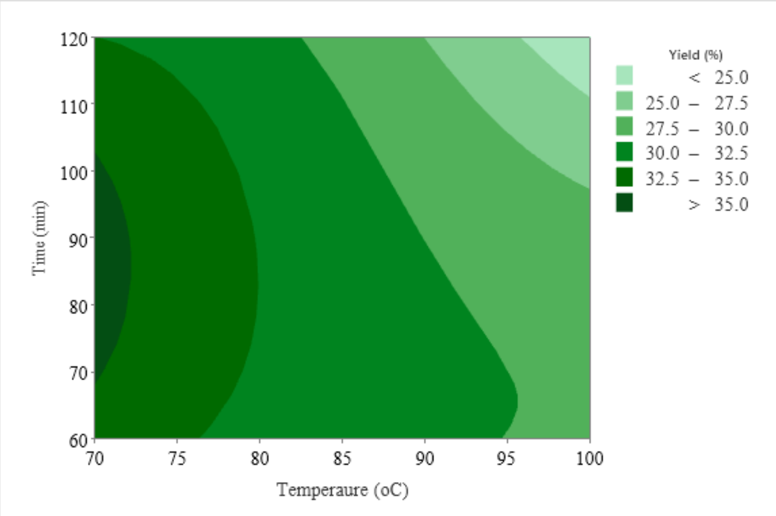


(a)

(b)

Figure 5

Contour plot for the effect of temperature and time on inulin yield



Physicochemical Characterization Results

Moisture content of the produced inulin

The measured moisture content of the produced inulin was found to be 6.104 ± 0.104%. The moisture content obtained in this study corresponds to that of commercial inulin that is 6% (Apolinario *et al.*, 2017), but also, with the required moisture content for food safety standards which ranges from 2 to 6%. Inulin powder storage in various humidities can lead to degradation, microbial growth, and enzymatic activity, hence lowering the product shelf life. Monitoring the water content of inulin during storage and quality control is very important to make the inulin more free-flowing and less prone to clumping and caking, and the powder has good flow ability, thereby improving the dispersion properties in its applications as well as easy handling (Escoba-Ledesma *et al.*, 2020; Alfano *et al.*, 2022).

Water- solubility of of the produced inulin

The determined water-solubility of inulin was found to be 124.92 ± 1.76 g/L. The water-solubility of inulin of 124.92 ± 1.76 g/L obtained in this study was higher similar to that of 126.68 g/L reported by Apolinario *et al.* (2017). However, in study by Bouaziz, *et. al.* (2014) where inulin was extracted from *Agave americana* leaves, the water solubility showed as relatively small value of 73 g/L as compared 113 g/L for commercial inulin obtained by lyophilization. In another study, Inulin extracted from chicory revealed the water solubility of about 178 mg/mL when analyzed at 25^{0}C (Chen *et. al.*, 2018). Determination of solubility is important since it affect the hydration properties of inulin, the inulin has high ability to absorb water and form gel like substance due to interaction of inulin and water molecules, the higher solubility of inulin allows greater amount of water to be absorbed resulting into increased hydration but also, the increased solubility in water allows inulin to be readily available for fermentation in the colon, promoting the growth of beneficial bacteria and contributing to overall gut health.

Effect of pH on inulin storage

The pH obtained in this study showed small deviation in comparison with that of commercial inulin which is 7 (El-Kholy *et al.*, 2020). The pH measurement is important and should be controlled at 7 to make sure that the extracted inulin is neither basic nor acidic. These make it safer and stable to be consumed and compatible for various formulations of food products. From the experiment the pH of the obtained inulin was 6.62 ± 0.38. Glibowski and Biaduń (2020) reported that Inulin does not undergo significant hydrolysis at pH 4 and higher in the presence of malic acid during a long-term storage 25°C, however at very acid conditions below pH 4 inulin could undergo hydrolysis. When inulin was added as Prebiotic carbohydrates in complex food matrix processed at low pH of 3, its stability was negatively affected, indicating that inulin low resistance to hydrolysis at low pH (Duar *et al*., 2015).

Discussion

Inulin yields results obtained in this study are slightly higher to that obtained from other plants such as jicama, cabuya and *Stevia rebaudiana* roots at the same temperature range (Escoba-Ledesma *et al.,* 2020; Mariano *et al.,* 2023). Although slight lower from that from Jerusalem artichoke and chicory roots (Zhang *et al.,* 2022), they are higher than that of garlic extracted at higher temperatures of more than 80°C (Lara-Fiallos *et al.,* 2021). The obtained yield is high compared to the dry extraction technique where the maximum yield from dry extraction was found to be 16.1 g/L (Elisante and Msemwa, 2010). Ultrasonic radiation method has also been reported to result in better yield during inulin extractions compared to dry methods (Esmael *et al.,* 2021). The inulin yield obtained in this study is higher than that obtained when an ultrasonic extractor was used to extract inulin from sisal boles using wet extraction at the same time and temperature of 80°C (Majaliwa *et al.,* 2023).

The *F*-value of 13.84 indicates that the model for inulin production from sisal bole was statisticaly significant at 95% confidence level. The *p*-value of 0.002 whuch is less than 0.01 for the regression model reveals that the regression equation and the system levels were significant. The p-value of 0.643 for Lack-of-fit test is greater than 0.05 indicating that this error tem is insignificant, suggesting that the model can adequately be used to predict the inulin yield (%) from sisal bole. Normal probability plot for standardized residuals in this model (Figure 1) shows almost all the data points approximately follow a straight line between the 95% confidence interval limits indicating that the normal distribution is a good fit and data were normally distributed.

The extraction time also showed the positive effect and appears to be a more significant variable (p = 0.028) in the inulin extraction yield. The temperature effect was less significant though it showed a negative effect to the inulin extraction yiled. Results show that extraction time was very significant on the yield than the extraction temperature. The Standardized Pareto chart also confirm that interaction effect between extraction time and temperature was also statistically significant with a negative effect.

Contour plot trends in Figure 4 shows that the inulin yield decreased with increase in tempetaure when temeprature was varies from 70 ^{0}C to 100 ^{0}C and it is significantly lowered at higher temperatures when the extraction time is longer. This effect is also seen on the ANOVA where the 2-Way Interaction between temparature and time was significant with a p-value of 0.064. The coefficient for interaction in the ANOVA results also showed that the combined effect of the two variables had a negative effect on the inulin extraction yield. In study by Duar *et al*. (2015), inulin recoveries and stability were significantly lowered at higher extruding temperature, aligning to findings from this study.

The wet extarction method of extarcting inulin from sisal bole was justfied to be an effective method and simple in application. The physicochemical characteristics of the inulin obtained from this study showed close similarities with the commercial inulin and those produced by previous ivestigators (Yankevich *et. al.,* 2022; Majaliwa *et al.,* 2023).

Conclusion

This study has shown the potency of sisal boles in producing inulin as compared to other tubers. The extracted inulin from sisal bole revealed a yield, moisture content, solubility and pH of 35.20%, 6.104 ± 0.104%, 124.92 ± 1.76 g/L and 6.62 ± 0.38, respectively. The study also showed that in the wet extraction process, extraction time is more significant as compared to temperature; hence time parameter needs attention during the production process. The relatively fairly high yield of inulin from sisal bole and the fairly good physicochemical characterization results paves a way for development of inulin production especially in Tanzania.

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