INTRODUCTION

Developments in lignocellulosic biomass depolymerization and yeast engineering contribute to advances in the production of biofuels and bio-driven chemicals (Hassan et al., 2018; Jiao et al., 2021; Kim & Auh, 2021; Liu et al., 2019; Lynd, 2017). With the development of physicochemical pretreatment processes, saccharification efficiency is increasing by deconstructing the recalcitrant lignocellulose structure into a more accessible form for hydrolytic enzymes (De Bhowmick et al., 2018; Park et al., 2020). The increased sugar yield...
through pretreatment also improves yeast fermentation (Abo et al., 2019). However, pretreated hydrolysates contain microbial-inhibiting substances such as acetate, furfural, and phenolic compounds, which negatively affect ethanol fermentation (Bhatia et al., 2020; Jönsson & Martín, 2016). Particularly, acetate, produced during widely used dilute acid pretreatment, is a potent inhibitor of fermentation (Bellissimi et al., 2009) and enzymatic saccharification (Chen et al., 2012; Jiang et al., 2016). Hemicellulose has an acetylated xylan structure (Agger et al., 2010). Therefore, acetate is often released from the xylan backbone through acid-based pretreatment and/or enzymatic hydrolysis (Ranatunga et al., 1997). Since most lignocellulosic biomass hydrolysates contain significant amounts of the toxic acetate (Demeke et al., 2013; Klinke et al., 2004), yeasts have a poor growth rate due to increased free radicals in cells, additional consumption of energy (adenosine triphosphate) to expel excessive protons to maintain the intracellular pH homeostasis, and inhibition of intracellular metabolic functions caused by acetate in pretreated hydrolyzate of biomass (Giannattasio et al., 2013). This results in the reduction of ethanol yield and productivity (Guaragnella et al., 2011; Pampulha & Loureiro-Dias, 2000; Vilela-Moura et al., 2011). In spite of tremendous efforts to use acetate as the carbon source for yeast fermentation, most metabolic engineering technologies to accomplish this goal have been established under low-to-moderate acetate concentration (1–3 g/L; Chen et al., 2016; Papapetridis et al., 2016). Keeping in mind that acetate concentrations present in acid hydrolysate of lignocellulose could range up to 15 g/L, this strategy is not sufficient alone (Klinke et al., 2004; Palmqvist & Hahn-Hägerdal, 2000). Therefore, a detoxification process focusing on the removal of the acetyl group of xylan is necessary prior to pretreatment to maximize the ethanol production.

Xylose in the form of xylan is the second most sugar produced from lignocellulose after glucose (Abo et al., 2019). It is an important carbon source for microbial fermentation released during hydrothermal pretreatment and/or saccharification for industry (Kim et al., 2013). However, *Saccharomyces cerevisiae*, the most widely used microbial platform for bioethanol production from lignocellulosic biomass due to its high resistance to ethanol and acetate, is not able to ferment xylose. Thus, engineered *S. cerevisiae* strains have been developed to simultaneously consume glucose and xylose obtained from lignocellulosic for improved ethanol production (Kim et al., 2013; Park et al., 2020).

Hemp (*Cannabis sativa*) and kenaf (*Hibiscus cannabinus*) are similar in appearance, but hemp is grass-like and kenaf is hardwood-like (Giwa et al., 2019; Shahzad, 2012). Hemp is widely used in industrial production of textiles, cloths, and paper (Shahzad, 2012). In addition, there are many studies that showed the potential for its use in bioethanol production due to its high content of cellulose and hemicellulose containing fermentable sugar units such as glucose and xylose (Agbor et al., 2014; Das et al., 2017; Kreuger et al., 2011; Kuglarz et al., 2016; Zhao et al., 2020). However, kenaf is limited to rope, fishing nets, and paper production because it is tough and less flexible than hemp (Ramesh et al., 2018). Recently, kenaf is also considered valuable as a lignocellulosic feedstock as it has a rapid growth and excellent CO$_2$ absorption (Ayadi et al., 2017; Park et al., 2021).

The acetyl group present in biomasses can be removed by immersion in alkaline solutions at a mild temperature before acid pretreatment (Chen et al., 2012; de Assis Castro et al., 2017; Wang et al., 2019). Previously, deacetylation effects on bioethanol production were evaluated using xylose-fermenting yeasts including native *Spasmodora passalidarum* (Lima et al., 2021) and engineered *S. cerevisiae* (Wang et al., 2019). However, they are limited to the common lignocellulosic feedstocks like sugarcane bagasse. In this study, using the two different lignocellulosic biomasses, hemp and kenaf, more unique but with great industrial values, the effect of alkaline deacetylation on the fermentation performance of xylose-consuming *S. cerevisiae* was evaluated. Our study demonstrates that deacetylation prior to hydrothermal pretreatment is necessary for the improvement of both enzymatic saccharification and microbial fermentation of hemp and kenaf.

# Materials and Methods

## Yeast strain and culture conditions

The previously developed xylose-consuming *S. cerevisiae* SR8 yeast strain expressing a heterologous xylose pathway derived from *Pichia stipitis* was used (Kim et al., 2013) and *S. cerevisiae* D452-2 (wild-type) was used as a control strain. For high initial cell density, all yeast strains were pre-cultured in YP medium (10 g/L yeast extract and 20 g/L peptone) containing 20 g/L glucose for 24 h at 30°C and 250 rpm. The pre-cultured yeast cells were harvested by centrifugation at 3134 × g for 5 min and then washed with distilled water. The initial cell concentration was 20 with an optical density at 600 nm (OD$_{600}$). The harvested cell pellets were suspended with distilled water.
and inoculated into the deacetylated or only diluted acid-pretreated hemp and kenaf hydrolysates.

2.2 | Biomass preparation

Hemp was grown for pharmaceutical purposes on the Sangsang farm (Andong, South Korea). Kenaf was planted in April 2019 and harvested in November 2019 (Jeju Island, South Korea). The harvested hemp and kenaf were dried at 60°C for 24 h and milled, and then stored at −80°C until used. The contents of moisture, cellulose, hemicellulose, and lignin of the dried biomass (Table 1) was analyzed as previously described (Park et al., 2021).

2.3 | Alkaline deacetylation

The mild-alkaline deacetylation process was carried out at different concentrations of NaOH. First, 2 g of hemp or kenaf were added to 18 ml of distilled water or different concentrations of NaOH (0.2%–1.6%, w/v) and treated at 65°C for 2 h. After alkaline deacetylation, the whole slurry was centrifuged at 3134 × g for 5 min and the supernatant was separated from pellet. The acetate and sugar contents of supernatant were analyzed using high-performance liquid chromatography (HPLC) to confirm the deacetylation efficiency. The pellet was washed twice with distilled water and completely dried at 65°C before acid hydrolysis.

2.4 | Dilute-acid pretreatment

Hydrothermal pretreatment was performed at 121°C for 30 min using 1% (v/v) H₂SO₄ solution against 2 g of each biomass. Pretreated hemp and kenaf hydrolysates were neutralized to a pH 5.5 or 6.5 using 7.5 M NaOH solution. Finally, before starting simultaneous saccharification and fermentation (SSF), all neutralized slurry without performing separation step were sterilized at 121°C for 15 min in an autoclave.

2.5 | Enzyme hydrolysis

The neutralized slurry obtained from acid pretreatment was treated with 80 filter paper cellulase units (FPU)/g biomass of Cellic® CTeC2 (Novozymes), and incubated at 30°C and 130 rpm for 24 h.

2.6 | Simultaneous saccharification and fermentation

Fermentation of hemp and kenaf hydrolysates was performed by inoculating xylose-consuming SR8 and wild-type D452-2. An initial OD 20 of each strain was inoculated in the prepared sample (deacetylated or only acid-hydrolyzed) in 100 ml of an Erlenmeyer flask with 80 FPU/g biomass of Cellic® CTeC2 (Novozymes). Fermentation was performed at 30°C and 130 rpm with a total medium volume of 20 ml.

2.7 | Analysis

The glucose, xylose, and acetate of hemp and kenaf hydrolysates were analyzed quantitatively and qualitatively using HPLC (1260 series; Agilent Technologies) equipped with a Rezex-ROA Organic Acid H⁺ column (8%, 150 mm × 4.6 mm; Phenomenex Inc.). The analytes were eluted with 0.005 N H₂SO₄ at 0.6 ml/min and 50°C, as described previously (Kim et al., 2019). A pH meter (F-51; Horiba) was used for the determination of hydrogen ion concentration. A t-test was performed to determine statistically significant differences in the averages.

|                | Moisture | Lignin | Glucan | Xylan | Acetate |
|----------------|----------|--------|--------|-------|---------|
| **Hemp**       |          |        |        |       |         |
| Raw material   | 6.7 ± 0.1| 8.1 ± 0.0| 46.6 ± 0.2| 8.8 ± 0.1| 3.89 ± 0.1|
| Deacetylated   |          |        | 45.9 ± 0.0| 6.7 ± 0.0| 0.43 ± 0.0|
| **Kenaf**      |          |        |        |       |         |
| Raw material   | 4.5 ± 0.1| 6.9 ± 0.4| 47.2 ± 0.2| 12.8 ± 0.0| 4.12 ± 0.0|
| Deacetylated   |          |        | 46.8 ± 0.0| 12.4 ± 0.0| 0.48 ± 0.0|

| TABLE 1 Composition of hemp and kenaf samples^a |

^a, g/100 g dried sample.
^b Measured acetate concentration of the hydrolysate samples in Figure 2.
^c Calculated glucan and xylan concentrations of the deacetylated samples based on the removed glucose and xylose concentrations.
3 | RESULTS

3.1 | Alkaline deacetylation of hemp and kenaf

In this study, to reduce acetate inhibition, acetyl groups were selectively removed from hemp and kenaf through alkaline deacetylation prior to acid pretreatment. The amounts of removed acetate and loss of sugars (i.e., glucose and xylose) from hemp and kenaf biomass were measured under the different NaOH conditions.

NaOH loading were 0.0%–1.6% (w/v) and treated at 65°C for 2 h in 10% (w/v) solid loadings of hemp and kenaf. The maximum removal of acetate was achieved at NaOH loadings higher than 0.8% in both hemp and kenaf (Figure 1a). The mathematical equations of the removed acetate content as a function of NaOH loading (X) with high prediction reliabilities (i.e., $R^2 > 0.98$) were established as the following Equations (1) and (2) (de Assis Castro et al., 2017).

\[
\text{Removed acetate from hemp (g/L)} = 0.59 \cdot X^3 - 4.77 \cdot X^2 + 8.99 \cdot X - 0.13 \quad (R^2 = 0.99)
\]

\[
\text{Removed acetate from kenaf (g/L)} = 2.03 \cdot X^3 - 9.75 \cdot X^2 + 14.86 \cdot X - 0.36 \quad (R^2 = 0.98)
\]

There was a positive correlation between the removed amount of acetate and NaOH loading between 0%–0.8% in both biomass in which linear slope was steeper for kenaf. This result indicates that kenaf may contain more acetyl groups and hemicellulose than hemp.

Cellulose and hemicellulose fractions are known to be slightly damaged under mild-alkaline conditions (Chen et al., 2013). For this reason, selection of optimal NaOH loading is important to ensure the maximum sugar recovery required for fermentation by minimizing the loss of glucose and xylose. Thus, the amounts of lost sugars were experimentally determined and the mathematical equations of the removed sugar (glucose and xylose) content as a function of NaOH loading (X) were established as the following Equations (3)–(6) (de Assis Castro et al., 2017).

\[
\text{Removed glucose from hemp (g/L)} = 1.20 \cdot X^2 - 3.25 \cdot X + 2.9 \quad (R^2 = 0.97)
\]

\[
\text{Removed glucose from kenaf (g/L)} = 0.96 \cdot X^2 - 2.62 \cdot X + 2.0 \quad (R^2 = 0.98)
\]

\[
\text{Removed xylose from hemp (g/L)} = 0.37 \cdot X^2 - 1.37 \cdot X + 2.97 \quad (R^2 = 0.96)
\]

\[
\text{Removed xylose from kenaf (g/L)} = 0.72 \cdot X^2 - 2.10 \cdot X + 1.74 \quad (R^2 = 0.97)
\]

As a result, the loss of sugar and 0.0%–1.0% (w/v) NaOH showed a strong negative correlation in both biomasses (Figure 1b,c). All models exhibited high coefficients of determination ($R^2 > 0.95$), indicating a close agreement between the experimental and predicted values. Both biomasses showed the least sugar loss in the NaOH concentrations higher than 1.0% (w/v) at which hemp lost more glucose and xylose than kenaf did (Figure 1d). When only treated with distilled water, the total sugar (glucose and xylose) loss was 5.7 g/L in hemp and 3.8 g/L in kenaf. Taken together, 1.0% (w/v) NaOH was used for the deacetylation of hemp and kenaf as the best compromise to achieve the maximal acetate removal and the minimal sugar loss in this study. Composition of deacetylated hemp and kenaf biomasses obtained under this condition showed no substantial difference in carbohydrate contents (i.e., cellulose and hemicellulose) compared with non-deacetylated biomasses (Table 1).

3.2 | Effect of alkaline deacetylation on saccharification efficiency

Prior to microbial fermentation, acid pretreatment and enzymatic saccharification precede to obtain fermentable monomeric sugars (i.e., glucose and xylose) from complex polysaccharides in the lignocellulosic biomass. The effect of deacetylation on the saccharification efficiency was examined by comparing the amounts of produced sugars from non-deacetylated (control) and deacetylated hemp and kenaf hydrolysates. Although Cellic CTec2 used in this study has an optimal temperature of 50°C, to understand the hydrolysis pattern during SSF performed at 30°C, enzyme saccharification was conducted at the same temperature at which ~60% of relative enzyme activity was shown (Paz-Cedeno et al., 2022).

After 24 h of enzymatic saccharification of hemp, the amounts of glucose and xylose obtained from the deacetylated hydrolysate were increased by 20.7% and 8.0%, respectively, compared with those from the control. Similarly, in deacetylated kenaf hydrolysate, the amounts of glucose and xylose were increased by 16.7% and 30.7%, respectively (Figure 2a,b). In kenaf containing more acetate and hemicellulose than hemp (Table 1), the enhancement of xylan saccharification was more pronounced than hemp. From these results, alkaline deacetylation conducted in this study was found to be effective in improving saccharification efficiency of cellulose and xylan both for hemp and kenaf, possibly by alleviating enzyme inhibition, which is often caused...
by the hindrance effect of acetyl group present in xyllose oligomers, produced during acid hydrolysis (Agger et al., 2010; Chen et al., 2012).

3.3 | SSF of deacetylated hydrolysates of hemp and kenaf

Through the deacetylation process, 4.7 and 6.3 g/L of acetates were removed from hemp and kenaf, respectively (Figure 1d). There was only a small amount of acetate remaining in hydrolysate both of hemp and kenaf after deacetylation and diluted acid pretreatment, whereas the hydrolysate of the control group subjected to only diluted acid pretreatment contained a considerable amount of acetate (3–4 g/L in hemp and 4–6 g/L in kenaf; Figures 3c and 4c).

When SSF was performed with xylose-consuming <i>S. cerevisiae</i> SR8, fermentation performance for deacetylated hemp and kenaf hydrolysates was improved showing the maximum ethanol titers at 24h of 18.9 and 16.2 g/L, respectively (Figures 3d and 4d). Ethanol yield (g ethanol/g
glucose and xylose consumed) at 24 h also increased with deacetylated hemp but the same was not true with kenaf (Table 2). Ethanol productivities obtained from deacetylated hydrolysates of hemp and kenaf at 24 h were higher by 33% and 6%, respectively, compared with those obtained from non-deacetylated hydrolysates, exhibiting a more pronounced improvement with hemp (Table 2 and Figures 3d and 4d). Consumption rates of both glucose and xylose consumed (Figure 3 and 4) were higher with deacetylated hemp, which led to a higher ethanol production compared to kenaf.
and xylose increased during SSF of deacetylated hemp and kenaf. However, the overall consumption was more noticeable for xylose. To be specific, whereas xylose was not fully consumed in non-deacetylated biomasses, there was little residual xylose in deacetylated biomasses. These results are consistent with previous studies showing that sugar fermentation by yeast are often affected by the presence of acetate with a higher inhibition of xylose fermentation (Wei et al., 2013). Higher concentrations of glucose and xylose in hydrolysates of non-deacetylated biomass were observed at the initial time points with large standard deviations (Figures 3a, b and 4a). This could arise from the technical errors associated with mixing of the high-solid biomass (i.e., 10%). Overall, the results demonstrate the deacetylation performed in this study was effective in enhancement of microbial fermentation of hemp and kenaf hydrolysates, as evidenced by the increase in sugar consumption rate, ethanol titer, and productivity.

3.4 | Comparison of deacetylation effects on SSF by wild-type and xylose-fermenting yeasts

Xylose is the monomeric sugar forming the backbone of xylan and represents the second most abundant sugar of lignocellulose after glucose. It is more economically practical to use strategies for simultaneous yeast fermentation of glucose and xylose for ethanol production (Kim et al., 2013). Application of xylose-using engineered yeasts is considered suitable for this purpose (Kim et al., 2013; Wei et al., 2013). In this study, to examine the performance of xylose-fermenting S. cerevisiae SR8, its fermentation was compared using hemp hydrolysates, which had shown a pronounced improvement for ethanol production previously (Figures 3 and 4) with that of wild-type S. cerevisiae D452-2 (Figure 5). The engineered SR8 strain showed a poor xylose consumption in the non-deacetylated hemp hydrolysate. The wild-type D452-2 strain also showed a basal level of xylose consumption due to its endogenous xylose reductase activity converting xylose into xylitol (Figure S1; Kim et al., 2013). Although the engineered SR8 strain had a slightly higher xylose consumption rate at 0.44 g/L-h (Table 2 and Figure 5), it did not completely consume xylose even after 24 h of fermentation and not show a significant increase in ethanol concentration compared with the wild type. Through the deacetylation process, the xylose consumption rate and the ethanol productivity at 24 h by the engineered SR8 strain were improved to 0.57 and 0.79 g/L-h (Table 2 and Figure 5), implying that increasing the fermentability of xylose fraction is helpful for more efficient ethanol production in particular with deacetylated biomass. With both strains, ethanol production (i.e., titer and productivity) obtained from deacetylated hemp was higher compared with that from non-deacetylated hemp (Figure 5). Even with kenaf, which showed no significant improvement in ethanol production after deacetylation (Figure 4), fermentation performance was superior with xylose-fermenting SR8 strain (Figure S2). These results indicate that in spite of higher performance of xylose-fermenting yeast, the deacetylation process could be also effective for the wild-type yeast in increasing lignocellulosic ethanol production.

4 | DISCUSSION

Energy crops represent low-cost biomasses cultivated exclusively for biofuel production (Lavanya et al., 2020; Singh et al., 2020). Recently, hemp and kenaf have received a lot of attention as alternative energy crops for bioethanol production (Agbor et al., 2014; Das et al., 2017;
Biomass yield is one of the major parameters to be considered when evaluating the economic feasibility of lignocellulose-derived bioethanol production. Excellent biomass productivity (i.e., production yield per unit area) are known to be a key signature of both hemp (5.3 ton/ha) and kenaf (10.9–27.2 ton/ha). These biomass yields for hemp and kenaf are comparable or superior to those obtained with the common agricultural wastes including corn stover (8.4 ton/ha), wheat straw (6 ton/ha), and rice straw (4.1–6.2 ton/ha) and woody biomasses including hardwood (4.5 ton/ha) and softwood (>4.5 ton/ha; Das et al., 2017; Park et al., 2021). With respect to ethanol production, technoeconomic analysis for hemp and kenaf is only available in comparison with other energy crops. Relevant report in comparison with agricultural and woody residues is lacking. According to Das et al. (2017), hemp (82.3 gal/dry ton) and kenaf (96.5 gal/dry ton) displayed higher or similar ethanol yields than or to those of switchgrass (82.0 gal/dry ton) and sorghum (89.5 gal/dry ton) when acid-pretreated biomasses were applied. Collectively, both hemp and kenaf can be regarded as promising biomasses for bioethanol production considering their excellent biomass productivities and high ethanol yields.

Pretreatment of lignocellulose, which is the process to make the biomass structure less recalcitrant, is required to obtain the improved enzyme saccharification and ethanol yield. Among the various biological, physical, and chemical pretreatment methods, hydrothermal treatment using dilute sulfuric acid is generally considered as the cost-effective and efficient way to disrupt the lignocellulose structure by solubilizing the hemicellulosic polysaccharides and reconstructing lignin (Park et al., 2020). Unfortunately, during hydrothermal pretreatment, the acetyl group present as the substituents of xylan, which is the major polysaccharide in hemicellulose, is inevitably hydrolyzed into the form of free acetate or remain as the side chain in the xylose oligomers in hydrolysates of biomass (Agger et al., 2010; Chen et al., 2012). The acetate present in the lignocellulosic hydrolysate often shows a detrimental effect on the subsequent enzyme saccharification and fermentation (Gurram et al., 2011; Qing et al., 2010). In previous studies, hydrothermal pretreatments using dilute acid were already proven to be effective for hemp and kenaf (Kamireddy et al., 2013; Park et al., 2021). However, like in the case of other lignocellulosic biomasses, substantial amounts of acetate were released into the hydrolysates of hemp and kenaf (Figures 3c and 4d). Therefore, as a strategy to enable to improve the hemp and kenaf-based ethanol conversions, we have performed alkaline deacetylation of the intact hemicellulose in biomasses through the systematic analysis. As a result, the optimal condition giving rise to the maximal acetate removal and the minimal sugar loss was determined (i.e., 1% NaOH). Although our approach was proven to be valid for both biomasses, acetate removal by NaOH was more effective with kenaf, indicating that kenaf may contain more acetyl groups than hemp, which

FIGURE 5 Deacetylation improved cellulosic ethanol production by both wild-type and xylose-fermenting *Saccharomyces cerevisiae* strains (D452-2 and SR8, respectively). Deacetylation was performed with 1% (w/v) NaOH at 65°C for 2 h before acid hydrolysis. Acid hydrolysis with 1% (v/v) H$_2$SO$_4$ at 121°C for 30 min was performed. Simultaneous saccharification and fermentation was performed with an initial OD of 20 at 30°C and 130 rpm for 24 h.
was confirmed by the compositional analysis in this study (Table 1). Structural difference between the two biomasses could be another explanation. This is inconsistent with previous studies reporting that industrial hemp contains more hemicellulose and acetate than kenaf (Jönsson & Martín, 2016). This could be well explained by the fact that the compositions of hemicellulose and acetate could highly vary depending on the cultivation conditions of biomasses (Park et al., 2021), further suggesting the necessity for the cultivar-specific customization when conducting deacetylation for hemp and kenaf.

Pectin is another main constituent of hemp and kenaf. Under alkaline and acidic conditions, pectin is degraded to release galacturonic acid (GalA) via β-elimination, which also acts as the inhibitor for yeast fermentation (Diaz et al., 2007; Jeong et al., 2020, 2021; Mao et al., 2019). Therefore, the possibility should not be excluded that GalA could be also produced and removed together with acetate during alkaline treatment followed by washing step in this study.

Acetate detoxification prior to acid pretreatment conducted here successfully enhanced the SSF performance for ethanol production from both biomasses when evaluated in terms of sugar consumption rate, ethanol titer, and ethanol productivity (Figures 3 and 4 and Table 2). In SSF system, enzyme saccharification and microbial fermentation occur simultaneously in one pot. Consequently, it is difficult to directly understand the relationship of the outcome of saccharification and that of subsequent fermentation (Kim et al., 2013; Wei et al., 2013). By removing acetyl group from biomass, the efficiency of enzyme saccharification, independently carried out for polysaccharides (i.e., cellulose and xylan), was significantly improved (Figure 2 and Table 2). This result implies that without deacetylation process, the free acetic acid and/or intact acetyl group present in the xylose oligomer, often generated after acid pretreatment, could cause a significant inhibitory effect on the efficiency of enzyme saccharification. Free acetate is known to little affect the cellulolytic enzyme activities (Kim et al., 2011). Thus, it is more plausible that enzymatic saccharification of xylan and cellulose was interfered by the xylose oligomer containing acetyl group with a hindrance effect as evidenced in earlier studies (Agger et al., 2010; Chen et al., 2012), leading to reduction in the overall sugar yields for glucose and xylose, (de Assis Castro et al., 2017; Qing et al., 2010). Structural modification of deacetylated biomass, associated with crystallinity, DP, and accessible surface area, could be another explanation (Šoštarić et al., 2022). Overall, the improved ethanol production with deacetylated biomasses obtained in this study could be highly associated with increased fermentable sugar yields from hydrolysis process (i.e., glucose and xylose).

Xylose is another major sugar component of lignocellulose together with glucose (Somerville et al., 2004). In this study, the amounts of xylose released from xylan fractions in acid-pretreated hemp and kenaf during enzyme saccharification were still substantial (12.6–17.3 g/L; Figure 2). This result implies that xylose utilization in fermentation could be helpful to achieve more industrially compatible ethanol production (Park et al., 2020). Indeed, S. cerevisiae SR8 strain contributed to additional increase of the maximal ethanol production by more consuming xylose than wild type (Figure 5), proving its applicability. Since xylose utilization by yeast was more affected than glucose utilization by the presence of acetate (Figures 3 and 4), deacetylation process is considered necessary in particular for xylose-using yeast to accomplish more efficient ethanol production.

Here, the effect of deacetylation prior to acid pretreatment on ethanol production by xylose-consuming S. cerevisiae was evaluated. Using hemp and kenaf with high industrial values, systematic optimization for alkaline deacetylation was conducted and proven to be effective for ethanol production. This study provides a simple and efficient approach for hemicellulose detoxification, which will be helpful for industrial production of lignocellulose-based bioethanol and biochemicals in the future. Considering high variations of biomass in composition and structure, further study needs to be directed towards evaluating deacetylation effects against various hemp and kenaf cultivars.

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CONFLICT OF INTEREST
The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT
The data that support the findings of this study are openly available in Research Gate at http://doi.org/10.13140/RG.2.2.10230.68169.

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**SUPPORTING INFORMATION**

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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